A three-year longitudinal study was carried out to explore the relationship of VP, VMI and handwriting with academic performance in elementary school children. The study sample was selected using convenience sampling from Shivalli village, Udupi district, Karnataka. A total of 208 students from 12 schools were recruited for the study and the dropout rate was observed to be 8.2%. The children of age seven years were selected for the study. Selected children were from one geographical location and hence the environmental factors were probably controlled. In order to control the family factors that influence academic performance, the socioeconomic status of children was taken into consideration. Children who had migrated from other geographical areas were not included in the study. A semi-structured interview was conducted on the teachers and parents of the children to identify any known physical defects. Screening was done to rule out MR, LD, visual defects, auditory defects, clinical syndromes such as Anxious/Depressed, Withdrawn/Depressed, Somatic Complaints, Social problems, Thought problems, Attention Deficit/Hyperactivity problems, Rule-Breaking Behavior, and Aggressive Behavior. Other variables such as gender, type of family, type of school, peer interaction, status of preschool and participation in extracurricular activities that affect children’s academic performance were adjusted during analysis using multiple linear regression.

TVPS-R, Beery VMI and ETCH-M were used to measure VP, VMI and handwriting legibility skills respectively. Academic performance based on school marks record was chosen for further analysis as the marks were calculated for all subjects from the two term examinations. This was considered more reliable and quantifiable. The analysis of the study revealed that the children who scored lower in VP, VMI and handwriting legibility were performing significantly lower in academics compared to
children who scored higher in VP, VMI and handwriting legibility. Results of the current study are discussed as follows:

5.1. Relationship between academic performances of children in second, third and fourth standard among various demographic variables

Various demographic variables that were considered for the analysis were gender, type of family, peer interaction, type of school, participation in extracurricular activities, exposure to preschool and socioeconomic status.

The results revealed that academic performance of girls was consistently higher in second, third and fourth standard than that of boys. A difference of five to eight marks was found, which was both statistically and clinically significant. Similar results were reported in other studies done in India, according to which girls scored better marks in academics than boys in primary school (Reddy & Reddy, 2016; Srinivas & Venkatkrishnan, 2016). This could be because of better behavior regulation in girls than boys which is similar to the results of the study conducted by Kuhl and Hannover (2012). According to this study, behavior regulation has a positive influence on achievements in German and mathematics. However, there was no significant gender difference in mathematical achievement when self-regulation variables (behavior regulation, problem oriented strategies and emotion oriented strategies) were entered into a model as mediator variables. In the current study, self-regulation strategies were not controlled and hence, analysis by controlling the self-regulation would have yielded reliable results.

The type of family had no significant influence on the academic performance of children in second, third and fourth standard. This raises the question as to whether different family types contribute in any way to academics in children. Intuitively one may expect smaller families to emphasize more on academics which has been found in a study by Suleman et al. (2012) in Pakistan. The lack of any such trend/difference could
be attributed to the nature of the sample selected and may limit the generalizability of this finding to other samples.

Research has shown that having friends or being liked by classmates has positive effect on academic performance (Fantuzzo, Sekino & Cohen, 2004) whereas peer rejection led to academic difficulties (Wentzel & Caldwell, 1997). In the present study, positive peer relations were considered as good and peer rejection was considered as poor ‘peer interaction’. Academic performance was compared between the children with good and poor peer interaction. The results showed that children with good peer interaction scored 9 to 14 marks higher than their counterparts which was statistically significant. This result is similar to the finding in a longitudinal study done by Zitzmann in the year 2005 who found that elementary school children with good peer interaction scored higher marks than their counterparts. It is possible that familiarity due to positive peer interaction may provide a comfortable classroom environment which could be the reason for better academic performance.

