

Effects of Training of Eye Pursuit Skills on Reading Capacity of Children with Oculomotor Dysfunction at Primary level

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ABSTRACT

The study was experimental in nature whereby Pretest-Posttest Control Group Design was applied. The population comprised of the children having poor reading capacity in addition to Oculomotor Dysfunction at primary level between the ages 5-14 years. Poor readers with the score of percentile rank below 15 or below average accuracy on KD Test were identified as Children with Oculomotor Dysfunction (OMD Children). Simple random technique was used to select a sample of 20 OMD Children from a pool of 50 OMD Children. The sample of study was divided into experimental and control group with 10 OMD children in each. Nova Southeastern University College of Optometry (NSUCO) Oculomotor Test was administered to appraise the level of Eye Pursuit Skills of the participants of both groups before and after the intervention. Manual and computer animated training of eye pursuit skills was given for 50 minutes per day for 7 days a week for 6 weeks to the experimental group only. Analysis of Covariance (ANCOVA) was employed to make a comparison between reading capacity of both groups. The results indicated that there was significantly positive effect ($p < 0.05$) of the training of eye pursuit skills on the reading capacity of Children with Oculomotor Dysfunction.

Keywords: Eye Pursuit Skills, Children with Oculomotor Dysfunction, Reading Capacity

INTRODUCTION

Reading is the primary skill needed for effective learning. Efficient eye movements have strong correlation with the effective reading. Regular participation of child in training exercises and sports activities like catching a ball and bike riding enhance the reading skills of the child which show improvement in visual tracking, peripheral vision, eye-hand coordination and eye teaming (Busten, 2014). Visual tracking exercises and eye teaming training can enhance the visual efficiency of a child and enable him/her to effectively focus on a line of print while reading (Sekznick, 2012). Visual tracking involves three types of visual skills i.e. fixation, saccade and pursuit. These skills are core of our visual system (Shaw-McMinn, 2014). Focusing on an object and watching carefully with visual attention refers to visual fixation, whereas rapid eye movement from one object to another is known

as saccadic eye movement (Knudson & Morrison, 2002). Following a moving object by an eye refers to visual pursuit (Koprinkova-Haristova, Mladinov & Kasabov, 2014).

Oculomotor Dysfunction (OMD) is a neuromuscular irregularity of visual control which denotes an inability to perform accurate and effective eye movement skills of fixation, saccades and pursuits. Underlying signs of OMD include the poor ability to visually direct and

coordinate movements, poor visual tracking ability, loss of place and repetition/omission of words and use of marker to avoid loss of place while reading (Garzia, 2010). The reading skills of Children with Oculomotor Dysfunction are affected due to their poor control over the eye movements. Rigorous training of visual tracking skills help to improve the eye movements which ultimately assists to enhance the reading ability of the students (Leong et al., 2014). The rehabilitation of three major components of visual tracking skills (Fixation, Saccade, and Pursuit) improves the control of eye movements, rate of reading and overall reading capacity (Thiagarajan et al., 2014).

The practice of visual tracking can result in better and efficient oculomotor skills and may enhance reading fluency (Leong et al., 2014). The training of visual tracking skills through vision therapy services or other visual exercises assists to improve visual performance and reading. Solan, et. al, (2001) found that comprehension therapy and visual movement therapy helps to improve reading skills. The training of eye movements has been linked with enhancement of reading speed; however, the students are not usually trained in somatic performance of reading in the educational institutions (Raouf et al., 2021; Abdulmuhsin et al., 2021). Wethe et al. (2015) conducted a research to observe effects of oculomotor training on the reading fluency outcomes on the students at the elementary level. "Pre-test and post-test training Academic Reading speed-related benchmarks were appraised for 09 children (Grade-1 to Grade-4) who underwent 6 weeks training in the school by the use of computer software". After the training the scores of reading fluency were improved and it was found significant ($p=0.008$, Wilcoxon signed-rank).

