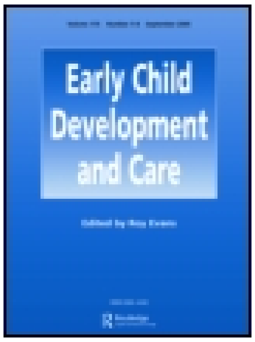


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# A motor-skills programme to enhance visual motor integration of selected pre-school learners

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# A motor-skills programme to enhance visual motor integration of selected pre-school learners

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**ABSTRACT**
Pre-schoolers are in a window period for motor skill development. Visual-motor integration (VMI) is the foundation for academic and sport skills. Therefore, it must develop before formal schooling. This study attempted to improve VMI skills. VMI skills were measured with the *Beery-Buktenica developmental test of visual-motor integration 6th edition*, and gross motor skills with the *Test of gross motor development 2nd edition*. One high and one low socio-economic school was conveniently selected. Seventy-seven children were tested, 23 scored below average VMI scores, and became the sample from which an experimental ($n = 12$) and a control group ($n = 11$) were randomly selected. The experimental group participated in a 14-week intervention of two 45 min sessions per week. Participants from the low socio-economic school showed significantly lower VMI skills ($p = .0013$). More research is needed to fully determine the potential of gross motor programmes in improving VMI.

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**KEYWORDS**
Socio-economic status; VMI; gross motor skills; intervention programme



## Introduction

Pre-school children are at a critical age of development (Hardy, King, Farrell, Macniven, & Howlett, 2010, p. 503). Researchers define the pre-school years as the most optimal time to intervene and remediate developmental lags since children are more pliant at this age and formal schooling has not yet begun (Hardy et al., 2010, p. 504; Ratzon et al., 2009).

Visual-motor integration (VMI) is one of the skills that must be developed early in childhood before formal education commences (Lotz, Loxton, & Naidoo, 2005, p. 63; Marr & Cermak, 2002, p. 663), seeing that it is an important perceptual-motor skill that a child needs to acquire in order to function successfully in an academic setting and beyond (Beery & Beery, 2004, p. 129; Lotz et al., 2005, p. 64). Academic skills, such as reading and writing, rely heavily on VMI, and academic success in schools today depends on whether a child can perform these skills optimally (Dankert, Davies, & Gavin, 2003, p. 543). Children entering into their formal school careers need to have developed their VMI skills to a point where their reading and writing can be performed at the appropriate level so that no academic lags will occur. Therefore, remediating children's VMI skill deficits in the pre-school years will help to decrease developmental and academic lags (Marr & Cermak, 2002, p. 662; Pienaar, Barhorst, & Twisk, 2013, p. 376; Ratzon et al., 2009, p. 1174).

The ability to coordinate visual perception skills and motor skills is referred to as VMI (Kulp & Sortor, 2003, p. 312). VMI has a perceptual or sensory and a motor component (Sortor & Kulp, 2003, p. 758). The VMI process effectively integrates the perceptual and the motor component. The sensory system perceives the environment on a visual level, after which the stimuli are transferred to the brain, and the brain attaches meaning to the visual stimuli received. The brain

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decides on an appropriate motor response to the visual stimuli and sends this response to the muscle groups that must be activated (Goodale, 1998, p. 491).

A child who has a VMI problem may have a problem with either visual perception, motor coordination of a motor response, or the combination of the two components (Pieters, Desoete, Roeyers, Vanderwalmen, & Van Waelvelde, 2012, p. 498; Sortor & Kulp, 2003, p. 758). VMI allows a person to copy a figure he/she sees onto a page, using his or her visual perception and motor skills together. A child with a VMI problem will have difficulty reproducing the figure he/she sees onto a page. Pieters et al. (2012, p. 498) highlighted the importance of focusing on the integration of both the visual and motor domains rather than focusing solely on visual perception or motor skills. Kulp and Sortor (2003, p. 313) allege that a child may have completely normal visual perception and motor skills, but may have difficulty integrating the two abilities and, therefore, research needs to place emphasis on the integration process.

Many underlying factors have been identified as having links to academic performance (VMI). Laterality and directionality are named by Cheatum and Hammond (2000, pp. 101, 110, 116) as influencing a child's ability to read and write, while other research lists postural control, upper body coordination and stability, motor control and planning, as well as proprioception as important factors that could influence writing and reading performance in a child (Van Der Merwe, Smit, & Vlok, 2011, p. 4; Van Jaarsveld, Vermaak, & Van Rooyen, 2011, p. 6; Wajuihian & Naidoo, 2011, p. 92).