There is a general perception that private school children score better than government/ government aided school children. This has been supported by previous studies in a report on school sector effects on student achievement in India (as cited in Kingdon, 2008). However, the current study found that the mean academic performance of children studying in the government aided schools were higher than in private schools in second, third and fourth standard. The difference in the mean academic performance ranged from four to nine marks which was likely to be clinically significant. However, statistical significance was not seen in the scores of second standard children. These results could have been obtained because of possible better student teacher ratio that provides opportunity for the teachers to give individual attention to each child. Another
possibility is that the private schools’ valuation might have been lenient in earlier standards and stricter in later standards as students move to more formal schooling than in the government aided schools. The medium of teaching also might have influenced this finding—children who studied in the government aided schools had Kannada as the medium of instruction, which is also the native language spoken in Karnataka. This would have facilitated their understanding of concepts better than children who studied in private schools where the medium of instruction is English. The parents’ familiarity with language used in the schools could have contributed to the better academic performance of children in government aided schools as the parents might have found it easier to coach their children at home. However, spoken language was not considered during the study design as the study population belonged to a single geographical location. Though the study population had differences in their mother tongue, the medium of instruction used in schools was either English or Kannada. Since the primary focus of the current study was on other factors, inclusion of the impact of spoken language and written language on academic performance is recommended to be studied in future research. Notwithstanding the above conjectures, the finding of better performance in government aided schools rather than private schools needs to be reassessed in future studies to see if it is a robust replicable finding, including the factors contributing to it.

Children who participated in extracurricular activities had higher mean academic performance score than their counterparts who did not, in second, third and fourth standard. The mean difference in the marks was 13 in second standard, 14 in third standard and eight in fourth standard children. Statistically and clinically significant difference was found in the academic performance between children who did and who did not participate in extracurricular activities. This could perhaps be due to extracurricular activities strengthening the skills required for academics such as
enhancing psychological skills, cognitive skills, social networks and peer cultures (Dumais, 2006). However, the exact relationship between higher extracurricular participation and higher academic achievement needs further study.

Some reports state that the benefits associated with preschool exposure fade over time, becoming unremarkable by second grade (United States, Department of Health and Human Services, 2010 as cited in Gayden-hence, 2016; Duncan & Maguson, 2013). It is not clear why the current study results showed a statistically significant difference between the children who had exposure to preschool and who did not, only in third standard and not in the second and fourth standard. This needs to be evaluated further and future studies may be replicated by controlling the confounding variables to identify the effect of exposure to preschool on academic performance. The four to five marks of mean difference may be clinically significant in the current study which has been supported by the studies done by Osakwe (2009), Bibi and Ali (2012). Anderson (2002) stated that “when children are exposed to early education, they will develop superior communication skills, necessary physical ability, social unity needed in adult life and an increased cognitive and effective educational balance” (as cited in Osakwe, 2009). This could be the reason for the result obtained in the current study.

According to a study by Adimora et al. (2015), socio-economic status has an impact on mathematics anxiety which may affect a child’s overall academic performance. Because of multi-dimensional nature of socio economic status, inconsistent results have been found on the influence of the same on academic performance as per a meta-analytical study (Sirin, 2005). In the current study, there was no significant difference in mean academic performance score among categories of socioeconomic status in the consecutive three years. As the information related to a child’s socioeconomic status was accessed from the school records, the reliability of this
information could be questioned. Kuppuswamy’s socioeconomic status scale (modified for 2007) that was used in this study may not have captured the current status of income per month which can be considered as one of the limitations of this study.

5.2. Relationship of VP, VMI and handwriting legibility scores with academic performance in second, third and fourth standard