Eye pursuit movement plays effective role in the process of reading. In a recent research, children with developmental coordination disorder underwent different types of visual exercises. There was no significant effect of visual exercises on the horizontal eye pursuit skills but very positive impact on vertical eye pursuit skills (Robert et al., 2014). The findings of the study of Powers and Grisham (2003) revealed a significant effect of web-based online computerized visual skills training in terms of visual pursuit skills, vergence, and accommodation on the reading performance of children and adults. The training of eye pursuit skills may help to improve involuntary visual movements and consequently increase the level of reading ability of the Children with Oculomotor Dysfunction (OMD). No any research has yet been documented in Pakistan on the eye pursuit skills in relation to the reading ability, present research aimed to determine the 'effect of training of Eye Pursuit Skills on the Reading Capacity of Children with Oculomotor Dysfunction at primary level'. The research may help the teachers and parents in improving the mechanical errors of eyes particularly eye pursuit skills and the reading capacity of the students accordingly.

The basic purpose of this study was to ascertain the influence of eye pursuit exercises on the reading capacity of Children with Oculomotor Dysfunction at primary level. The present study also examined the effect of training through eye pursuit exercises on the improvement of eye pursuit ability among the Children with Oculomotor Dysfunction.

Methodology

Procedure

The present study was experimental and quantitative in nature whereby Pretest-Posttest Control Group Design was applied to exhibit the effects of independent variable (training of Eye Pursuit Skills) on dependent variable (Reading Capacity of OMD Children) after the intervention (Salkind, 2010). Researcher identified poor readers having weak oculomotor skills with the help of teachers from the Govt. Primary Schools of district Toba Tek Singh, Pakistan. King Devick Test was administered on the poor readers to assess their oculomotor skills with the help of online reading cards. Finally a pool of 50 Children was selected to be included in the study who was having Oculomotor Dysfunction with below average accuracy and below 15 percentile rank on King Devick Test out of total 56 identified OMD Children. Thereby, Nova Southeastern University College of Optometry (NSUCO) Oculomotor Test was also administered to assess the below average oculomotor skills (pursuit, saccade). The gaze fixation skills were assessed with the help of manually recorded videos. 20 Children with Oculomotor Dysfunction were randomly selected from the pool of 50 identified OMD Children and divided into two groups with 10 OMD Children in each group i.e. Group A (Experimental) and Group B (Control). Pretest assessment of reading capacity and eye pursuit skills of both the groups was made. Experimental group underwent visual training through eye pursuit exercises; however no treatment was given to control group. Posttest assessment of the reading capacity and the eye pursuit skills of both the groups was made and compared to examine the effect of intervention.

Study Participants

All the children with poor reading capacity in addition to Oculomotor Dysfunction at primary level between the ages 5-14 years were the population of the study. In order to locate the prospective population of the study, 10 randomly selected primary schools of district Toba Tek Singh were visited. 209 children with poor reading capacity were identified with the help of their teachers. The assessment of basic three components of visual tracking abilities (Pursuit, Fixation and Saccade) was made before the treatment to confirm the inclusion of OMD Children on account of their weak visual tracking skills. Researcher selected 50 children having poor visual tracking skills (Pursuit, Fixation and Saccade). A sample of 20 children was selected from the pool of 50 diagnosed OMD Children on draw basis. These 20 OMD children were randomly assigned to 2 equivalent groups i.e. Group A (experimental) and Group B (Control).

Instruments

Appraisal of Visual Pursuit, Fixation and Saccadic Skills, Assessment of Reading Capacity and the Diagnosis of OMD Children was made as follows:

Diagnostic Procedure of Children with Oculomotor Dysfunction

Children with Oculomotor Dysfunction were diagnosed with the help of King Devick Pro Reading online test (KD Test) which was applied on the poor readers. The KD Test was a reliable tool to assess the OMD Children with established test-retest reliability of $r=0.87$ (Oberlander, Olson & Weidauer, 2017; Basheer et al., 2021; Yan et al., 2020; Nuseir et al., 2020; Asada et al., 2020; Shehzadi et al., 2020). Poor readers had to read alphanumeric values loudly on the Timed KD Test with full speed inhibiting the errors. The age of OMD Children and total number of reading error score was put in the KD Computer Software. The KD Test app automatically compared test results with age-related normative data and displayed reading capacity of the subjects in the form of percentile rank and accuracy (Mayo

Clinic, 2015). Children having below 15 percentile rank or below average accuracy represented with (N=56) Oculomotor Dysfunction (Nazir & Nabeel, 2019).

