*South African Journal for Research in Sport, Physical Education and Recreation, 2015, 37(3): 69-81.*
*Suid-Afrikaanse Tydskrif vir Navorsing in Sport, Liggaamlike Opvoedkunde en Ontspanning, 2015, 37(3): 69-81.*
*ISBN: 0379-9069*

# INTERRELATIONSHIPS BETWEEN VISUAL-MOTOR INTEGRATION, VISUAL PERCEPTION, MOTOR COORDINATION AND OBJECT CONTROL SKILLS OF GRADE 1-LEARNERS: NW-CHILD STUDY

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***ABSTRACT***

*The aim of this study was to determine the interrelationship of visual-motor integration, visual perception and motor coordination with object control skills in Grade 1-learners in the North-West Province of South Africa. This study is based on only the baseline data of a longitudinal study (NW-CHILD study) in progress. The Grade 1-learners (N=806) had a mean age of 6.84±0.39 years. The Developmental Test of Visual-Motor Integration ($4^{th}$ ed.) (VMI), was used to evaluate visual skills, while the Test of Gross Motor Development-2 evaluated six object control skills. There was a statistical significant ($p\leq0.01$) association between VMI, two object control skills and total score for object control skills. Visual perception had the highest correlation with all the object control skills where a statistically significant ($p\leq0.05$) association with five object control skills and the total score was obtained. Motor coordination had small but significant correlations with two object control skills. Understanding the influence that VMI, visual perception and motor coordination have on ball handling skills should enable practitioners to address them appropriately during the early years.*

**Key words:** Visual-motor integration; Visual perception; Motor coordination; Object control skills.

## INTRODUCTION

Visual-motor integration refers to the action of merging visual information with fine motor skills and is important in the acquisition of perceptual-motor skills such as handwriting, keyboarding and the throwing or catching of a ball (Avi-Itzhak & Obler, 2008). Fine motor skills require rigorous movements of the hands and fingers and depend on hand-eye coordination to perform a task successfully (Beery & Buktenica, 1997; Baard, 1998). Deficiencies in these skills could contribute to problems pertaining to academic skills, participation in school activities and self-concept (Ercan *et al*., 2011).

Visual-motor integration involves not only hand-eye coordination, but also visual perceptual skills (Pereira *et al*., 2011). Visual-motor integration is referred to also as changing visual perception into a motor output. According to Weil and Amundson (1994), visual-motor integration is supported by skills, such as visual perception, psychomotor speed and hand-eye coordination. Wilson and Falkel (2004) further indicate that good hand-eye coordination is necessary for sport, such as basketball, volleyball and baseball, and they highlight the importance of foot-eye coordination, to get into the best position to perform a hand-eye coordination task. Barnhardt *et al*. (2005) found in their study of eight- to 13-year-old American children (N=37), that the child who had poor visual-motor integration skills made significantly more errors in skills with a visual perceptual component. According to Tepeli (2013), visual perception and motor performance are linked closely. Bonifacci (2004), in his study of 141 Brazilian children, aged 6 to 10 years, found a significant difference in visual-motor integration skills between children with low and high gross motor skills.

Visual perception is a complex process involved in both object identification and locating of an object in space (Jeannerod, 2006). This system is also intricately connected to the action systems of the body (Jeannerod, 2006), and relies on the candour of the posterior parietal cortex and cortical networks produced from the occipital lobe (Lieberman, 1984; Ganis *et al*., 2004). Visual perception comprises of more than one concept and includes object/form perception and spatial perception. Object/Form perception can be broken down further into form consistency, visual closure and figure-ground perception (Schneck, 2010). These concepts are all relevant in a situation where object control skills are used.

Form consistency is the ability to recognise objects in different environments, sizes and positions; figure-ground perception includes being able to define objects from the fore- or background; visual closure is the ability to recognise a shape or form when incomplete; and spatial perception is the ability to locate an object in space (Schneck, 2010). These perceptual abilities will enable learners to locate a ball in space for instance, and be able to accurately catch or throw it back to a team mate in a sporting situation.