5.2.1. Academic performance between categories of VP score in the second, third and fourth standard

VP was assessed using TVPS-R and the converted total scaled scores were obtained. In the current study, children’s performance was grouped into low, average and high categories based on tertiles obtained from the total scaled scores. In second standard, the mean academic performance score was lower in children with low VP skills compared to children with average and high performers in VP. This difference in the mean academic performance was found to be approximately nine marks which was both statistically and clinically significant. The power of the test was found to be 0.928. Analysis of TVPS-R subtests showed statistically significant difference in mean academic performance among the categories of visual memory, visual spatial relationship, visual form constancy, visual figure-ground and visual closure. In a cross sectional study that was conducted by Chen et al. (2011) in year-2 children (8-years old) regarding the relation of visual perception to academic achievement it was found that all subtests in TVPS-R had shown significant difference between low and high academic achievers except visual memory which is supporting the current study results. Cross-sectional studies by Sortor and Kulp (2003), Kulp, Edwards and Mitchell (2002) across second through fourth grade children found a positive relationship between visual memory (component of VP) and academic activities (mathematics and reading) when controlled for age and verbal ability but not for intelligence. In the current study, as years
passed, the mean difference of one mark in third standard and four marks in fourth standard was not significant statistically among low, average and high performers in VP. This could be due to the intelligence factor which was controlled in the current study. It was found that the children in later grades were in a better position to visualize mentally. Hence, the children were better able to add mentally, remember simple mathematical tables and break down larger problems to simple ones, which could also be the reason for the results obtained in the current study. Children with IQ $\geq 90$ in the standard score were included in the current study. Academic performance of all children remained same even with differences in VP. According to a meta-analysis done by Kavale and Forness in 2000, the relationship between perception and reading cannot be generalized beyond grade three when IQ scores are known and the phonemic awareness can predict the reading ability better than IQ and VP. The findings in the current study could similarly be explained as reading ability is a part of academic performance. The above mentioned same study by Kavale and Forness (2000) also found that the reading abilities in third grade students involve not only the perception of the stimuli but also interpretation and memorizing the stimuli. Similar logic can be applied to the current study which found that VP had significant relationship in academic performance in second standard only. This could be due to the fact that skills evaluated in lower standards might involve more of visual perception rather than interpretation.

5.2.2. Academic performance between categories of VMI score in the second, third and fourth standard

Beery VMI was used to assess the VMI skill. Standard score which was converted from raw score was used for further analysis. For the current study, scores were divided into three categories based on tertiles as low, average and high VMI skill and the mean academic performance was compared among those categories. Second and
third standard children with low VMI score had seven to nine marks lower than the children with high VMI score which was found to be statistically significant and the power to detect an effect size was determined to be 0.925 and 0.753 respectively. Similar results were found in the studies done by Pereira et al., (2011) in Brazil among second grade and Pienaar et al., (2014) in South Africa among first grade children. Barnhardt et al., (2005) found similar results in their cross sectional study in third grade children that was conducted in the United States in which it was found that low VMI group made more errors in the tasks such as alignment of numbers, organization of numbers, spacing between letters and words. The initial elementary school curriculum is the time for children to start learning and exploring sentence writing which involves more VMI skills. This could have been the reason for the current finding. According to Pienaar et al., (2014) also, VMI has a positive association with basic academic skills. The basic academic skills that are required to perform academic activities are learnt and practiced by children at early grades as they become familiar and habituated with them. Refinement of VMI skill at a later stage could have been the reason for not resulting in significant differences in fourth standard. It could also be that tasks related to VMI might not be important in later stages as it is learnt overall in early schooling.

5.2.3. Academic performance between categories of handwriting legibility score in the second, third and fourth standard

The ETCH-M tool was used to assess the legibility of handwriting. The handwriting total legibility score was categorised as good, average and poor based on tertiles for the current study. Children with good legibility score had significantly higher mean academic performance than the children with poor legibility score in all three years i.e. second, third and fourth standard with the power of the test as 0.999, 0.967 and 0.746 respectively. The difference in the scores obtained ranged from 7 to 14 marks which was
found to be clinically significant. Results of the current study are consistent with other studies that have reported that handwriting is a contributing factor towards academic performance (Dinehart & Manfra, 2013; Pontart et al., 2013). It is also supported by the statements such as “handwriting is tied to academic achievement,” (Cahill, 2009), “failure to attain handwriting competency during the school-age years often has far-reaching negative effects on academic success” (Denton, Cope & Moser, 2006). Difficulty in handwriting has an impact on academic success and life skills (Feder & Mejnemer, 2007). Hence, handwriting has a relationship in the current study as the outcome of academic performance is measured mainly through writing in this context.

Since no multicollinearity was found in the multiple linear regression analysis it could be understood that the skills such as VP, VMI and handwriting were divergent in nature in the current study. Hence, these skills can be considered as independent that contribute differentially towards academic performance over three years.

5.3. Predictors of Academic Performance

Multiple linear regression analysis using the variables of those univariate p values less than 0.15 were included to assess the predictors of academic performance. The variables such as gender, type of school, peer interaction, participation in extracurricular activities and status of preschool were included as categorical variables. The primary independent variables namely VP, VMI and handwriting were included in the model as continuous variables.