Table 1: OMD Children diagnostic score on KD Test

Groups	Class	Accuracy test		Percentile Rank		Reading Error	
		B.A	A	Mean	S.D	Mean	SD
A	2	2	0	5.50	6.36	15.0	9.90
	3	3	0	1.33	.577	6.00	2.65
	4	3	0	6.00	4.35	6.33	1.53
	5	2	0	6.00	.0	4.50	.707
	All	10	0	4.50	3.70	7.60	5.36
B	2	2	0	1.00	.0	10.0	1.41
	3	3	0	5.00	1.00	6.00	1.73
	4	3	0	4.00	3.00	8.00	1.00
	5	2	0	4.50	2.12	6.00	1.41
	All	10	0	3.80	2.25	7.40	2.01

B.A=Below Average, A=Average, S.D=Standard Deviation

Appraisal of Eye Pursuit and Saccadic Skills

Nova Southeastern University College of Optometry (NSUCO) Oculomotor Test was applied to appraise the level of Eye Pursuits and Saccadic Skills of OMD children. The NSUCO Test provided economic and very quick measurement of oculomotor skills with slight cooperation of the client. It took less than two minutes to complete the test. Two targets of pencils having coloured balls on the top were used (two targets for the measurement eye saccade skills and one target for evaluation of eye pursuit skills). The child stood on feet before the researcher at a distance no less than Harmon Distance and not more than 40 cm with the arms naturally hanging. The subject was given any direction about the movement of his/her head. The head, body and eyes movements were assessed in the test. Four areas of performance were classified in both the pursuit and saccade portions of the test. The areas included: 1) Ability, 2) Accuracy, 3) Degree of head movement, and 4) degree of body movement of the child used to complete the task. There were eight areas evaluated in total; four for eye pursuit and four for visual saccade skills. The established intra-rater reliability values for the four variables tested with Saccades: “ability” indicated 90%, “accuracy” showed 62%, “head movement” displayed 86%, and “body movement” revealed 95% intra-rater reliability. The Eye Pursuit Skills areas indicated intra-rater reliability: “ability” indicated 95%, “Accuracy” indicated 90%, “Head Movement” revealed 76%, and “Body Movement” showed 100% intra-rater reliability (Maples, 1995). The level of Visual Pursuit Ability was determined before and after the intervention, whereas the level of Eye Saccadic Ability was assessed before the intervention only.

Assessment of Gaze Fixation Ability

The level of gaze fixation ability in form of time duration was assessed during reading a paragraph for one minute. Total numbers of gaze fixations while reading was noted down with the help of recorded videos. Time duration of Gaze Fixation ability of OMD Children was gained by dividing the total reading time (in seconds) by the number of fixations made before the intervention. The intra-class coefficient (ICC) for duration of Gaze Fixation was established ($r=0.89$) on Visagraph II instrument (Borsting, Rouse, Shin, & McClallen, 2007). The level of Gaze Fixation Ability was assessed merely before the treatment.

Evaluation of Reading Capacity

The reading capacity of OMD Children was evaluated before and after the treatment with the help of Word Correct Per Minute (WCPM) Method. Researcher randomly selected five passages of Urdu subject of grade 1 to grade 5 to evaluate the reading capacity of OMD Children from Punjab Textbook Board. WCPM Method helps to evaluate the reading rate (Tindel & Joseph, 2013). WCPM score was calculated by subtracting total numbers of errors from total number of words read in one minute. The reading errors of the students while reading the paragraphs were: 1) word addition (out of text), 2) omission, 3) substitutions, 4) reading a word after a pause / break of 3-5 seconds, 5) mispronunciation, 6) out of order reading, and 7) self-corrected error by the student. The reliability of selected paragraphs from Punjab Textbook Board was evaluated to assess its suitability for the research. The test-retest reliability coefficient (Cronbach Alpha) for the Grade-2 was $r=0.98$, Grade-3 was $r=0.97$, Grade-4 was $r=0.94$ and Grade-5 was $r=0.98$.