The current study and the intervention thereof focused on a handful of these underlying factors related to VMI and academic performance. Looking at laterality in a gross motor sense within physical education, the internal awareness of a left and right side will help a child to use one side, the other side or both sides of the body when performing a movement. For example, like catching a ball with the left, right or both hands can be executed successfully (Cheatum & Hammond, 2000, p. 101). In academic tasks (reading, writing and mathematics) as well as physical activities (target games and manipulative skills), it is important to discriminate between right and left.

Directionality can develop successfully only once a child has learnt a sense of laterality because directionality requires a child to transfer his or her understanding of a left and right side of their body into the space around them. In academic settings, directionality is an important skill, especially when referring to reading and writing. Many children have difficulties distinguishing between letters that look very similar like *b* and *d*, *t* and *f* and *p* and *q* (Cheatum & Hammond, 2000, pp. 115; 117). In physical activity settings, it is important for the child to have a sense of direction when moving up, down, under, over, around objects through space.

For the purpose of the current study, upper body coordination and strength include postural stability/control, with most of the intervention activities focused on upper body stability aiming to improve arm strength along with postural stability and core strength. Postural control has been described as an automatic process; however, literature shows that maintaining posture while performing an additional task deviates attention from maintaining balance and results in postural sway particularly in children (Legrand et al., 2011, p. 96). Children with difficulties maintaining postural control will have difficulty performing daily activities in an academic setting, like sitting at a desk. Postural stability and core strength are imperative in all gross motor skills as it is vital for maintaining balance.

Motor planning is the child's ability to plan, organize and execute a specific skill. Handwriting is a process that requires continuous motor planning, as the process of learning to write is a new and unfamiliar skill at the pre-school level (Cornhill & Case-Smith, 1996, p. 733; Feder & Majnemer, 2007, p. 314). The child needs to think about and plan how he or she will move his or her hand to form the letters with the pencil. The same applies to any motor skill.

Proprioception gives a sense of the body's position and how it is moving without relying on vision (Goble, Noble, & Brown, 2010, p. 54). Proprioceptive feedback is important for coordinated movement; it helps to control muscle forces, timing of the different limb segments during movement, the trajectory of the movement, and provides an internal representation of the limb all of which help with adaptation of the movement (Goble, Lewis, Hurvitz, & Brown, 2005, p. 156).

On the premise of the importance of VMI skills, the current study investigated the use of a gross motor intervention programme in remediating VMI skills of selected pre-school children.

## Problem statement

The primary aim of this study was to determine whether the VMI skills in pre-school children can be improved through an intervention of gross motor activities.

## Methodology

### *Study design*

This study made use of a quasi-experimental design, because the participating pre-schools were not randomly selected, but were selected subject to their proximity for financial and logistical reasons. Two pre-schools in the Stellenbosch region, South Africa, were approached to participate in the study.

### *Sample*

The Grade R learners ($N = 77$) in the selected pre-schools were asked to volunteer to be part of the study. After the participants' VMI skills were determined, participants were excluded if their VMI skills were found to be average or above. Twenty-three participants scored below average on VMI skills and were all from a lower socio-economic status (SES) school. No participants from the higher SES school qualified to participate further. The participants were randomly divided into an experimental ($n = 12$) and a control ($n = 11$) group. The boys ($n = 17$) and girls ($n = 6$) were randomly distributed between the two groups.

### *Testing procedures*

In the current study, two motor tests were performed before and after the intervention programme. The participants performed the *Beery-Buktenica developmental test of visual-motor integration (DTVMI), 6th edition* (Beery & Beery, 2004), and the *Test of gross motor development, 2nd edition* (Ulrich & Sanford, 2000).

The DTVMI is designed to measure the VMI skills of individuals aged between 2 and 100 years (Beery & Beery, 2004, p. 15). The test measures the degree to which a person can integrate his/her visual perception and motor abilities. The DTVMI can be administered by anyone with a qualification in childhood education or a similar field (Beery & Beery, 2004, pp. 1, 17).

Two qualified individuals administered the test: a Kinderkineticist (South African Professional Institute for Kinderkinetics [SAPIK] no: 01/013/03/1314/005) and an occupational therapist (OT0067628). This allowed for more in-depth monitoring of the participants. Once the screening tests had been scored and the results interpreted, the occupational therapist was able to identify participants who had a VMI skills deficit. These participants completed the two supplemental tests of the Beery VMI.

