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Enhancing visual-motor integration and visual perception of 6-year-old children

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Background: Perceptual motor development is crucial during early childhood and not properly addressing it in physical education (PE) can be detrimental.

Aim: To determine the effect of a South African curriculum-aligned PE intervention on the visual-motor integration (VMI), visual perception (VP) and motor coordination (MC) of 6-year-old children.

Setting: Quintile 3 schools in Mangaung, Free State Province, South Africa.

Methods: Grade 1 children from two quintile 3 schools in Mangaung were recruited. Complete data sets were obtained for 44 participants. A quantitative randomised control trial design was followed. The Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition (Beery VMI-6), determined participants' VMI, VP and MC during the pre- and post-tests. The *KaziKidz* toolkit was used as intervention during 10 sessions of 40 min each for the experimental group, while the control group continued with the South African PE curriculum. The Fisher's exact and Kruskal–Wallis tests were used for pre- and post-test comparisons, with $p < 0.05$ indicating statistical significance.

Results: The median age of the control ($n = 18$) and intervention ($n = 26$) groups was 6.7 and 6.5 years, respectively. Post intervention, the intervention group displayed significantly improved VMI ($p = 0.042$) and VP ($p < 0.001$), compared to the control group. No significant differences between the groups were observed for MC.

Conclusion: Exposure to PE including perceptual motor aspects significantly improved the VMI and VP of 6-year-old children.

Contribution: Results deemed the *KaziKidz* toolkit to be a successful mode of PE delivery to improve the perceptual skills of Grade 1 learners in South Africa.

Keywords: children; motor coordination; perceptual motor; motor skills; physical activity; intervention.

Introduction

Physical education (PE) during the beginning years of primary school can be employed to enhance children's motor abilities, fundamental movement skills and physical activity levels. A recent review described that high-quality PE participation positively influences health-related physical fitness components and brings about improved fundamental movement skills (García-Hermoso et al. 2020). In England, interventions during PE lessons also increased the amount of time children participate in moderate to vigorous physical activity (Wood & Hall 2015); consequently, PE can lead to several health benefits (Lonsdale et al. 2013). Physical education curricula or intervention in general constitute not only physical activity but also encompass many other movement aspects, depending on the child's age (Department of Basic Education [DBE] 2011; García-Hermoso et al. 2020). In a typical setting, PE lessons are seen as the actual classes within a school's curriculum designed to educate learners on physical activity, but it can also refer to the process of continuous physical experiences that lead to learning, growth and development (Johnson & Turner 2016). Physical education can in fact be regarded as a multifaceted concept that not only plays an important role in children's physical activity participation and motor skill development but also enhances holistic development during the early childhood years.

Early childhood years are characterised by rapid development in several domains (Goodway, Ozmund & Gallahue 2020), with children being exposed to various environments that can enhance or hinder their development. Bronfenbrenner's Ecological Systems Theory explains the possible negative effect that environments with restricted resources can have on a child's development (Guy-Evans 2020). With South Africa being a developing country and having a high poverty rate (Statistics South Africa [SSA] 2020), low-resourced environments are common and their effects are detrimental to physical, emotional, social and cognitive domains, among others. Sixty-two percent of South African children between 0 and 17 years of age are multidimensionally poor, indicating deprivation in at least three out of the identified seven dimensions: education, health, housing, information, nutrition, protection, sanitation or water (SSA 2020). This number of affected children should alarm educators and policy makers within the South African school setting, while ample and high-quality developmental opportunities during school hours should be emphasised and prioritised.

In South Africa, the first few years of primary school is identified as the Foundation Phase (children 5–9 years of age) and include Grades R, 1, 2 and 3 (DBE 2011). The South African DBE highlighted that PE during these early childhood years should focus on perceptual and locomotor development, rhythm, balance and laterality (DBE 2011). The DBE also indicated perceptual skill development in young learners as a foundational building block for future learning and developmental success (DBE 2011). Goodway et al. (2020) clearly pointed out that movement influences the development of perceptual skills, although the extent thereof is still debatable.

Perceptual motor skills refer to voluntary movements that depend on any form of sensory information to attach meaning to the movement and to the immediate environment in which the movement takes place (Goodway et al. 2020). Perceptual motor task execution depends on sensory stimuli, with vision playing one of the primary roles in successful motor task performance (Magill & Anderson 2021; Schneck 2010). Visual system problems can therefore be a stumbling block to children, negatively impacting their motor skills and academic success (Cheatum & Hammond 2000). Schneck (2010) emphasised the important role of visual perception (VP) in the development of object vision, whereas Du Plessis, Coetzee and Pienaar (2015) and Tepeli (2013) highlighted VP as an important component of object control skills. In this regard, attention is drawn to eye-motor coordination (MC), form constancy and figure ground perception as important visual perceptual concepts (Tepeli 2013). Well-developed perceptual abilities are also important for success in academic tasks (Dhingra, Manhas & Kohli 2010). Diamond (2015) focused attention on underlying cognitive processes and brain activation involved in both perceptual motor- and academic tasks. Furthermore, children's perceptual learning experience increases when they are exposed to stimulating environments, consequently enhancing their visual-cognitive function development, which is regarded as foundational to academic task execution and success (Schneck 2010). De Waal, Pienaar and Coetzee (2018) reported in this regard that basic as well as complex visual perceptual processes correlated significantly with children's academic achievement, while learners from low socioeconomic backgrounds portrayed poorer visual perceptual skills compared to their counterparts residing in high socioeconomic environments.