Treatment Protocol

The training of Eye Pursuit Exercises was given to the subjects of the experimental group to improve their reading capacity. The training period of 42 sessions for the experimental group was lasted for 50 minutes session per day, 7 sessions a week for 6 weeks. In order to improve the reading capacity of the OMD Children, five manual and two computer-animated eye pursuit exercises were arranged every week. The training visual tracking skills improve the reading capacity (Thiagarajan, 2012). The selection of Eye Pursuit Exercises was made from reliable resources (Heidi, 2011). The exercises of eye pursuit skills were conducted on OMD Children of experimental group individually by collecting them at a central place with the help of research assistant. The detail of Eye Pursuit Exercises is given below:

Table 2: Taxonomy of Exercises for Eye Pursuit Skills

Type	Exercises
Manual Exercises for Eye Pursuit Skills	<ol style="list-style-type: none">1. Capturing Rolling Marbles2. Swinging ball pursuits3. Flash light tag4. Pie pan rotation5. Holding and moving small target
Computer Animated Exercises for Eye Pursuit Skills	<ol style="list-style-type: none">1. Bug Run2. Bug Walk

Data Analysis

The effect of training of eye pursuit skills on the reading capacity of OMD Children was analyzed by making comparison between Experimental and Control group scores of reading ability. The equivalence in visual tracking skills (Pursuit, Fixation and Saccade), reading capacity and the age of OMD Children was determined by applying the Analysis of Variance (ANOVA) before the intervention between experimental and control group. Analysis of Covariance (ANCOVA) was used to compare the reading capacity level of both the groups. The effect of intervention (Eye Pursuit Exercises) was also examined on the improvement of eye pursuit skills using ANCOVA.

Results

The study was carried out to ascertain the effect of training of eye pursuit skills on the reading capacity of OMD Children at primary level. Pretest-posttest control group design was used in the study with two groups (experimental and control) having 10 OMD Children in each. There was no any significant difference ($p>0.05$) in the eye pursuit skills, reading capacity and the age of the OMD Children before the intervention between both of the groups.

Effect of Eye Pursuit Skills training on Reading Capacity of Children with Oculomotor Dysfunction at primary level

The Shapiro-Wilk's test (10)=0.916, $p>0.05$ for Group A, (10)=0.923, $p>0.05$ for Group B showed that score of the reading capacity of both the groups was normally distributed. The Levene's test $F(1, 18)=0.401$, $p>0.05$ verified the equality of variance among the subjects. The ANCOVA values, $F(1, 16)=0.082$, $p>0.05$ verified the Homogeneity of Regression Slope and showed that there was no interaction between the covariate and the treatment. The visual inspection of Scatter plot showed that the scores of covariate and dependent variable were linearly related with each other. The above values showed that ANCOVA could be applied for the analysis of reading capacity of OMD Children. Partial eta-squared was explained using the values: 1) *Partial Eta Squared Value* 0.01=Small Size, *Partial Eta Squared Value* 0.06=Medium Size, and *Partial Eta Squared Value* 0.14=Large Size (Gray & Kinnear, 2012).

Table 3: The Reading Capacity level between experimental and control group on post-test scores of WCPM Method after controlling pre-test scores

Class	Group A				Group B				ANCOVA				
	n	Pre-test		Post-test		n	Pre-test		Post-test		F Value	p Value	η^2
		M	SE	M	SE		M	SE	M	SE			
2	2	38.5	2.50	45.5	.0	2	42.5	7.50	43.5	.0	11.01	.013	1.0
3	3	60.7	14.0	72.1	1.47	3	65.3	11.1	64.5	1.47	13.11	.036	.814
4	3	60.0	14.6	57.7	1.30	3	43.0	4.04	54.3	1.30	3.017	.181	.501
5	2	69.5	14.5	77.6	1.60	2	74.5	.500	74.8	1.60	1.536	.432	.606
All	10	57.8	6.63	64.1	.832	10	55.9	5.54	59.0	.832	19.50	.001	.534