According to Wilson and Falkel (2004), visual perception in sport involves a player being able to focus on the ball, whilst in addition keeping track of the different placing's of his team mates and of the opposition. Researchers (Smith *et al*., 2003; Cinelli, 2006; Gabbard, 2008), claim that visual perception is the ability to perceive if an environment is safe enough, which then leads to perception, which is necessary to discern actions. Wilson and McKenzie (1998) found that problems with visual components were associated with problems in motor coordination. A study by Tepeli (2013) on Turkish children (N=322), ranging from 54 to 59 months, found that the visual perception skills of these children improved as their gross motor skills (locomotor and object control skills) improved and vice versa. This researcher also found that visual perception could be a predictor of good execution of object control skills (Tepeli, 2013).

Motor coordination describes the process of obtaining visual information and responding with the correct coordination of the mind and body (Maneval, 1999), while Cheatum and Hammond (2000) refer to motor coordination as the ability to coordinate body movement and vision. Visual-motor skills are inadmissible to success in school and social life (Maneval, 1999), and plays a crucial role in activities where hand-eye and foot-eye coordination is important, especially in sport such as rugby, hockey, netball and soccer, where a ball has to be kicked, hit or caught, while paying attention to an opponent (Cheatum & Hammond, 2000). Wilson and Falkel (2004) indicated that visual-motor integration is one of the most basic components to be linked to sport performance. They also indicated that if the eyes were unable to move quickly and efficiently, a child would not be able to perform well in sport (Wilson & Falkel, 2004). They emphasised the importance of the integration of visual perception and motor coordination to be able to perform unforeseen movements on the sport field.

Coetzee and Du Plessis (2013) in their study of 816 children (419 boys and 397 girls) in the North-West Province of South Africa, found significant correlations between visual-motor integration and visual perception, and visual-motor integration and motor coordination. There were also significant correlations between visual perception and motor coordination (Coetzee & Du Plessis, 2013). It could be concluded that because of the inter-relationship of these skills, any problems that could arise in one of these skills could affect the others adversely. Sortor and Kulp (2003) reported that problems with visual-motor integration could be affected by difficulties experienced in visual perception and/or motor skills.

Manipulation skills, or object control skills as referred to in this study, include those skills that apply force or receive force, such as when throwing, catching, striking, dribbling and kicking a ball (Gallahue & Donnelly, 2003). Jeannerod (1996) and Winnick (2011) found that locating an object in space was dependent on more complex visual skills, such as figure-ground perception, the perception of distance and form constancy. According to Cheatum and Hammond (2000), Pienaar (2014) and Willoughby and Polatajko (1995), the development and/or improvement of motor skills that involve coordination (hand-eye and foot-eye) are dependent on the visual systems functioning effectively and on good eye-muscle control.

Deficits in visual perception will contribute to locating an object inaccurately, which would affect goal-directed movement negatively. Generally, movements could become less skilful due to inadequate visual information (Jeannerod, 1988). However, Bonifacci (2004) indicates that poor performance in motor skills is not necessarily associated with problems in visual perceptual abilities. Tsai *et al.* (2008) support this finding by claiming that visual perception shortcomings and motor tasks may be task-specific and do not necessarily have an interrelationship.

From the literature, it seems that visual-motor integration, visual perception and motor coordination may play an important role in object control skills, sporting activities and everyday life. If problems arise in any of these three areas, it could have a debilitating effect on future sport participation and life skills.

## PURPOSE OF RESEARCH

Little research has been reported on the effect that poor visual-motor integration, visual perception and motor coordination abilities could have on object control skills. Investigating these relationships will shed light on the potential role that these skills could have on perceptual-motor ability and sport performance of children, and may contribute to a better understanding among teachers of how to improve these skills in the different areas in South Africa.

## METHODOLOGY

### Research design

This study is based on a longitudinal study, Child-Health-Integrated-Learning and Development study (NW-CHILD study), which spans over a period of 6 years (2010-2016) and include 3 sequential measurements throughout. For the current research, only the baseline data of this project, collected in 2010, were used. Therefore, for this particular research, a one-time cross-sectional design was applied.

## Participants

The target population for this study was Grade 1 learners in the North-West Province of South Africa. The total number of participants identified for the study was 880 Grade 1 learners. The research group was selected by means of a stratified random sample in conjunction with the Statistical Consultation Services of the North-West University. To determine the research group, a list of names of schools in the North-West Province was obtained from the Department of Basic Education of the North-West Province. This list of schools was grouped in 4 educational districts, each representing 12 to 22 regions, with approximately 20 schools (minimum 12, maximum 47) per region. Regions and schools were selected randomly with regard to population density and school status (Quintile 1, that is schools from poor economic sectors, to Quintile 5 schools from affluent economic sectors).