After the participants had been identified as having 'below-average' VMI skills, the two supplemental tests were performed with each participant individually. The researchers followed up the DTVMI screening test with these supplemental tests in order to determine in which domain the participant had a deficiency. A participant may have a problem solely with the integration of visual and motor abilities or, on the other hand, have a problem with visual perception skills and/or motor coordination (Beery & Beery, 2004, p. 16; Sortor & Kulp, 2003, p. 758). When all three tests are administered, they must be administered in a specific order: VMI; Visual Perception; and

Motor Coordination. A statistical and graphical representation of the three tests' results can be easily illustrated on the front cover of the DTVMI test booklet (Beery & Beery, 2004, p. 16).

Testing took place in a classroom with the participants at their school desks, after ensuring that their desks and writing areas were comfortable and posed no obstacles for writing or drawing. The testing procedure steps were followed as described by the test manual and the instructions were given to the children as stipulated by the manual (Beery & Beery, 2004, pp. 20–24).

The scoring on the DTVMI follows the scoring from previous editions of the test. The participant received 1 point for each item he or she copied correctly, the test and scoring stops once the individual reaches three consecutive failed attempts at reproducing the shapes (Beery & Beery, 2004, p. 26).

The reliability of the DTVMI is as follows: Test–retest reliability – the Beery VMI, 0.84 for the Visual Perception test and 0.85 for the Motor Coordination test and inter-scorer reliabilities of 0.93 for the VMI test, 0.98 for the Visual Perception test and 0.94 for the Motor Coordination test (Beery & Beery, 2004, pp. 107, 108). The DTVMI has also been correlated to an older visual-motor test, namely the Bender-Gestalt. The correlations ranged from 0.29 to 0.93 (Beery & Beery, 2004, p. 111,112).



## Intervention programme

A 14-week intervention followed the pre-test. The intervention sessions were performed twice a week and each session lasted 45 min, with actual activity-time being 30 min. The sessions were implemented within a small group setting. The experimental group consisted of 12 participants across the 2 Grade R classes; this group of 12 was divided into 2 groups of 6 participants from each class, in order to minimize the influence that different teachers might have on the results. The control group sat in their classroom with their teacher and listened to children's stories on a CD during this time.

The gross motor intervention focused first and foremost on VMI, which includes activities like target games, where various objects must be thrown, kicked or rolled to a specific target, either on the floor, in the air, or to a person who catches the object. Catching is also included as a VMI skill. Visual perception skills (perceiving picture differences) and motor coordination (threading beads onto a lace, connecting dots on pictures) were practised separately as well.

The following specified underlying factors relating to VMI and academic skills were also the focus of the gross motor intervention: laterality; directionality; upper body strength and coordination; motor planning and coordination; and proprioception.

For a more in-depth discussion regarding the nature and the foundation of the intervention programme, please refer to the introduction of this article.

## Statistical analysis

Baseline comparisons of schools and gender were done using two-way factorial ANOVA. Comparisons of the experimental and control groups from pre- to post-testing were done using mixed-model repeated-measures ANOVA. Group and time were treated as fixed effects and the subjects as random effects. Post hoc testing was performed using Fisher Least Significant Difference testing. Summary statistics were reported as means with standard deviations. A 5% significance level ($p < .05$) was used as the guideline for significance.

## Ethical aspects

Ethical clearance for this study was obtained from the Research Ethical Committee Humanoria at Stellenbosch University (HS1013/2013). Thereafter, permission for the study to commence in the schools was obtained from the Western Cape Education Department (WCED). Permission from the principals of the schools and the head teachers of the Grade R classes was obtained after permission had been received from the WCED.

Each participant's parent or legal guardian gave written informed consent for their child to participate in the study. The procedures were explained to the children and each child was asked to sign an assent form, giving their consent and willingness to participate in the testing and the intervention procedures.

## Results and discussion

### Visual-motor integration

#### Response to intervention

It was found that there was no significant difference between the experimental and control groups' response to the intervention period, as both groups improved equally well from pre- to post-test ($p = .52$). The experimental group improved more than the control group, but not significantly.

Table 1 shows the VMI mean scores with standard deviations, from pre- to post-test for the experimental and control groups. The difference between the groups at pre-test was small; 0.25 standard score points. The difference between the experimental and control group at post-test was relatively larger with the experimental group scoring 2.77 standard score points higher than the control group. Both the experimental and control groups increased their scores from pre- to post-test, by 16.33 and 13.81 standard score points, respectively. The difference over time for the experimental and control groups is depicted in Figure 1. The experimental group improved by an average of 2.52 points over the control group on their VMI scores. This suggests that the intervention programme had some positive effect on the experimental group; this is, however, statistically insignificant.

#### Discussion of VMI results

No exact replicas of this study have been found. Most studies that measure the effect of an intervention focus on occupational therapy, fine-motor and handwriting activities and not gross motor activities (Dankert et al., 2003, p. 542; Dibek, 2012, p. 1924; Ohl et al., 2013, p. 507; Poon, Li-Tsang, Weiss, & Rosenblum, 2010, p. 1554; Van Der Merwe et al., 2011, p. 3; Van Jaarsveld et al., 2011, p. 5; Vinter & Chartrel, 2010, p. 479).