Perceptual motor skill development is important during the early childhood years, and although PE can involve many aspects and address many developmental domains, its focus in the South African milieu for Grade R–3 learners is on perceptual motor development (DBE 2011). If applied, incorporation of this focus into the South African public primary school PE curriculum could be a determining factor in preparing young children, especially from low socioeconomic status schools, for perceptual motor- and academic success. Reportedly, South African Foundation Phase teachers find teaching the Curriculum and Assessment Policy Statement (CAPS) Life Skills (PE in particular) challenging because they do not have the adequate content knowledge for PE (Hebron 2015). Supporting this finding, Stroebel, Hay and Bloemhoff (2017) identified unqualified PE teachers as one of the main limitations in South Africa's Foundation phase PE, calling on the DBE to prioritise training of Life Skills teachers, especially regarding the PE component thereof. Addressing perceptual motor development in PE in low socioeconomic environments is particularly important, as these environments typically experience a lack of stimulation opportunities and limited resources. Teachers from resource-restricted schools in Gqeberha, South Africa, recently identified specific PE challenges, namely negative beliefs about their own ability and competency to teach PE and having a low regard for PE as a subject (Kahts-Kramer, Du Randt & Wood 2022). Systemic barriers included poor infrastructure, limited equipment, large class sizes, individual learner characteristics, lack of parental support, poor safety and lack of supportive environments (Kahts-Kramer et al. 2022).

Limited research has been conducted to explore the influence of PE, which specifically includes perceptual motor activities, on VP and the integration of vision and MC (Gouws 2015; Van Zyl 2020). Limited research, in addition to the current challenges experienced by Life Skills teachers in the Foundation Phase in South Africa, led us to ask whether a PE intervention aligned with the South African curriculum would influence perceptual activities used in class. Therefore, the aim of this study was to determine the effect of a South African curriculum-aligned PE intervention on the visual-motor integration (VMI), VP and MC abilities of Grade 1 learners in Mangaung in the Free State Province of South Africa.

Research methods and design

Study design

A quantitative randomised control trial design was used in this study. The study sample was determined by obtaining a list of schools in Mangaung from the Free State Province DBE. Two quintile 3 schools were selected based on convenience. Of the two schools, one was randomly assigned as the control group and the other as the experimental group. The school quintile ranking system in South Africa is mainly based on the allocation of financial resources. When determining a school's quintile rank, the DBE takes into account the level of literacy, income and unemployment of the community in which a school is situated (Education [WCPP] 2020). Quintile 1–3 schools are predominantly schools where no fees are paid by the learners' parents or caregivers and represent children from low socioeconomic environments. Funding is determined according to the amended national norms and standards for school funding as outlined in the *South African Schools Act 1996 (Act No. 84 of 1996)* (DBE 2021).

Participants

Fifty-seven (*n* = 57) Grade 1 learners from two quintile 3 schools in Mangaung were included in the study, of whom 24 (42.1%) were boys and 33 (57.9%) were girls. Baseline data were collected for all 57 participants, while 44 of these learners participated in the post-test data collection. At the commencement of the study, one of the schools (School 1) was randomly identified as the control group, while the other one acted as the experimental group (School 2). Eighteen complete data sets were available for the control group (School 1), while the experimental group (School 2) had 26 complete data sets. Participants in the control group had a mean age of 6.7 years, while the experimental group's participants were on average 6.5 years of age. Inclusion criteria included all Grade 1 learners in the identified schools, from whom the required consent and assent had been obtained, and who had complete pre- and post-test data sets. Learners were excluded if they were older than 7 or younger than 5 years, or if they were absent or ill on the day of testing. In principle, participants in the experimental group were excluded from the study if they missed more than 4 of the 10 intervention sessions. However, none of the experimental group's participants missed more than four of the intervention sessions.

Procedures

The Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition (Beery VMI-6) (Beery & Beery 2010) was used to collect pre- and post-test data on participants' VMI, VP and MC skills in both the experimental and control groups. The experimental group then participated in the PE intervention presented by two student biokineticists. The control group continued with their PE sessions as presented by their teacher. The intervention was presented during the allocated PE periods and no academic time was lost. The PE intervention followed by the experimental group is discussed in detail in the following section, while the differences between the PE intervention received by the experimental group and the PE sessions presented to the control group have also been highlighted. After an intervention period of 12 weeks (including 10 intervention sessions), both groups were again evaluated with the Beery VMI-6 to determine any differences from pre- to post-test.