Boys and girls in Grade 1 were selected randomly from each school. A total of 20 schools were involved in the study, from 4 districts with a minimum of 40 children per school and with an even gender distribution. The total group consisted of 806 learners (413 boys; 393 girls) with a mean age of 6.78±0.39 years. During the entire study, 13 (1.5%) parents/legal guardians did not consent to participation, whereas 35 (4.0%) of the selected participants were absent from school on the day of testing or had to be excluded because of incorrect ages provided by the schools.

The principals of the various identified schools were asked for permission to collect the data during school hours. If the number of learners in the school allowed it, 60 Grade 1-learners were selected. These learners received informed consent forms that had to be completed by their parents/legal guardians. This was done to ensure that informed consent would be granted by the parents/legal guardians for a minimum of 40 learners that needed to be tested at each school, so that the study would have sufficient the power/impact. Only the learners, whose parents consented, participated.

## Ethical considerations

Ethical approval was obtained from the Ethics Committee of the North-West University, Potchefstroom Campus (No. NWU-0070-09-A1), and permission was granted by the Department of Basic Education of the North-West Province to conduct the study. At a formal meeting with each principal, the aim and protocol of the study were explained and permission was asked to collect the data during school hours. The purpose of this study was explained verbally to all the participants, and any questions about the procedures answered. Trained interpreters were used to convey the instructions of the evaluators to the children, if English was not their first language.

## Measuring instruments

### *Developmental Test of Visual-Motor Integration (4$^{th}$ ed.) Test battery (VMI-4)*

The VMI-4 (Beery & Buktenica, 1997) consists of the visual-motor integration test and 2 subtests which include visual perception and motor coordination. The aim of the VMI-4 is to identify children who need special assistance, by means of early detection. The complete 27-item-VMI-4 test can be administered individually or in groups, it takes about 10 to 15 minutes to complete, and can be used from pre-school children to adults. The visual-motor integration subtest consists of a list of consecutive geometrical shapes, which have to be drawn with a pencil on paper. Ten to 15 minutes is allowed to complete the test or it is stopped after 3 consecutive mistakes. The visual perception subtest requires matching shapes with each other and takes 3 minutes to complete or until 3 consecutive mistakes are made. The last subtest, motor coordination, involves completing dots in a shape and takes 5 minutes to complete.

The criteria for awarding marks in the VMI-4 are as follows: a "0" is awarded for wrong figures; and a "1" is awarded for the correct figures. The data is captured under the 3 categories: visual-motor integration; visual perception; and motor coordination. The raw score is converted to a standard score and then to a percentile. Using the standard score, children can be grouped into 5 different classes, ranging from very high (133 to 160), high (118 to 132), average (83 to 117), low (68 to 82) to very low (40 to 67). The VMI-4 was developed to measure the extent to which an individual can integrate his visual and motor capabilities. The VMI-4 subtests have a validity of 0.92, 0.91 and 0.89 respectively (Beery & Buktenica, 1997).

***Test of Gross-Motor Development-2 Test battery (TGMD-2)***

The TGMD-2 test is designed to test the gross motor functioning of children from 3 to 10 years old (Ulrich, 2000). This test consists of 12 motor skills and is divided into 2 subtests, namely locomotor (run, hop, gallop, leap, horizontal jump and slide) and object control (striking a stationary ball, stationary dribble, catch, kick, overhand throw and underhand roll), skills. For the purpose of this study, only the object control subtest was used.

Each of these fundamental motor skills has 3 to 5 performance criteria. For example, there are 5 performance criteria for striking a stationary ball: 1) "Dominant hand grips bat above non-dominant hand"; 2) "Non-preferred side of the body faces the imaginary tossed ball with feet parallel"; 3) "Hip and shoulder rotation during swing"; 4) "Transfers body weight to front foot"; and 5) "Bat contacts ball". Marks were allocated as follows: "1" point was awarded for each correct execution of the specific skills; and "0" for a failed attempt. The child was allowed 2 attempts at each skill. A visual demonstration was given for each skill before it was tested, however, the component that was assessed for every skill, was not mentioned to the child.