The result showed that 43%, 26% and 17% of the variance in academic performance could be predicted in second, third and fourth standard consecutively by them. This clearly shows that the overall variance in the academic performance using VP, VMI and handwriting legibility gradually reduces as years pass on from second to
third and from third to fourth standard when adjusted for factors such as gender, type of school, peer interaction, participation in extracurricular activities and the status of preschool. The current study suggests that children with academic difficulty in this age group, could be due to problems in VP, VMI and handwriting which needs to be borne in mind during evaluation. As children grow, the contributions to academic performance may also be due to other factors that need to be identified and intervened. In the current study, VMI was found to be a significant predictor of academic performance in all the three years when adjusted for other factors. This could be because children in elementary school are engaged predominantly in visual motor skills as cited in Schneck, 2010. VP was found to be a significant predictor only in third standard when adjusted for other factors. But, it is not clear why the VP was a significant predictor only in third standard. However, reliability of these results may not be assured as this could have occurred due to few methodological flaws. The test for VP is time consuming, with similar pattern of test items which make it monotonous and boring for children who perform them. Children’s involvement in performing the tasks would be better if the test items are administered in parts as the test guidelines permits to do so. This test was not administered in parts in the current study because of time constraints in the fixed school system. Handwriting was found to be a significant predictor only in second standard when controlled for other factors. In the current study, increase in legibility as years pass could be the reason for handwriting not being a significant predictor in third and fourth standard. This is also supported by a study done by Overvelde and Hulstijn (2011) who found that there was an improvement in the quality of handwriting from grade 2 to grade 3.
5.4. Developmental trend of VP, VMI and handwriting legibility

Repeated measures of ANOVA was used to analyse the yearly changes in primary measures such as VP, VMI and handwriting legibility over a period of three years. The results were interpreted as follows:

VP score showed 30.90% increase in third standard when compared to second standard which was statistically significant. However, reduction in VP score of 4.84% was observed in fourth standard compared to third standard which was not statistically significant. It indicates that the development of VP may have attained a ceiling effect by third standard and hence VP has to be evaluated for academic difficulties until third standard. VP may not be a major contributing factor of academic performance in fourth standard onwards. Williams (as cited in Schneck, 2010) estimated that the visual perceptual skill development occurs between three and nine years of age. The current study result is consistent with the above mentioned statement. It was mentioned that children between 6 and 7 years of age prefer to learn through kinesthetic, tactile, visual and auditory senses. Since the predominant mode of learning is tactile and kinesthetic in children between 6 and 7 years of age, they learn easily through sense of touch and whole body movement. Ability to integrate, understand, remember and reproduce the detailed information on figures depends predominantly on their visual motor skills in elementary school children (as cited in Schneck, 2010). This could be the reason for not having significant change in VP from third to fourth standard. However, reliability of these results may not be assured as the observed reduction could have occurred because of a few methodological flaws which has been discussed earlier. More longitudinal studies with strong methodology are needed to establish a developmental trend of VP.

There was a 1.52% increase in VMI score from second to third standard and 1.78% of reduction from third to fourth standard. But, the change in VMI score among
second, third and fourth standard children was not statistically significant. This may be due to the fact that the development of VMI would have attained a ceiling effect by second standard itself. It means that children with academic difficulties by second standard may have problems in VMI and intervention for the same would improve academic performance. Even though there was no significant change in the VMI scores over a period of three years, it was found to be a significant predictor of academic performance in all the three years when adjusted for other factors in multiple linear regression analysis. This could be because children in lower grades are engaged in academic activities involving visual motor skills. Hence, when a child shows difficulties in academic performance, VMI could be considered for evaluation. A cross sectional study was conducted in the year 2014 by Becker, Miao, Duncan and Mcclelland on effect of behavioral self-regulation and executive functions (inhibitory control and working memory) with visual motor skills in 127 prekindergarten and kindergarten children. It was found that behavioral self-regulation and working memory were related to visual motor skills which could be the reason for the current study results.