Measures

The Beery VMI-6 can be applied to individuals from 2 years of age and measures their ability to integrate visual stimuli with motor movement and thus allows for screening of VMI deficits. The Beery VMI-6 is a standardised test with good reliability (0.96) and high validity values of 0.80–0.95 (Beery & Beery 2010).

In this study, the Beery VMI-6 test required participants to copy geometric designs that included curved lines and angles. This test was conducted in group format, took approximately 10 min to complete and was terminated after a third consecutive mistake occurred. The two supplemental tests are the Beery VP and Beery MC tests. The VP test was administered individually, and participants had to identify matching shapes. Three minutes were allocated to complete this test and execution was terminated after three consecutive mistakes occurred or if time ran out. During the MC test, participants had to connect dots to form certain figures while staying within set lines. Five minutes were allowed to complete this test and termination of the test took place after the time has elapsed.

Specific scoring instructions for each item involved a pass or a fail. All raw scores were converted to standard scores and percentiles that were categorised into different descriptive categories and used for data analysis. Standard scores were interpreted as follows: >129 indicated very high performance, 120–129 high performance, 110–119 above-average performance, 90–109 average performance, 80–89 below average performance, 70–79 low performance and <70 very low performance (Beery & Beery 2010).

Physical education intervention programme

The *KaziBantu* programme was developed in 2014 by the University of Basel in Switzerland in collaboration with the Nelson Mandela University in South Africa (KaziBantu 2018), where *Kazi* in Swahili means active and the isiXhosa word *Bantu* refers to people. The programme sets out to create long-lasting positive changes in health and provide an opportunity for physical activity by implementing a multifaceted approach to address the health problems faced in disadvantaged settings in low- and middle-income countries. *KaziKidz* is part of the *KaziBantu* programme and is a specially tailored school-based intervention programme aimed at consolidating the practice of PE and ensuring the physical literacy and healthy active living of school children (KaziBantu 2018).

In the South African primary school curriculum, PE is a subtheme (in addition to three other subthemes: Beginning Knowledge, Creative Arts, and Personal and Social Well-being), which falls under Life Skills (DBE 2011). The *KaziKidz* toolkit has been designed in line with South Africa's CAPS and includes three pillars, namely (1) PE, (2) moving to music and (3) health and hygiene and nutrition education (DBE 2011). The lessons are standardised for 40 min divided into a warm-up (10 min), a main part (20 min) and a cool-down (10 min). Each lesson in the *KaziKidz* toolkit for Grades 1–7 has the same structure and consists of age-appropriate activities that progress in difficulty for the specific age group. The toolkit includes educator manuals, lesson plans and cue cards. The fundamental structure of each lesson consists of a list of material and equipment needed throughout the lesson. To aid in teachers' understanding, the content is subdivided into 'equipment', 'how to play', 'goal of the game' and 'what to watch out for' (see Appendix 1 for an example of a lesson) (KaziBantu 2018). The PE intervention in this study included activities addressing a variety of perceptual motor skills, as set out in the toolkit.

With specific challenges faced by the Foundation Phase teacher in South Africa in mind, the *KaziKidz* toolkit was deemed a suitable intervention to explore. Expected similarities for both groups' PE sessions included the length of sessions and number of sessions per week. Two main differences included the actual content of sessions and the individuals presenting it.

Regarding actual content, the intervention programme's activities were very structured, with specific equipment, age-appropriate and designed to address the set curriculum, whereas activities in the control group's sessions were left to the teacher's interpretation of the curriculum. The curriculum provides only a few examples of activities, and depending on content knowledge, the guidelines can seem broad. The control group was thus exposed to sessions set up by the teachers themselves using the time, equipment and knowledge they had to their disposal (whether limited or not). The intervention programme was presented by movement specialists, while teachers (with no specialisation in movement development of young children) were responsible to present the PE sessions to the control group. Although the *KaziKidz* toolkit was designed in line with South Africa's CAPS and could have been quite similar to the PE sessions presented to the control group, we reasoned that the quality of content and the expertise of presenters would set the intervention apart.

Statistical analysis

The data analysis for this article was performed by a biostatistician using SAS software (copyright SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA). For the pre- and post-test measurement, medians and percentiles were calculated for the numerical data as the distribution was skew, and frequencies and percentages were calculated for categorical data per group. Groups were compared and described using the Fisher's exact test for sparse categorical data and the Kruskal–Wallis test for numerical data. A *p*-value of <0.05 indicated a statistically significant difference.

Ethical considerations

After approval was obtained from the Health Sciences Research Ethics Committee (HSREC) of the University of the Free State (ethics clearance number UFS-HSD2020/1406/2411) and the Free State Province DBE, principals of the two identified schools gave permission to conduct the study at their schools during school hours. The parents or legal guardians of all the Grade 1 learners who participated in the study at each of the selected schools also gave consent to allow their children to be part of the study. Assents were also provided by all participating children before data collection commenced. All information documents and consent forms were available in English, Sesotho, Setswana and Afrikaans to ensure that everyone involved received information in a language in which they were fluent.