Dibek (2012, p. 1927) found that an intervention programme for five-year-old children ($N = 33$) using 2D reading materials and 3D models and board games and pen to paper exercises had a positive effect on the experimental group in VMI, visual perception and motor coordination ($p < .00$). Dankert et al. (2003, p. 546) also found that their experimental group of pre-school children with developmental delays ($N = 12$) showed a significant improvement in VMI skills after an occupational therapy intervention ($p < .0005$). Vinter and Chartrel (2010, p. 479) investigated the effect of different types of handwriting training on handwriting performance of pre-school children ($N = 48$). They found that visual-motor training was the most effective in improving the participants' handwriting (Vinter & Chartrel, 2010, p. 484). Ohl et al. (2013, p. 507) investigated the effects of an intervention programme on the visual-motor and fine-motor abilities of kindergarten participants ($N = 113$). Ohl and co-workers found that the participants significantly improved VMI skills scores ($p = .009$) and fine-motor skills scores ($p = .023$), from pre- to post-intervention, while control participants' scores

**Table 1.** VMI score means, standard deviations and differences between pre- and post-test in experimental and control groups.

| Group | Pre-test: Mean ± SD | Post-test: Mean ± SD | Mean differences within groups (pre–post) |
|---|---|---|---|
| Experimental | 76.16 ± 10.28 | 92.50 ± 8.74 | −16.33 |
| Control | 75.90 ± 6.17 | 89.72 ± 10.37 | −13.81 |
| p+ | −0.25 | −2.77 | |

Note: P+: Difference between groups in pre- and post-tests.

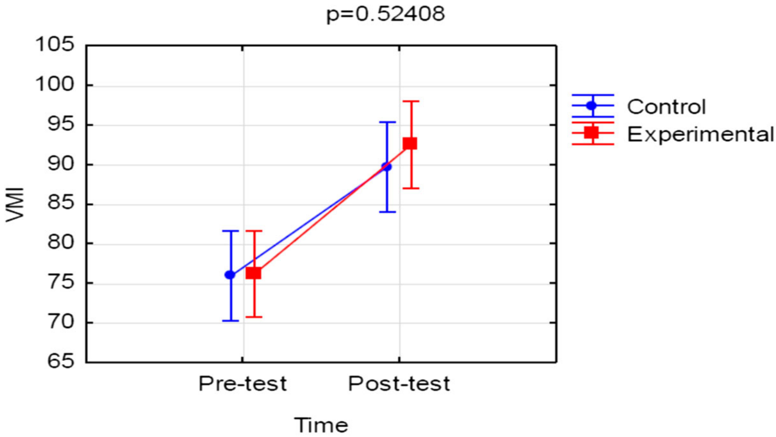


**Figure 1.** Difference over time between the experimental and control groups.

slightly decreased in these skills (Ohl et al., 2013, p. 511). Poon et al. (2010, p. 1558) found that their intervention programme of computerized games had no effect on the VMI skills of participants in Grade 1 ($N = 26$).

## *Visual perception and motor coordination supplemental tests*

### *Visual perception*

The experimental and control groups' improvements over the intervention period were the same ($p = .86$).

Both groups improved over the 14-week period, with the experimental group improving more, but not significantly so. Table 2 provides a summary of the results for visual perception test of both groups.

In the pre-test, the experimental and control groups differed by 1.40 points. In the post-test, the difference between the groups increased to a difference of 2.53 standard score points. The experimental group improved by 8.58 standard score points in visual perception skills, which is slightly more than the control group (7.45). This suggests that the intervention may have aided in improving visual perception skills although only on a small scale. Figure 2 presents the differences between the experimental and control groups before and after the intervention programme.

### *Motor coordination*

The second supplemental test performed on the sample was the test for motor coordination skills. The interaction found showed that both the experimental and control groups improved from pre- to post-test ($p = .27$).

The experimental group scored marginally lower at post- than at pre-test, while the control group improved after the 14-week period. This improvement and difference were, as mentioned earlier, insignificant.

**Table 2.** Visual perception mean scores, standard deviations and mean differences over time in experimental and control groups.

| Group | Pre-test: Mean ± SD | Post-test: Mean ± SD | Mean differences within groups (pre–post) |
|---|---|---|---|
| Experimental | 79.50 ± 12.33 | 88.08 ± 12.65 | −8.58 |
| Control | 78.09 ± 14.34 | 85.54 ± 13.47 | −7.45 |
| p+ | −1.40 | −2.53 | |

P+: Difference between groups in pre- and post-tests.