The developmental trend of increase in legibility was noticed with 5.11% increase in handwriting legibility score from second to third standard and with 1.14% increase in handwriting legibility score from third to fourth standard. A similar result was found in a study done in 2011, where handwriting development of primary school children were assessed. The children from grade two and three were assessed on handwriting in Dutch and English twice a year for two consecutive years and it was found that prevalence of handwriting problem was less from grade two to grade three (Overvelde & Hulstijn). In this study, they found that there was an improvement in the handwriting quality in grade 2 (i.e. letter formation, fine motor ability and organization of written work) and improvement of two items in grade 3 (i.e. consistency in letter size
and steadiness of writing trace). A longitudinal study done in Netherlands reported that handwriting develops rapidly through grades 2 to 3 and slows down with minimal changes from grade 3 to 4 (Blote & Hamstra-Bletz, 1991). Both the above mentioned studies concluded that the maximum development of handwriting happens until grade three. The current study is in alignment with the above mentioned results. The increase in legibility as years pass on could be due to improvement in handwriting quality. This could be because of the training received in schools that facilitate refinement of writing skills. Lack of proper guidance and feedback during these grades might lead to illegible handwriting in later ages.

5.5. Implications of the current study

The results of this study adds to the knowledge base of healthcare professionals working with children, regarding the relationship of VP, VMI and handwriting with academic performance in some Indian elementary school children. School based occupational therapists could investigate and address these problems early.

Occupational therapists could contribute to the design of the curriculum for kindergarten and elementary schools to include activities that enhance VP and VMI skills. They can also increase the awareness of teachers in kindergarten or elementary schools to identify the children at risk for benefit of early intervention.

Early screening could be recommended in schools to identify children who are at risk to have problems in VP and VMI as these are basic academic skills that need to be developed at an early age to achieve academic success in later life.

Occupational therapists working with children can also evaluate VP, VMI and handwriting while assessing the contributing factors that can influence a child’s academic performance.
5.6. Strengths and limitations of the study

The longitudinal nature of the research methodology with a large sample size (adjusting for attrition) maintained adequate power of the study. The involvement of specialists such as optometrist (every year) and psychologist (during initial phase of study and training the investigator) in the screening process had given an added advantage to this study. Use of well standardized tests to assess the primary independent variables, and the compilation of academic performance through marks obtained in all subjects during two consecutive exams was an added asset. Though the location to conduct the study was limited to one geographical area and convenience sampling was used, this study has created reliable data in the research area, especially in the Indian context.

Though efforts were made to control the confounders while designing the methodology, there are chances of certain problems in the design which may have impacted the study- such as the qualification or job status of the mother, mother tongue, spoken language and inclusion of children with learning difficulty. Auditory abilities of children were not assessed using standardized assessment tool. Legibility of handwriting was assessed without considering the time factor. Assessing the speed of handwriting could be a factor as academic performance was evaluated through exams which are time bound. Considering the average of all the three components of handwriting legibility (i.e. word legibility, letter legibility and numeral legibility) during analysis would have compromised the results obtained. Certain details about the child such as extracurricular activities, peer interaction, status of attendance and socio-economic status were obtained only during the initial stage of the study. Investigator and administration bias could have occurred as the primary measures were administered solely by the principal investigator.

The primary measures were administered to children in groups, but efforts were made to
minimize the bias by seating the children away from each other to prevent discussions between them while answering. Certain sampling errors (errors due to convenience sampling) and non-sampling errors (errors while scoring, data entry) would also have occurred during the study process.

5.7. Future directions

Future research may use probability sampling for better generalizability of results. Though marks obtained from exams are included, standardized academic performance measures can be used for testing the correlation of academic performance based on mark record. Research to analyse the association of VP, VMI with academic performance in other lower and higher standards would give a clear picture to health professionals for clinical implications. Using parent report form of the CBCL test to assess the child’s behaviour would be more beneficial. Future studies can focus on identifying the influence of each component of handwriting legibility (i.e. word legibility, letter legibility, numeral legibility) on academic performance. In the current trend of digitalization, there are high chances that handwriting would be replaced by key strokes. Hence, the impact of digitalization on academic performance may be studied in future. If the findings of this preliminary study are confirmed, then we should think of intervention modules and their effect on VP, VMI and handwriting.