A=Experimental Group, B=Control Group, WCPM = Word Count/Minute Method

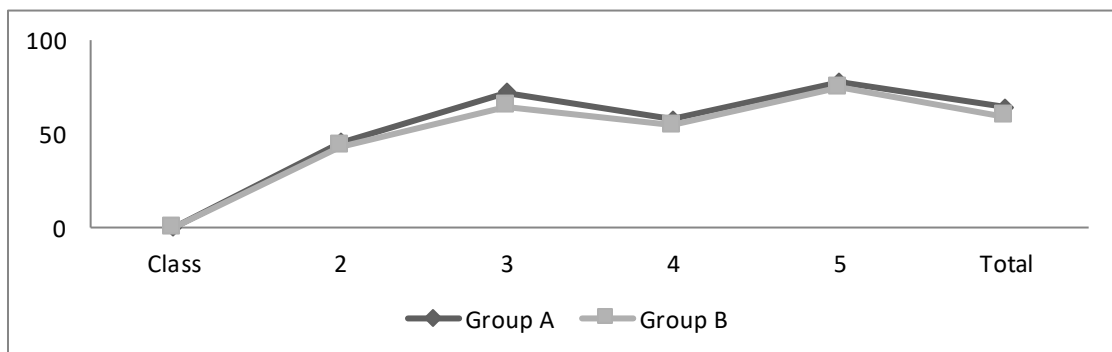
A One-way between groups analysis of covariance was applied to compare the effect of two different treatments intended to enhance the reading capacity of OMD Children. The independent variables were the type of interventions and the dependent variable was the level of reading capacity after the treatment. The pre-intervention score of the

respondents was used as covariate in the analysis. The level of Reading Capacity was appraised before and after the intervention using WCPM Method. After adjusting for pre-treatment, there was a significant differences in class 2, $F(1,1)=11.01, p=0.013$, partial eta squared=1.0, class 3 $F(1,3)=13.11, p=0.036$, partial eta squared=0.814, but there was no significant difference in class 4, $F(1,3)=3.017, p=0.181$, partial eta squared=0.501, and class 5, $F(1,1)=1.536, p=0.432$, partial eta squared=0.606. There was significant difference in combined scores of both groups, $F(1, 17)=19.50, p=0.001$. Partial eta squared=0.534 showed that Effect size was large. The mean score of Group A ($M=64.0, SE=.832$) was greater than mean score of Group B ($M=59.0, SE=.832$). It revealed that there was significant effect ($p<0.05$) of Eye Pursuit Skills training on the reading capacity of Children with Oculomotor Dysfunction.

Figure 1:Representation of Reading Capacity between group A and B on post-test scores of WCPM Method after controlling pre-test scores

Effects of training through Eye Pursuit Exercises in enhancing the Eye Pursuit Skills of Children with Oculomotor Dysfunction

The equality of variance among the samples was tested and satisfied via the Levene’s test $F(1, 18)=0.440, p>0.05$. The values of Shapiro-Wilk’s test (10)=0.852, $p>0.05$ for Group C, and (10)=0.930, $p>0.05$ for Group E showed that data regarding the level of Visual Pursuit Skills of both groups was normally distributed. The visual inspection of



Scatterplot showed that the scores of covariate and dependent variable were linearly related with each other. The ANCOVA values, $F(1, 16)=0.754, p>0.05$ verified the Homogeneity of Regression Slope and showed that there was no interaction between the treatment and covariate. The above values showed that ANCOVA could be applied for the analysis of Visual Pursuit Skills of Children with Oculomotor Dysfunction.

A One-way between groups analysis of covariance was conducted to compare effectiveness of two different interventions designed to improve the Eye Pursuit Skills of OMD Children of experimental group A and control group B. The independent variable was type of treatment (manual training through eye pursuit exercises) and the dependent variable was the level of Eye Pursuit Skills after intervention. The pre-intervention score of the respondents was used as covariate in the analysis. The level of Visual Pursuit Skills was assessed before and after the treatment on NSUCO Oculomotor Test.