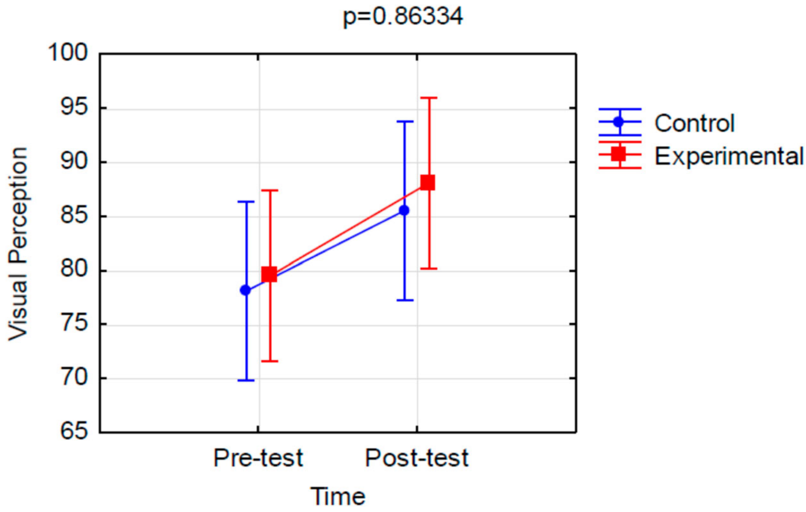


**Figure 2.** Differences in visual perception scores from pre- to post-test in experimental and control groups.

The differences within this sample are summarized in Table 3. The experimental group's slight decline by 0.25 standard score points is marginal. The control group improved by 4.72 standard score points over the 14-week period.

Figure 3 compares the experimental and control groups and their change from pre- to post-test in motor coordination scores.

### *Discussion of visual perception and motor coordination results*

Studies using the DTVMI tend to include the supplemental tests of visual perception and motor coordination in the testing procedures. It is reported that difficulties in VMI can be due to one of three deficits, namely in problems with perceiving visual stimuli, the ability to perform a coordinated motor response to the stimuli, or an integration of these two aforementioned skills (Kulp & Sortor, 2003, p. 758; Pieters et al., 2012, p. 498). Testing participants using all three tests (VMI, VP and MC) allows the researcher to understand in which skill the participant has the deficit.

This particular sample in the current study scored lower in visual perception skills (78.79 ± 13.04) than in motor coordination skills (98.73 ± 9.94) at the pre-test. Therefore, it can be said that the group generally had a more notable visual perception deficit and not a motor coordination problem.

Vinter and Chartrel (2010, p. 479) studied the effect of purely visual training on handwriting performance of five-year-old children ($N = 48$). Vinter and Chartrel (2010, p. 485) also found improvements in handwriting with motor training; however, the positive effect of motor training was slighter than that of visual training. Poon et al. (2010, pp. 1553, 1556) investigated the effect of a computer games intervention programme on the visual perception skills of Grade 1 learners ($N = 26$), and found that visual perception skills were improved through the intervention programme ($p = .012$). Dankert et al. (2003, p. 546), as discussed earlier, reported the effects of an occupational therapy intervention programme on pre-school children ($N = 43$), and found a significant improvement in visual

**Table 3.** Motor coordination means, standard deviations and mean differences over time for experimental and control groups.

| Group | Pre-test: Mean ± SD | Post-test: Mean ± SD | Mean differences within groups (pre–post) |
|---|---|---|---|
| Experimental | 99.50 ± 12.19 | 99.25 ± 14.34 | 0.25 |
| Control | 97.90 ± 7.24 | 102.63 ± 6.42 | −4.72 |
| p+ | −1.59 | 3.38 | |

P+: Difference between groups in pre- and post-tests.