Data collection and management were performed according to the ethical guidelines and principles of the South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research, including the Helsinki Declaration. As the *KaziKidz* toolkit for Grade 1 learners comprises 224 lessons (covering all three pillars) and can be followed for a whole year, the teaching material was made available to Grade 1 teachers at both participating schools for implementation after post-test data collection.

Results

Table 1 represents the differences between the two groups in the pre- and post-test for the Beery VMI-6 test. In the pre-test, a significant difference in the VMI percentile score between the control and experimental groups was observed, with the intervention group performing better. In the post-test, significant differences were found between the standard score (p = 0.042), scaled score (p = 0.043) and percentile (p = 0.042), where the intervention group outperformed the control group.

Table 1 further indicates no significant differences between the control and intervention groups in the VP pre-test. In the post-test, the intervention group performed significantly better than the control group, as reflected by the values of the VP standard score ($p < 0.001$), scaled score ($p < 0.001$), percentile ($p < 0.001$) and age equivalent (p = 0.001). No significant differences between the control and intervention groups were observed in the pre- and post-tests for the MC test, as shown in Table 1.

Taking the descriptive values in Table 2 into consideration, it was evident that the intervention group performed better than the control group in the post-test, with a higher percentage of learners performing in the average and above-average categories. The descriptive values for VMI and VP indicated that a higher percentage of learners in the intervention group (VMI: n = 20, 76.9%; VP: n = 18, 69.1%) compared to the control group (VMI: n = 10, 55.6%; VP: n = 3, 16.7%) fell in the average and above-average categories in the post-test. These differences in percentages are also presented in Figure 1 and Figure 2. Regarding the MC test, a similar number of participants fell in the different categories and the experimental group did not present better MC skills than the control group. Figure 3 shows the evidently similar performance between the experimental and control groups for MC.

A significant difference (p = 0.001) was observed between groups for the VP descriptive values during the post-test, but not for VMI (p = 0.160) and MC (p = 0.749) (Table 2). None of the participants performed in the very-high category. During baseline testing, both groups had a large percentage of participants performing very low, low and below average in the VMI (45.6%) and VP (61.4%) tests.

Discussion

This study determined the effect of a South African curriculum-aligned PE intervention on the VMI, VP and MC of 6-year-old children attending two quintile 3 schools in Mangaung. The main findings confirmed a significant positive effect of the intervention on the VMI and VP of the participating children. Comparatively, Altun (2019) reported a significant positive effect of movement on visual perceptual skills of 7-year-old primary school learners in Turkey, where games involving physical activity were the intervention mode of delivery. The improved VMI scores of the experimental group in our study could be explained by the nature of the test, as well as the components included in the intervention. In the current study, the VMI test required the use of vision to guide small hand and finger movements (Beery & Beery

TABLE 1: Beery visual-motor integration, sixth edition results – Summary of pre- and post-test differences between the control and intervention groups.