After adjusting for pre-treatment, there was no significant difference between group A and B in class 2, $F(1,1)=0.400, p=0.641$, partial eta squared=0.286, class 3, $F(1,3)=8.294, p=0.064$, partial eta squared=0.734, class 4, $F(1,3)=1.142, p=0.364$, partial eta squared=0.276, and class 5, $F(1,1)=1.841, p=0.404$, partial eta squared=0.648. The comparison of combined scores revealed that there was significant

difference between group A and B, $F(1,17)=8.540, p=0.010$. Partial eta squared=0.334 showed that Effect Size was large. The overall mean score of Group B ($M=11.6, SE=0.352$) was less than mean scores of Group A ($M=13.1, SE=0.352$). It was concluded that the level of Eye Pursuit Skills of experimental group A was significantly improved ($p<0.05$) after the intervention in terms of training through eye pursuit exercises than the control group B.

Table 4

Comparison of the Eye Pursuit Skills between groups (A & B) on basis of training through eye pursuit exercises

Class	Group	n	Ability		Accuracy		Head Movement		Body Movement		Total		ANCOVA			
			M	SE	M	SE	M	SE	M	SE	M	SE	F	P	η^2	
2	A	7	Pre	3.00	1.0	3.0	.00	2.0	1.0	3.50	.50	11.5	.50	.400	.641	.286
			Post	3.95	.46	2.25	.00	2.35	.23	4.00	.56	11.2	.83			
	B	7	Pre	2.50	.50	1.50	.50	1.50	.50	3.00	.00	8.50	.50			
			Post	2.55	.46	3.25	.00	1.65	.23	3.59	.56	12.2	.83			
3	A	3	Pre	2.67	.33	2.33	.33	2.67	.33	3.33	.33	11.0	.58	8.294	.064	.734
			Post	3.77	.51	3.33	.34	3.41	.25	4.33	.38	14.8	.46			
	B	3	Pre	3.00	.58	2.33	.67	3.0	.00	3.33	.33	11.7	.67			
			Post	3.56	.51	2.67	.34	2.92	.25	3.67	.38	12.9	.46			
4	A	7	Pre	3.00	.58	2.67	.33	2.33	.33	3.33	.33	11.3	.88	1.142	.364	.276
			Post	3.67	.35	3.0	.00	2.75	.42	3.58	.38	12.6	.77			
	B	7	Pre	3.00	.58	2.0	.00	1.67	.33	3.00	.00	9.66	.33			
			Post	3.33	.35	2.0	.00	2.25	.48	3.42	.38	11.3	.77			
5	A	7	Pre	2.50	.50	2.50	.50	3.0	.00	2.50	.50	10.5	.50	1.841	.404	.648
			Post	3.50	.87	2.25	.56	3.0	.00	3.25	.43	12.4	.92			
	B	7	Pre	3.50	.50	2.0	.00	2.0	.00	3.50	.50	11.0	1.0			
			Post	3.50	.87	2.75	.56	1.50	.50	3.25	.43	10.6	.92			
All	A	10	Pre	2.80	.25	2.60	1.6	2.50	.22	3.20	.20	11.1	.31	8.540	.010	.334
			Post	3.74	.20	2.91	.16	2.85	.15	3.80	.17	13.1	.35			
	B	10	Pre	3.00	.26	2.0	.21	2.10	.23	3.20	.13	10.3	.47			
			Post	3.26	.20	2.49	.16	2.25	.15	3.50	.17	11.6	.35			

A=Experimental Group, B=Control Group, M=Mean, SE=Standard Error

Figure 2: Representation of the level of Eye Pursuit Skills between experimental group A and control group B on post-test scores

Discussion

The study determined the effect of eye pursuit skills training on the reading capacity of OMD Children at primary level. No any significant difference was noted in the level of