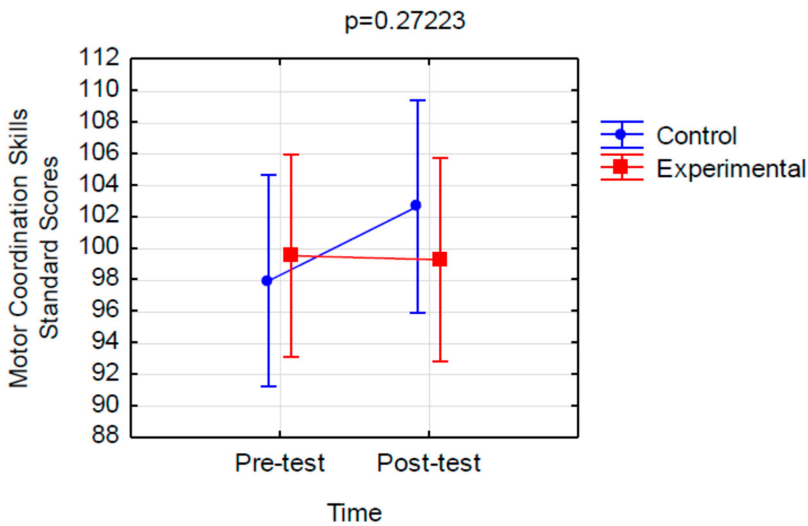


**Figure 3.** Differences in motor coordination scores from pre- to post-test in experimental and control groups.

perception skills ($p < .005$), but no significant improvement with motor coordination skills ($p = .001$). Dibek (2012, p. 1927) found significant increases in VMI skills of five-year-olds ($N = 33$) and reported significant increases in both motor coordination skills and visual perception skills ($p < .000$).

### *VMI: conclusions*

Regarding VMI, the current study found that there was no significant difference between the experimental group and the control group in response to the intervention. It could be seen that the experimental group improved more over the intervention period than the control group did. This could suggest that the intervention programme had some positive effect on the VMI skills of the experimental group.

It can be noted that the current study showed the results of a predominantly gross motor intervention programme on the improvement of VMI skills. With the improvements found in the current study, it can be said that gross motor activities can help improve VMI skills in children. No exact replicas of the study were found; most studies found used predominantly fine-motor or occupational therapy intervention programmes (Dankert et al., 2003, p. 542; Dibek, 2012, p. 1924; Ohl et al., 2013, p. 507; Poon et al., 2010, p. 1554; Van Der Merwe et al., 2011, p. 3; Van Jaarsveld et al., 2011, p. 5; Vinter & Chartrel, 2010, p. 479).

### *VMI: recommendations*

The current study implemented a gross motor intervention programme over 14 weeks, which included two sessions per week of 30 min of activity in each session. It is recommended that intervention programmes in future should be longer and have more sessions per week. This recommendation is based on evidence from other studies which found significant results regarding VMI skills by using different numbers of sessions per week and longer intervention programmes (Cho, Kim, & Yang, 2015, p. 412). Dibek (2012, p. 1927) had a higher frequency of sessions with three sessions per week, over a 10-week period. Another study differed in length of intervention. Dankert et al. (2003, p. 546) used an intervention that lasted eight months. Poon et al. (2010, p. 1558) noted that a long-term and intense intervention programme is required in order to improve visual-motor skills (Poon et al., 2010, p. 1558).

### *Visual perception and motor coordination: conclusions*

The current study found no significant differences between the groups regarding both the supplemental tests of visual perception and motor coordination. It was found that the participants scored on average lower in visual perception skills than in motor coordination skills.

In visual perception skills, both groups improved over the intervention period. In motor coordination skills, however, the control group improved while the experimental group decreased slightly. The result regarding the motor coordination test could, therefore, show that the control group received better motor coordination practice than the experimental group. This could be because the control group spent more time in the classroom doing class work (drawing and worksheets) compared to the experimental group. The teachers were asked to keep the control group children seated on the classroom mat while listening to the taped children's stories during the intervention time. It was observed that the teachers on occasion allowed the children to continue with schoolwork instead. This meant that the control children may have received more practice in motor coordination activities such as drawing and writing, which could have affected the results.

### *Visual perception and motor coordination: recommendations*

Intensive visual training was not included in the current study, which may account for the very slight improvement of visual perception skills within the experimental group. Beery and Beery (2004, pp. 16 and 17) state that any researcher who find severe visual perception problems in a participant should refer that participant to a vision specialist or ophthalmologist to deal with any vision problems. This suggests that visual perception is difficult to remediate unless done so by a specialist or with the aid of eye glasses. Vinter and Chartrel (2010, p. 479) used a specific visual training intervention programme when helping to improve children's reproduction of letters. The research of Poon et al. (2010, p. 1554) is another study that included very specific visual training activities in the intervention programme. They used a non-motor intervention to improve visual perception skills. It may be recommended that in order to improve visual perception skills, a more specific visual perception intervention programme is needed.

Similarly as to visual perception skills, the current study did not include very explicit fine-motor coordination activities. It is recommended that future interventions include more fine-motor coordination, pen and paper activities. Vinter and Chartrel (2010, p. 485) found improvement in handwriting skills with a purely fine-motor training intervention programme.

## Recommendations

It is recommended that intervention programmes in future should be longer and have more sessions per week. This recommendation is based on evidence from other studies which found significant results regarding VMI skills, by using different number of sessions per week and longer intervention programmes.