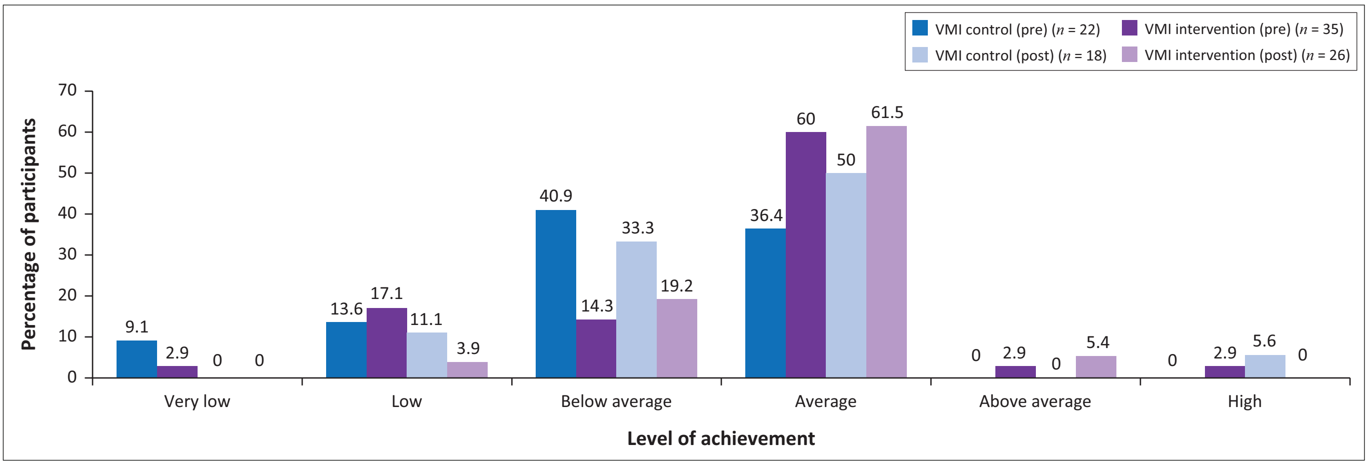
Beery tests	Derived scores	Median		Lower quartile to upper quartile		*P*
		Control group	Intervention group	Control group	Intervention group	
Visual-motor integration						
Pre-test (n = 57) Control group: n = 22 Intervention group: n = 35	Standard score	84.0	92.0	80.0–96.0	83.0–100.0	0.085
	Scaled score	7.0	8.0	6.0–9.0	7.0–10.0	0.082
	Percentile	13.5	30.0	7.0–37.0	13.0–50.0	0.034*
	Age equivalent	5.0	5.5	4.3–5.9	4.5–5.9	0.339
Post-test (n = 44) Control group: n = 18 Intervention group: n = 26	Standard score	90.0	98.0	84.0–98.0	91.0–104.0	0.042*
	Scaled score	8.0	9.5	7.0–10.0	8.0–11.0	0.043*
	Percentile	25.0	44.5	14.0–45.0	27.0–61.0	0.042*
	Age equivalent	5.9	6.3	5.5–6.3	5.5–7.5	0.214
Visual perception						
Pre-test (n = 57) Control group: n = 22 Intervention group: n = 35	Standard score	83.5	89.0	68.0–89.0	69.0–101.0	0.151
	Scaled score	7.0	8.0	4.0–8.0	4.0–10.0	0.305
	Percentile	17.0	23.0	3.0–30.0	3.0–53.0	0.264
	Age equivalent	4.3	4.7	3.8–5.1	3.6–6.3	0.516
Post-test (p = 44) Control group: n = 18 Intervention group: n = 26	Standard score	77.5	96.5	73.0–87.0	89.0–103.0	< 0.001*
	Scaled score	5.5	9.0	5.0–7.0	8.0–11.0	< 0.001*
	Percentile	6.5	40.5	4.0–19.0	23.0–58.0	< 0.001*
	Age equivalent	4.5	5.7	4.0–4.7	5.1–7.3	0.001*
Motor coordination						
Pre-test (n = 57) Control group: n = 22 Intervention group: n = 35	Standard score	95.5	96.0	87.0–102.0	90.0–105.0	0.582
	Scaled score	9.0	9.0	7.0–10.0	8.0–11.0	0.434
	Percentile	38.0	39.0	19.0–55.0	25.0–63.0	0.582
	Age equivalent	5.6	5.3	4.9–6.3	4.9–6.3	0.830
Post-test (n = 44) Control group: n = 18 Intervention group: n = 26	Standard score	100.0	99.0	93.0–102.0	94.0–103.0	0.886
	Scaled score	10.0	10.0	9.0–10.0	9.0–11.0	0.720
	Percentile	50.0	47.0	32.0–55.0	34.0–58.0	0.886
	Age equivalent	6.3	6.5	5.9–6.7	5.3–7.3	0.952

*Statistically significant difference (p-value determined with the Kruskal-Wallis test).

TABLE 2: Descriptive pre- and post-test values for visual-motor integration, visual perception and motor coordination between the control and intervention groups.