The score for each of the 2 attempts for each performance criteria was added together. To obtain the skill score, all the total scores for each criterion were added together. At the end of the object control subtest, the 6 skill scores were added up to determine the subtest raw score of 48 points. The child's age, gender and raw score were used to calculate the standard score and percentile rank. The descriptive categories of the TGMD-2's manual are: excellent (subtest standard score 17 to 20); good (15 to 16); above average (13 to 14); average (8 to 12); below average (6 to 7); poor (4 to 5); and very poor (1 to 3). A standard score between 1 and 3 is considered, therefore, as very low mastery of the object control skill, while a score of 17 to 20 is considered as very good mastery of the object control skill. Content-description, criterion-prediction and construct-identification validity support the use of the TGMD-2 to identify children who are significantly behind their peers in gross motor development with a reported coefficient alpha of 0.90. Furthermore, the test has been found to be reliable in all demographic subgroups with quotients reaching or exceeding 0.87 (Ulrich, 2000).

### Statistical analysis

The STATISTICA software package (StatSoft, 2013) was employed for the analysis of the data. Firstly, descriptive statistics, (mean [M], standard deviations [SD], minimum and maximum values), of each variable was calculated. Secondly, Spearman rank order correlation was used to determine the correlations among visual-motor integration, visual perception, motor coordination, striking a stationary ball, stationary dribble, catching, kicking, underhand rolling, overhand throwing and the object control skills total. The strength of the correlation was set at $r \approx 0.1$ indicating a small effect, $r \approx 0.3$ a medium effect and $r \approx 0.5$ a large effect (Cohen, 1988). Lastly, ANOVA was used to determine the relationship between visual-motor integration, visual perception, and motor coordination and object control skills. The statistical significance level was set at $p \leq 0.05$.

## RESULTS

A total of 413 boys and 393 girls were identified as participants (N=806) for this study. The group had a mean age of 6.84±0.39 years with the boys having a slightly higher mean age of 6.87±0.39 years compared to the girls (6.81±0.38 years). Table 1 displays the age composition of the study population by gender.

*TABLE 1.* **AGE OF PARTICIPANTS BY GENDER**

| Study population | N | M±SD | Minimum | Maximum |
|---|---|---|---|---|
| Boys | 413 | 6.87±0.39 | 6.00 | 7.67 |
| Girls | 393 | 6.81±0.38 | 6.00 | 7.67 |
| Total | 806 | 6.84±0.39 | 6.00 | 7.67 |

N= Number of participants M= Mean SD= Standard Deviation

Table 2 displays the results of the mean scores obtained in each test variable for the 806 participants. The mean scores vary from high to low in the various object control skills, where the participants obtained the highest mean score in striking a stationary ball (6.78±1.84). The participants also received high mean scores in visual-motor integration (91.46±13.78), motor coordination (92.88±14.72) and a slightly lower mean score in visual perception (79.12±22.96).

*TABLE 2.* **DESCRIPTIVE DATA FOR VISUAL-MOTOR INTEGRATION, VISUAL PERCEPTION, MOTOR COORDINATION AND OBJECT CONTROL SKILLS OF PARTICIPANTS** (N=806)

| Variables | M±SD | Min | Max |
|---|---|---|---|
| *Object control skills* | | | |
| Striking a stationary ball | 6.78±1.84 | 0.00 | 10.00 |
| Stationary dribble | 4.17±2.42 | 0.00 | 8.00 |
| Catch | 4.70±1.12 | 2.00 | 8.00 |
| Kick | 6.07±1.42 | 1.00 | 8.00 |
| Overhand throwing | 2.88±2.34 | 0.00 | 8.00 |
| Underhand rolling | 4.36±1.87 | 0.00 | 8.00 |
| Object control skills: Total | 7.10±2.16 | 1.00 | 14.00 |
| *VMI-4* | | | |
| Visual-motor integration | 91.46±13.78 | 0.00 | 155.00 |
| Visual perception | 79.12±22.96 | 0.00 | 139.00 |
| Motor coordination | 92.88±14.72 | 0.00 | 140.00 |

N= Number of participants; M= Mean; SD= Standard Deviation; Min= Minimum Max= Maximum
VMI-4= Visual-Motor Integration (4th ed.)