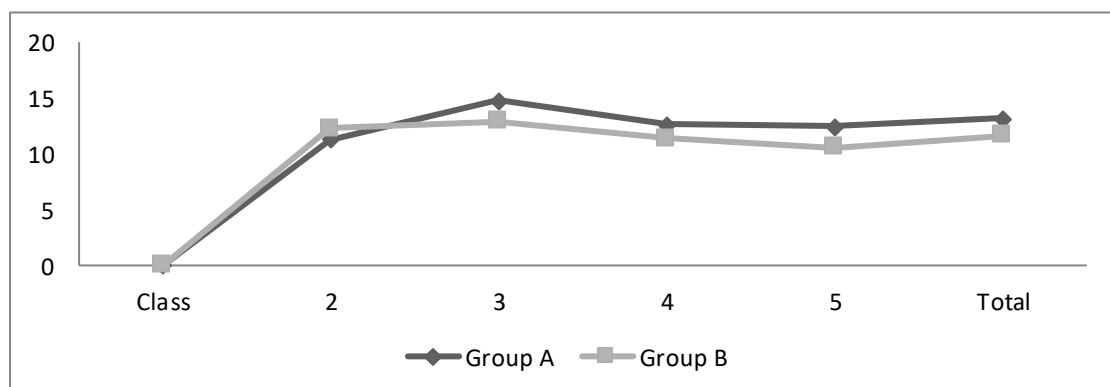
reading capacity of both of the groups in initial assessment. Moreover, the effect of intervention (training through eye pursuit exercises) was also determined on the improvement of Eye Pursuit Skills of OMD Children. The level of Eye Pursuit Skills of both the groups was statistically equal.

Effect of Intervention on Reading Capacity of OMD Children

The reading capacity of experimental group A was significantly improved (64.1 Words Per Minute) after the training in terms of Eye Pursuit Exercises. Whereas control group B indicated low reading capacity level (59 Words Per Minute). The reading capacity mean score of group B ($M=59.0, SE=0.832$) was lesser than mean score of group A ($M=64.0, SE=0.832$). The data values $F(1,17)=19.50, p=0.001$. Partial eta squared=0.534 indicated that Effect size was large. It revealed that there was significant effect ($p<0.05$) of the training of Eye Pursuit Skills on the reading capacity of OMD Children. Similar findings have been reported by the Thiagarajan et al. (2014) in his study and they explained that rehabilitation of three major components of visual tracking skills (Fixation, Saccade, and Pursuit) improves the control of eye movements, rate of reading and overall reading capacity. It showed that training of visual pursuit skills was effective in improving the reading capacity of the children.

Effect of Treatment on Eye Pursuit Skills of OMD Children

The post-treatment appraisal indicated significant difference in the level of Eye Pursuit Abilities between the experimental and control group, $F(1,17)=8.540, p=0.010$. Partial eta squared=0.334 revealed that effect size was large. A significant improvement ($p<0.05$) was noted in the level of Eye Pursuit Skills of group A ($M=13.1, SE=0.352$)



than group B ($M=11.6, SE=0.352$) on the basis of treatment in terms of Eye Pursuit Exercises. It was concluded that the level of Eye Pursuit Skills of experimental group was significantly improved ($p<0.05$) after the intervention in terms of training through eye pursuit exercises than the control group. In a recent research, children with developmental coordination disorder underwent different types of visual exercises. There was no significant effect of visual exercises on the horizontal eye pursuit skills but very positive impact on vertical eye pursuit skills (Robert et al., 2014). The findings of the study of Powers and Grisham (2003) also revealed a significant effect of web-based online computerized visual skills training in terms of visual pursuit exercises, vergence, and accommodation on the reading performance and eye pursuit ability of children and adults.

Conclusions

The level of reading capacity of Children with Oculomotor Dysfunction was significantly improved when provided with the training of manual and computer animated Eye Pursuit Exercises. The eye pursuit abilities of the OMD children were enhanced after the exposure of eye pursuit exercises. This research may help the teachers in developing a plan based on the eye pursuit exercises to improvise the reading and oculomotor skills of the OMD Children in addition to others who experience mechanical errors of the eyes.

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