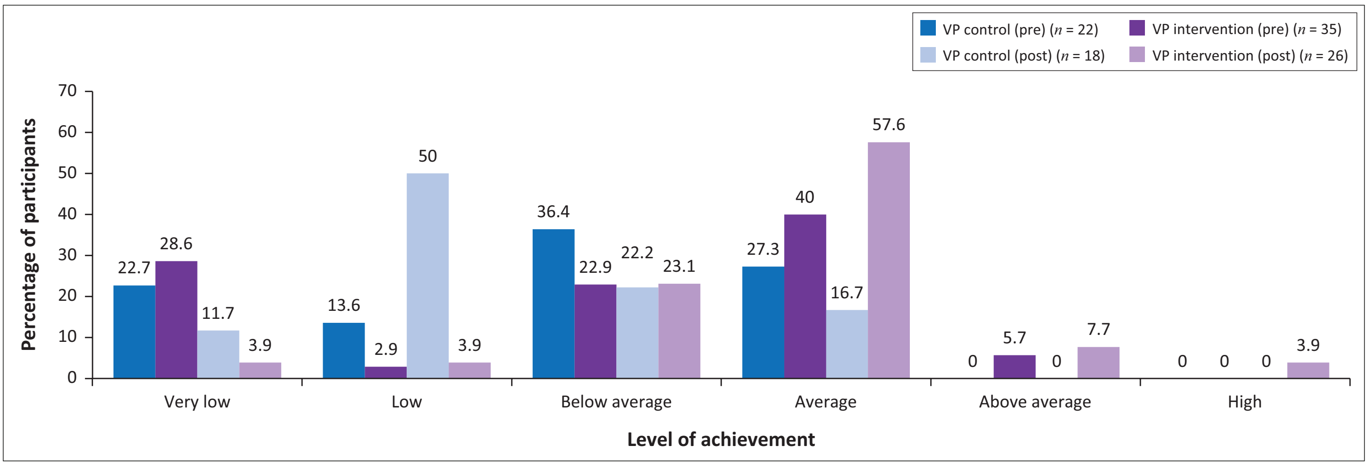
Beery tests	Group	Test	Very low		Low		Below avg.		Avg.		Above avg.		High		*P*
			n	%	n	%	n	%	n	%	n	%	n	%	
VMI	Control	Pre (n = 22)	2	9.1	3	13.6	9	40.9	8	36.4	0	0	0	0	0.123
		Post (n = 18)	0	0	2	11.1	6	33.3	9	50.0	0	0	1	5.6	0.1599
	Interv.	Pre (n = 35)	1	2.9	6	17.1	5	14.3	21	60.0	1	2.9	1	2.9	-
		Post (n = 26)	0	0	1	3.9	5	19.2	16	61.5	4	5.4	0	0	-
VP	Control	Pre (n = 22)	5	2.27	3	13.6	8	36.4	6	27.3	0	0	0	0	0.314
		Post (n = 18)	2	11.1	9	50.0	4	22.2	3	16.7	0	0	0	0	0.001
	Interv.	Pre (n = 35)	10	28.6	1	2.9	8	22.9	14	40.0	2	5.7	0	0	-
		Post (n = 26)	1	3.9	1	3.9	6	23.1	15	57.6	2	7.7	1	3.9	-
MC	Control	Pre (n = 22)	0	0	0	0	6	27.3	14	63.6	2	9.1	0	0	0.307
		Post (n = 18)	0	0	0	0	2	11.1	15	83.3	1	5.6	0	0	0.749
	Interv.	Pre (n = 35)	1	2.9	1	2.9	3	8.6	25	71.4	5	14.3	0	0	-
		Post (n = 26)	0	0	1	3.9	3	11.5	18	69.3	4	15.4	0	0	-

Note: P-value determined either with the Kruskal-Wallis test or the Fisher's exact test.
Avg., average; Interv., intervention; VMI, visual-motor integration; VP, visual perception; MC, motor coordination.



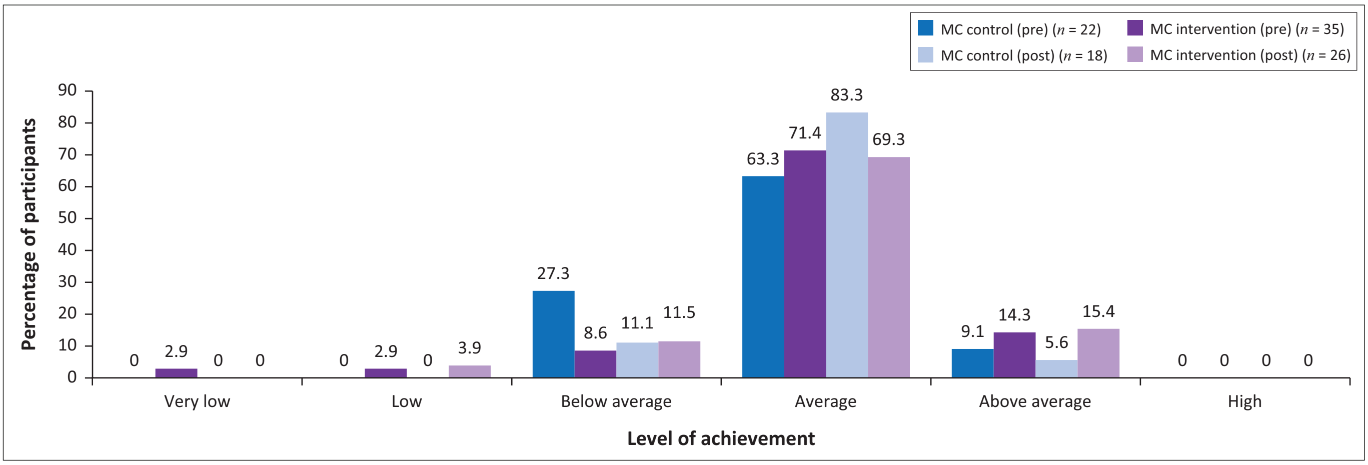
VMI, visual-motor integration.

FIGURE 1: Descriptive pre- and post-test values for visual-motor coordination.



VP, visual perception.

FIGURE 2: Descriptive pre- and post-test values for visual perception.



MC, motor coordination.

FIGURE 3: Descriptive pre- and post-test values for motor coordination.

2010), while the intervention specifically focused on perceptual motor skills. The ability to use vision to coordinate hand and finger movements (handwriting) in young children requires not only cognitive processes but also the ability to coordinate perceptual and motor processes (Maldarelli et al. 2015). Consequently, we argue that participants' perceptual motor skills improved because of the intervention, leading to improved perceptual and motor skills involved in coordinating hand and finger movements.