*TABLE 3.* **CORRELATION BETWEEN VISUAL-MOTOR INTEGRATION, VISUAL PERCEPTION, MOTOR COORDINATION AND OBJECT CONTROL SKILLS**

| Variable | VMI SS | VP SS | MC SS |
|---|---|---|---|
| Striking a stationary ball | 0.06 | 0.12* | 0.07 |
| Stationary dribble | 0.14* | 0.14* | 0.14* |
| Catch | 0.11* | 0.16* | 0.06 |
| Kick | -0.06 | -0.12* | 0.02 |
| Overhand throw | 0.09* | 0.14* | 0.00 |
| Underhand rolling | 0.17* | 0.19* | 0.09* |
| Object control skills: TOTAL | 0.21* | 0.27# | 0.18* |

VMI= Visual-motor integration; VP= Visual perception; MC= Motor coordination; SS= Standard Score
Significance accepted: r≥0.1*= small r≥0.3#= medium

A Spearman rank order correlation was used to determine the correlations among visual-motor integration, visual perception, motor coordination and the 6 object control skills. The latter includes striking a stationary ball, stationary dribble, catch, kick, underhand roll and overhand throw. The results in Table 3 indicate small significant correlations (r≥0.1) between visual-motor integration and 4 of the object control skills (stationary dribble, catching, overhand throwing, underhand rolling), including the object control total. Visual perception also showed a small correlation (r≥0.1) with all 6 of the object control skills (striking a stationary ball, stationary dribble, catching, kicking, overhand throwing, underhand rolling), while a correlation with medium practical significance (r≥0.3) was found between visual perception and the object control skills total.

*TABLE 4.* **INTERACTION BETWEEN VISUAL-MOTOR INTEGRATION, VISUAL PERCEPTION, MOTOR COORDINATION CLASSES AND OBJECT CONTROL SKILLS**

| **Variables** | **Class 2** | **Class 3** | **Class 4** | **Class 5** | **MSE** | **p** |
|---|---|---|---|---|---|---|
| *Visual-motor integration* | | | | | | |
| Striking a stationary ball | 6.64 | 6.87 | 6.62 | 6.14 | 3.38 | 0.082 |
| Stationary dribble | 4.52 | 4.36$^{(4)}$ | 3.54 | 3.43 | 5.75 | ≤0.001* |
| Catch | 5.04 | 4.73 | 4.50 | 4.74 | 1.24 | 0.060 |
| Kick | 5.76 | 6.09 | 6.12 | 5.83 | 2.02 | 0.475 |
| Overhand throw | 3.12 | 2.95 | 2.68 | 2.34 | 5.45 | 0.291 |
| Underhand rolling | 5.36$^{(5)}$ | 4.44 | 4.09 | 3.49 | 3.42 | ≤0.001* |
| Object control skills total | 7.92$^{(5)}$ | 7.23$^{(4)}$ | 6.45 | 6.23 | 4.52 | ≤0.001* |
| *Visual perception* | | | | | | |
| Striking a stationary ball | 7.05 | 7.02$^{(5)}$ | 6.78 | 6.41 | 3.34 | ≤0.001* |
| Stationary dribble | 4.47 | 4.57$^{(4, 5)}$ | 4.00 | 3.80 | 5.77 | ≤0.001* |
| Catch | 5.05 | 4.84$^{(5)}$ | 4.65 | 4.50 | 1.23 | ≤0.001* |
| Kick | 5.66 | 5.96 | 6.16 | 6.19 | 2.01 | 0.057 |
| Overhand throw | 3.89$^{(5)}$ | 3.17$^{(5)}$ | 2.74 | 2.49 | 5.34 | ≤0.001* |
| Underhand rolling | 4.74 | 4.78$^{(4, 5)}$ | 4.25 | 3.88 | 3.37 | ≤0.001* |
| Object control skills TOTAL | 8.11$^{(5)}$ | 7.57$^{(4, 5)}$ | 6.99$^{(5)}$ | 6.29 | 4.36 | ≤0.001* |
| *Motor coordination* | | | | | | |
| Striking a stationary ball | 6.73 | 6.83 | 6.63 | 6.43 | 3.39 | 0.434 |
| Stationary dribble | 3.60 | 4.33$^{(4)}$ | 3.47 | 3.57 | 5.77 | ≤0.001* |
| Catch | 4.67 | 4.70 | 4.78 | 4.43 | 1.25 | 0.381 |
| Kick | 5.40 | 6.13 | 5.99 | 5.69 | 2.01 | 0.052 |
| Overhand throw | 3.67 | 2.84 | 3.13 | 2.67 | 5.45 | 0.335 |
| Underhand rolling | 4.60$^{(4, 5)}$ | 4.45$^{(4, 5)}$ | 4.07 | 3.74 | 3.47 | 0.033* |
| Object control skills total | 7.33$^{(4, 5)}$ | 7.19$^{(4, 5)}$ | 6.63 | 6.17 | 4.59 | ≤0.003* |