It is also recommended that future studies use more fine-motor and specific hand manipulation activities in the intervention programme, along with gross motor activities. Based on the findings and conclusions of the study, some additional recommendations can be made:

A larger sample size over a greater geographical area would be more useful when attempting generalizations about the population.

- A larger sample size with an equal number of boys and girls would allow for a better interpretation of gender differences in VMI and gross motor skills.
- Pre-school teachers should be guided and trained by specialists in the identification and remediation of VMI skills and gross motor skills problems. This will enable a school-based intervention programme to be performed, where specific activities can take place on a daily basis, supplementary to the curriculum.

## Limitations

- The sample size for the study was relatively small, after excluding participants due to VMI skills scores.
- The small number of girls and the random distribution of girls across the experimental and control group did not allow for further investigation into gender differences.
- Time constraints due to the school term dates and holidays meant that the intervention programme was shorter than optimal.
- Due to the temperamental nature of children in pre-school, it could be said that the participants did not perform the testing according to their optimal ability on the given testing day.
- The temperamental nature of children could also have affected the experimental group's participation in the intervention programme sessions. The participants may not have given their utmost effort and concentration for each activity equally.
- It could be noted that some participants may have had comorbidities. All participants had visual-motor deficits, but some may have had additional developmental delays not specifically investigated in the study. These possible comorbidities may have influenced the effect of the intervention programme.

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## Disclosure statement

No potential conflict of interest was reported by the authors.

## Notes on contributors

***Eileen K. Africa*** received her PhD in Sport Science in 2006 from Stellenbosch University and began her career in 2007 at the same university, where she is currently lecturing. She started her research journey in the field of motor skills development in 2004 and continued in the field of adolescent health. She made a U-turn in 2007, where she re-directed her focus to early childhood development and gross motor skills and became increasingly interested in and fascinated with the Autistic population. In 2010, she initiated the Honours Kinderkinetics programme at the Department of Sport Science, Stellenbosch University and qualified as a Kinderkineticist at the end of 2010. She is currently the coordinator of the programme and has delivered 4 Masters students and supervised 14 honours research projects since starting the programme. She has also published 6 peer-reviewed articles, 2 abstracts, presented papers and posters at 4 national and 7 international conferences.

***Karel J. van Deventer*** began his career as a teacher in Physical Education in 1980 after he completed his Masters in Physical Education at Stellenbosch University in 1979. He was appointed as the Head of Department for Physical Education, Geography and History in 1985, during which period, he obtained his PhD in Human Movement Science at the University of the Free State in 1993. In 1994, he was appointed as a Lecturer in the Department of Human Movement Science, Faculty of Education, Stellenbosch University. He was appointed as a Senior Lecturer in the Department of Sport Science in 2005 and as Associate Professor in 2015. His areas of specialisation include Physical Education, Subject Didactics, Sport Ethics and Gymnastics. He is an established researcher with a C-3 NRF rating. At present he has 34 publications in subsidised scientific journals, 10 articles in E. K. AFRICA AND K. J. VAN DEVENTER journals, 6 articles in non-subsidised journals, 11 chapters in books, 5 research reports and 4 published abstracts. He has presented 3 keynote lectures of which 2 were international (Commonwealth Games, 2002 and UNESCO, Benin, West Africa, 2005), and 1 national (SASReCon, Durban, 2010). Papers and poster presented in subject related conferences total 48. Since 2000, he has acted as a Subject Editor for the South African Journal for Research in Sport, Physical Education and Recreation and in June 2010, he was appointed as the Editor of the aforementioned journal. In 2008, he was selected as Secretary-general of the first official Executive Committee of the South African Association for Movement Sciences until 2014. His research foci are within the field of Physical Education and related topics such as physical activity and cognitive functioning.

## References

Beery, K. E., & Beery, N. A. (2004). *The Beery-Buketenica developmental test of visual motor integration: Administration scoring and teaching manual*. Minneapolis, MN: NCS Pearson.

Cheatum, B. A., & Hammond, A. A. (2000). *Physical activities for improving children's learning and behaviour: A guide to sensory motor development*. Champaign, IL: Human Kinetics.

Cho, M., Kim, D., & Yang, Y. (2015). Effects of visual perceptual intervention on visual-motor integration and activities of daily living performance of children with cerebral palsy. *Journal of Physical Therapy Science*, *27*, 411–413.

Cornhill, H., & Case-Smith, J. (1996). Factors that relate to good and poor handwriting. *American Journal of Occupational Therapy*, *50*(9), 732–739.

Dankert, H. L., Davies, P. L., & Gavin, W. J. (2003). Occupational therapy effects on visual-motor skills in preschool children. *American Journal of Occupational Therapy*, *57*, 542–549.