Foundational support for these findings can be found in the concept of *grounded cognition* (Lobo et al. 2013), which is embedded in the dynamic system theory (Thelen et al. 2001) and ecological systems theory (Araújo & Davids 2009). The dynamic system theory poses that mental events involved in perception, planning, remembering and deciding are the same as used in physical movements (Thelen et al. 2001). Including perceptual skills in movement (such as in the intervention) can thus influence perceptual constructs used in class. Grounded cognition refers to a wide range of mental processes going further than just traditional cognitive abilities by including processes of perception, problem solving, action, language, memory, social interaction, reasoning and decision making (Lobo et al. 2013). In this regard, Lobo et al. (2013) made the important argument that perceptual motor behaviours facilitate development across several domains, not only in the present moment but also contributes to children's future readiness to learn in school. Exposing children to perceptual motor behaviours, such as the curriculum-aligned PE intervention of the current study, not only advances the specific perceptual motor skills but, as stated by Lobo et al. (2013), also has a positive influence on other domains, such as VP and VMI. These positive influences can further assist children to achieve academic success.

Regarding MC results, no significant changes occurred in either the experimental or control group. These findings could be explained by the nature of the Beery MC test, the type of perceptual motor content included in the PE intervention and the fine-motor writing activities used in class by South African Grade 1 learners. The MC supplemental test of the VMI-6 greatly eliminates visual perceptual demands by providing starting dots, paths and strong visual guides to the examinee during task execution (Beery & Beery 2010), while no specific fine MC tasks were included in the PE intervention of the current study. In addition, most (88.7%) of the complete group of participants were already on average or above-average level at baseline testing, which minimises the opportunity for improvement due to a ceiling effect. Moreover, the continuous exposure to drawing of shapes and figures during academic teaching time in class might have contributed to the small and non-significant improvements observed in the two groups' MC post-test results. Although the inclusion of figures and shapes during academic teaching time was not explicitly controlled for, both the experimental and control groups were exposed to the exact same curriculum and teaching materials.

Although not the focus of this study, it is noteworthy to highlight the overall performance of both groups at baseline, specifically for VMI and VP. Alarmingly, 61.4% and 45.6% of participants performed below the expected level for their age in the VP and VMI tests, respectively. Only 19.3% of participants in the current study portrayed below expected performance in the MC test. These percentages could be compared to findings of a similar study conducted on children of similar age. In agreement with our findings, 59% of Grade 1 learners in the North-West Province of South Africa performed below the expected level in the VP supplemental test of the VMI-4 (Coetzee & Du Plessis 2013). Coetzee and Du Plessis (2013) further reported that 23% of participants also portrayed poor VMI, while 18% had MC abilities below the expected level. With these results in mind, we emphasise the importance of high-quality perceptual motor stimulation during PE sessions, such as the *KaziKidz* toolkit. This is especially important at an early stage in young children's development, in order to minimise the possible negative impact that poor perceptual abilities can have on academic task execution later in the child's school career.

Conclusion

Physical education for 6-year-old children with intentional incorporation of perceptual motor skills significantly enhances their VMI and VP. Diamond (2015) asserted that:

> [*S*]tudies of the cognitive benefits of physical activity need to move beyond simple aerobic activities that require little thought (treadmill running, riding a stationary bicycle, or rapid walking) and resistance training. (p. 1)

In accordance with this statement, we conclude that PE should involve more than merely physical movement. It should be well thought through, age-appropriate, developmentally based, and curriculum-aligned in order to maximise children's learning potential.

Limitations and recommendations

The main limitation of this study was the COVID-19 pandemic. Due to the national COVID-19 lockdown regulations, slightly fewer intervention sessions were presented than planned and loss of participants during post-testing occurred due to the earlier closing of schools for school holiday.

It is recommended that when PE is presented to young children, it should include perceptual motor skills to enhance learners' VMI and VP, especially because these skills are required in the classroom setting for the achievement of academic success. In the South African context, where perceptual skill development is a focus area during the foundation phase, using the *KaziKidz* toolkit by teachers is recommended to assist them in presenting curriculum-aligned, and thus age and developmentally appropriate, PE sessions. Becoming familiar, the *KaziKidz* toolkit can also minimise challenges, such as limited content knowledge, experienced by PE teachers in South Africa. Future research recommendations include employing the *KaziKidz* toolkit as an intervention method by primary school teachers on larger sample sizes, in other provinces of South Africa, and on children of older ages.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

E.vdM. designed the study, assisted with data collection and interpretation and wrote the final draft of the article. C.B. and B.R. presented the PE intervention, collected the data obtained by the pre- and post-tests and assisted with the initial writing of the Methods and Results sections. All the authors approved the article for submission.