Class 2= *High* Class 3= *Average* Class 4= *Low* Class 5= *Very Low*

* For statistical purposes, scores of learners in Class 1 (very high) and Class 2 were combined due to small number in both classes; Significance level= p≤0.05; MSE= Mean Square Error; Superscript= Significant difference between classes

Motor coordination (Table 3) only shows small significant (r≥0.1) correlations with 2 of the object control skills (stationary dribble, underhand rolling and the object control total), as well as the object control skill total, while no correlations were found between striking a stationary ball, catching, kicking and overhand throw ($r \leq 0.1$).

In Table 4, the results of an ANOVA are presented, which indicate the relationship between values obtained and classified into different visual-motor integration-, visual perception- and motor coordination classes with the different object control skills. Visual-motor integration scores were grouped into 5 different classes, ranging from very high (Class 1= 133 to 160), high (Class 2= 118 to 132,), average (Class 3= 83 to 117), low (Class 4= 68 to 82) to very low (Class 5= 40 to 67).

For the purposes of this study, the children in Class 1 and Class 2 were combined due to the small number of children who were classified in Class 1. Furthermore, the results reveal that there was a statistically significant ($p \leq 0.01$) association between visual-motor integration and stationary dribble, underhand rolling and the object control skills total. In stationary dribble, a tendency of a decline of the visual-motor integration mean scores was seen from Class 2 to Class 5. It seems that as the visual-motor integration values decreased so did the stationary dribble values. The same tendency was found in the underhand rolling and the object control total scores. In all these skills and the object control skills total there were statistically significant associations ($p \leq 0.05$) between VMI that ranged from high (Class 2) to very low (Class 5).

Visual perception had a statistically significant association ($p \leq 0.05$) with striking a stationary ball, stationary dribble, catch, overhand throw, underhand rolling and the object control skills total. A tendency of higher mean scores for visual perception was found for the participants that were classified in Class 2 (high), with a linear decline to Class 5 (very low), that could be observed in striking a stationary ball, catch, overhand throw and the object control skills total. Only the mean scores for underhand rolling and stationary dribble had a slight incline from Class 2 to Class 3.

In motor coordination, underhand rolling and the object control skills total scores showed a consistent decline from Class 2 to Class 5. Stationary dribble had a slight increase from Class 2 to Class 3 and then continued declining from then on. There was a statistically significant association ($p \leq 0.05$) between the VMI categories in these 3 skills: visual-motor integration; visual perception; and motor coordination (Table 4).

## DISCUSSION

The aim of this study was to determine the interrelationship between visual-motor integration, visual perception, motor coordination and object control skills.

The results indicate that there were small to medium correlations between visual-motor integration, visual perception, motor coordination and the various object control skills. Visual perception showed the strongest relationship within all the object control skills and the object control skills total compared to visual-motor integration and motor coordination. The study reported by Tepeli (2013) on 54- to 59-months-old Turkish children in Konya, investigated the relationship between gross motor skills and visual perception. The findings of Tepeli (2013) are in agreement with our findings as this researcher indicates that visual perception was a strong predictor of object control skills.

When the possible interaction between visual-motor integration, visual perception and motor coordination with the different object control skills was investigated, visual perception indicated the most significant effect ($p \leq 0.05$) in five of the six object control skills. These findings are supported by the results of Wilson and Mackenzie (1998), which showed that children who experience problems with visual perception would have problems in motor tasks. Oktay and Unutkan (2003) also support this finding by stating that visual perception is crucial for tasks, such as throwing and grasping. The positive relationship that was found between visual perception and successfully performed object control skills make sense, based on the assumption that a motor action can only be carried out by perceiving sensory information correctly and reacting accordingly. Thus, the task is accomplished by using body and brain together.