Dibek, E. (2012). Implementation of visual motor ability enhancement program for 5 years old. *Procedia – Social and Behavioral Sciences*, *46*, 1924–1932.

Feder, K. P., & Majnemer, A. (2007). Handwriting development, competency and intervention. *Developmental Medicine and Child Neurology*, *49*, 312–317.

Goble, D. J., Lewis, C. A., Hurvitz, E. A., & Brown, S. H. (2005). Development of upper limb proprioceptive accuracy in children and adolescents. *Human Movement Science*, *24*, 155–170.

Goble, D. J., Noble, B. C., & Brown, S. H. (2010). Where was my arm again? Memory-based matching of proprioceptive targets is enhanced by increased target presentation time. *Neuroscience Letters*, *481*, 54–58.

Goodale, M. A. (1998). Visuo-motor control: Where does vision end and action begin? *Current Biology*, *8*, R489–R491.

Hardy, L. L., King, L., Farrell, L., Macniven, R., & Howlett, S. (2010). Fundamental movement skills among Australian preschool children. *Journal of Science and Medicine in Sport*, *13*, 503–508.

Kulp, M. T., & Sortor, J. M. (2003). Clinical value of the Beery visual-motor integration supplemental tests of visual perception and motor coordination. *Optometry and Vision Science*, *80*(4), 312–315.

Legrand, A., Bui-Quoc, E., Wiener Vacher, S., Ribot, J., Lebas, N., Milleret, C., & Bucci, M. P. (2011). Postural control in children with strabismus: Effect of eye surgery. *Neuroscience Letters*, *501*, 96–101.

Lotz, L., Loxton, H., & Naidoo, A. V. (2005). Visual-motor integration functioning in a South African middle childhood sample. *Journal of Child and Adolescent Mental Health*, *17*(5), 63–67.

Marr, D., & Cermak, S. (2002). Predicting handwriting performance of early elementary students with the developmental test of visual-motor integration. *Perceptual and Motor Skills*, *95*, 661–669.

Ohl, A. M., Graze, H., Weber, K., Kenny, S., Salvatore, C., & Wagreich, S. (2013). Effectiveness of a 10-week tier-1 response to intervention program in improving fine motor and visual-motor skills in general education kindergarten students. *The American Journal of Occupational Therapy*, *67*(5), 507–514.

Pienaar, A. E., Barhorst, R., & Twisk, J. W. R. (2013). Relationships between academic performance, SES school types and perceptual-motor skills in first grade South African learners: NW-CHILD study. *Child: Care, Health and Development*, *40*(3), 370–378.

Pieters, S., Desoete, A., Roeyers, H., Vanderwalmen, R., & Van Waelvelde, H. (2012). Behind mathematical learning disabilities: What about visual perception and motor skills? *Learning and Individual Differences*, *22*, 498–504.

Poon, K. W., Li-Tsang, C. W. P., Weiss, T. P. L., & Rosenblum, S. (2010). The effect of a computerized visual perception and visual-motor integration training program on improving Chinese handwriting of children with handwriting difficulties. *Research in Developmental Disabilities*, *31*, 1552–1560.

Ratzon, N. Z., Lahav, O., Cohen-Hamsi, S., Metzger, Y., Efraim, D., & Bart, O. (2009). Comparing different short-term service delivery methods of visual-motor treatment for first grade students in mainstream schools. *Research in Developmental Disabilities*, *30*, 1168–1176.

Sortor, J. M., & Kulp, M. T. (2003). Are the results of the Beery-Buktenica developmental test of visual-motor integration and its subtests related to achievement test scores? *Optometry and Vision Science*, *80*(11), 758–763.

Ulrich, D. A., & Sanford, C. B. (2000). *Test of gross motor development second edition: Examiner's manual*. Austin, TX: Pro-ed.

Van Der Merwe, J., Smit, N., & Vlok, B. (2011). A survey to investigate how South African occupational therapists in private practice are assessing and treating poor handwriting in foundation phase learners: Part 1 demographics and assessment practices. *South African Journal of Occupational Therapy*, *41*(3), 3–9.

Van Jaarsveld, A., Vermaak, M., & Van Rooyen, C. (2011). The developmental status of street children in potchefstroom, South Africa. *South African Journal of Occupational Therapy*, *41*(1), 5–9.

Vinter, A., & Chartrel, E. (2010). Effects of different types of learning on handwriting movements in young children. *Learning and Instruction*, *20*, 476–486.

Wajuihian, S. O., & Naidoo, K. S. (2011). Dyslexia: An overview. *The South African Optometrist*, *70*(2), 89–98.