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Data availability

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials. Any additional information is available from the corresponding author, E.vdM. upon reasonable request.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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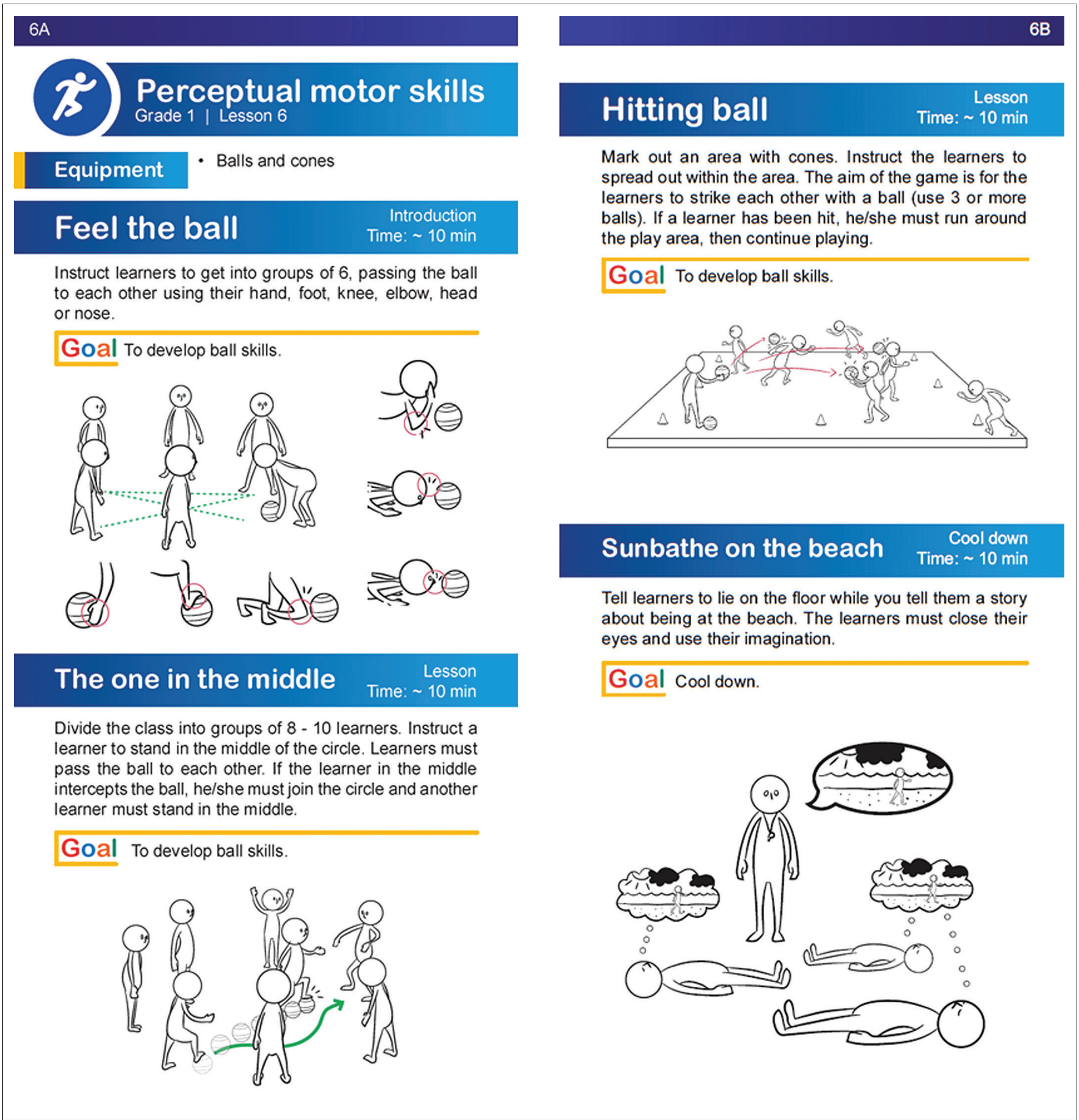
Appendix starts on the next page →

Appendix 1:



6A

Perceptual motor skills
Grade 1 | Lesson 6

Equipment
- Balls and cones

Feel the ball — Introduction, Time: ~ 10 min

Instruct learners to get into groups of 6, passing the ball to each other using their hand, foot, knee, elbow, head or nose.

Goal: To develop ball skills.

The one in the middle — Lesson, Time: ~ 10 min

Divide the class into groups of 8 - 10 learners. Instruct a learner to stand in the middle of the circle. Learners must pass the ball to each other. If the learner in the middle intercepts the ball, he/she must join the circle and another learner must stand in the middle.

Goal: To develop ball skills.

6B

Hitting ball — Lesson, Time: ~ 10 min

Mark out an area with cones. Instruct the learners to spread out within the area. The aim of the game is for the learners to strike each other with a ball (use 3 or more balls). If a learner has been hit, he/she must run around the play area, then continue playing.

Goal: To develop ball skills.

Sunbathe on the beach — Cool down, Time: ~ 10 min

Tell learners to lie on the floor while you tell them a story about being at the beach. The learners must close their eyes and use their imagination.

Goal: Cool down.

FIGURE 1-A1: Example Lesson.