As mentioned previously, visual perception includes form consistency, visual closure and figure-ground perception (Schneck, 2010). Form consistency is necessary to recognise an approaching ball of whichever size or position, and figure-ground perception enables the child in any given game situation to be able to focus on an oncoming ball or team mate. Visual closure and spatial perception is needed so that during a game a child can track a ball thrown by a team mate accurately or to position him-/herself to be available for the opportunity to catch a ball (Schneck, 2010).

Kicking was the only skill, which had a negative interaction with visual perception, although the relationship was not significant. According to Bonifacci (2004) in his study on 6 to 10 year old children (N=144), poor performance in motor skills was not necessarily associated with poor visual perceptual skills. Tsai *et al*. (2008) also found motor tasks and visual perception to be specific and not to necessarily have a relationship. Other studies that made similar comparisons are, however, limited to compare with the current findings.

Visual-motor integration only had significant correlations with four of the six object control skills, as well as the object control skills total. On examination of the possible interaction between visual-motor integration and object control skills, only stationary dribble, underhand rolling and the object control skills total were significantly better in Class 2 (high) and Class 3 (average), compared to Class 4 (low) and 5 (very low). This finding supports that of Wilson and Falkel (2004), who reported that visual-motor integration is one of the components that can be linked easily to performance in sport, furthermore that good coordination between the hands and eyes are important for sport, such as basketball, volleyball and baseball. Bonifacci (2004) in his study of Brazilian children (N=141), aged 6 to 10 years, found a significant difference in visual-motor integration skills between children with low and high gross motor skills.

Motor coordination correlated with two of the six object control skills and when the possible interaction was studied, motor coordination only had significant relationships with stationary dribble, underhand rolling and the object control skills total. The children had higher mean scores in Class 2 (high) and 3 (average), compared to Class 4 (low) and 5 (very low). Motor coordination showed a very small correlation with object control skills in this study. This is in contrast with previous research, which found that motor coordination is crucial in activities where hand-eye and foot-eye coordination is important (Cheatum & Hammond, 2000). Possible reasons for this could be that the motor coordination task in this study relies on hand control and more on fine motor skills in comparison to the object control skills that rely on the use of gross motor skills during this study.

## PRACTICAL APPLICATION

The value of this article is that it sheds light on the potential role that these skills could have on the perceptual-motor ability and sport performance of children, and may contribute to a better understanding among coaches of how to improve these skills in the Grade 1-learners in South Africa. Children with poor ball handling skills can be assessed for visual perception and then supported by interventions that address these possible deficiencies.

## CONCLUSION

While conducting the current research, it became clear that it is the first of its kind, investigating the interrelationship between the VMI-4 and TGMD-2. Due to the possible and various effects that visual skills may have on sport skills, it seemed important to investigate the effect that these skills might have on basic ball skills, which could later have an effect on sport skills. It was difficult to find literature specifically with regard to a normal South African population to support or disprove our findings. A possible reason for this could be the fact that the VMI-4 test battery was not designed originally to be compared to gross motor skills, but rather with test batteries focusing on visual skills and fine motor skills. However, there were small correlations between components that required hand control, such as dribbling, rolling and striking a stationary ball and motor coordination, but there were little to no relationship with components, which did not require it, such as kicking and catching. Important information with regard to visual-motor integration, visual perception, motor coordination and object control skills has been reported herewith. The findings of this study indicate that there were limited interactions between visual-motor integration, motor coordination and object control skills. However, there were various relationships between visual perception and object control skills.

### Acknowledgement

The authors wish to offer their sincere gratitude to the Department of Basic Education of the North-West Province, the principals and the children of the schools for the permission granted for this study to take place. Thank you also to the North-West University, MRC and the National Lottery of South Africa, being the key contributors to providing financial support that made this study possible.

Disclaimer: Any opinion, findings and conclusions or recommendations expressed in this article are that of the authors and, therefore, the MRC and/or NRF do not accept any liability in this regard.

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