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Sex differences in fundamental movement skills of a selected group of 6-year-old South African children

Anita E. Pienaar, Irma van Reenen and Angelique M. Weber

PhaSRec, Faculty of Health Science, North-West University, Potchefstroom Campus, Potchefstroom, South Africa

ABSTRACT

Background: Motor competence is emerging as an important marker of health, while adequate basic movement patterns, body control and body awareness are important building blocks of more specialized body movements and scholastic adjustment during early childhood. This study examined fundamental movement skill competency and explored sex differences in 6-year-old children. *Method:* A convenience sample ($N = 72$, 35 boys, 37 girls, 6.3 years) was assessed cross-sectionally, using both qualitative and quantitative methods of assessing locomotor (8), object control (4), stability (6), body awareness (3), and body coordination skills (3). *Results*: Descriptive statistics, frequency tables and independent *t*-testing ($p \leq .05$) indicated that overall body coordination and throwing skills showed poor mastery. Sex differences favouring girls were found in rope jumping, one-legged balancing, hopping and body awareness ($p < .05$) while boys showed superior kicking skills ($p = .04$). *Conclusion:* Opportunities should be provided to improve overall body coordination, body awareness, and stability skills in boys, and object control skills in girls with targeted support in certain skills.

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Fundamental movement skills; perceptual-motor skills; motor competence; 6-year-olds; sex

Introduction

The lasting benefits of motor competence is emerging as an important marker of health already in childhood (Cattuzzo et al., 2014; Lloyd, Saunders, Bremer, & Tremblay, 2014; Lubans, Morgan, Cliff, Barnette, & Okely, 2010). Evidence provided by Cattuzzo et al. (2014) indicates that the development of both motor competence- and health-related physical fitness may promote positive and sustainable trajectories of health and lead to health outcomes. The nature of early motor proficiency is often expressed as motor development or fundamental movement skills (FMS), although motor coordination, motor fitness (or often called skill-related physical fitness) and motor ability are also used to describe motor competence (Cattuzzo, et al., 2014; Ruiz et al., 2009). Stodden et al. (2008) defined important aspect of general motor competence as proficiency in fundamental movement skills including locomotor and object control skills. Stodden et al. (2008) developed a theoretical model emphasizing the role of developing motor competence on the development of health-related physical fitness, physical activity and obesity prevention throughout childhood. Vameghi, Shams, and Dehkordi (2013) report in this regard that children who do not receive optimal stimulation during childhood will be inclined to be less active in school as their motor skills are underdeveloped, thereby contributing to the inability to master movement skills during adulthood. Evidence also exists that precursors of cardiovascular disease have their origin in childhood and adolescence (McGill et al., 2000; Strong, Malcom, Newman, & Oalmann, 1992). Ruiz et al. (2009) report that people with a good level of motor-related fitness will be more likely to engage in

CONTACT Anita E. Pienaar anita.pienaar@nwu.ac.za

regular physical activity and, for this reason, may have enhanced health-related fitness which is traits and capacities that are associated with a healthier cardiovascular profile and a subsequent lower risk for the development of chronic disease and premature death. A healthier body composition during childhood and adolescence is also associated with lower risk of death in adulthood. Martinez-Tellez et al. (2015) report in this regard an association between motor fitness and total and central body fat in pre-school children. Lubans et al. (2010) furthermore report a consistent positive association between motor competence and cardiorespiratory fitness and an inverse association between motor competence and weight in a systematic review on the relationship of FMS with health-related variables which is also confirmed by Cattuzzo et al. (2014), who also report an association with musculoskeletal fitness across childhood and adolescence.

Besides the lasting health benefits, current benefits of proficient FMS are of particular importance for children, since these skills are also considered to be the building blocks of more advanced forms of movement (Goodway & Robinson, 2006; Vameghi et al., 2013). Stodden et al. (2008) report that FMS are important skills to master during the childhood years, as it will be used later in their lives for sport-specific application. Furthermore, FMS contribute to the general development and well-being of young children (Pienaar, 2009, 2014), which is a prerequisite for daily life skills (Stodden et al., 2008) and affecting children's physical, social and cognitive development (Livonen & Sääkslahti, 2014). Garcia, Garcia, Floyd, and Lawson (2002) describe early childhood as a unique period in a child's life, as this is the period during which physical, emotional and intellectual development primarily takes place, while it is also considered to be a key developmental period of FMS (Hardy, Reiten-Reynolds, Espinel, Zask, & Okely, 2012). Well-mastered FMS also result in improved scholastic adjustment and social behaviour (Bart, Hajami, & Bar-Haim, 2007; Pienaar, Twisk, & Barhorst, 2014).

FMS develop between the ages 4 and 6 years, where a 6-year-old child should already be proficient in most of the skills which is described as the mature or final phase of the development of these skills (Gallahue & Ozmun, 2006; Malina, 2004). Evidence is, however, emerging from the literature that motor competence, and motor and physical fitness are declining in children internationally (Du Toit, 2001; Foulkes et al., 2015; Pienaar & Kemp, 2014; Pienaar, Visagie, & Leonard, 2015; Tomkinson & Olds, 2007). The development of FMS is therefore considered essential in the promotion of an active lifestyle in childhood and adolescence.

FMS refer to basic movement patterns which are required during the execution of more specialized and complex movements (Gallahue & Ozmun, 2006). It is also defined as the degree of skilled performance in a wide range of motor tasks as well as the movement control and coordination underlying a motor outcome (D'Hondt et al., 2013). FMS comprise locomotive skills, stability skills and object control skills, while body awareness and spatial orientation form significant components of perceptual-motor development during the early stages of child development (Sherrill, 2004; Gallahue & Ozmun, 2006). The development of FMS is further subdivided into three stages of development, of which the initial phase describes the execution of these skills in a relatively crude and uncoordinated manner. Children are typically in this phase of development between the ages of 2 and 3 years. Children are usually in the second phase of development, known as the elementary phase between the ages of 4 and 5 years which characterizes a child showing improved coordination and rhythm, one who exerts greater control over movement during the execution of these skills, although the execution is not yet completely fluent (Gallahue & Ozmun, 2006). When a child can execute a fundamental movement skill in a well-coordinated, mechanically correct and fluent manner, the execution falls in the mature phase of development, which usually occurs between the ages of 6 and 7 years (Gallahue & Ozmun, 2006). In addition, the early childhood years are a developmental period, characterized by gross motor development which contributes to greater control over bodily movement. Overall body coordination refers to the ability to integrate different motor systems with various sensory aspects into a successful movement pattern (Gallahue & Ozmun, 2006). Rope jumping, caterpillar walk and jumping jacks are some of the most complex gross motor skills which require overall bodily coordination that a child of 6 years should be able to master (Charlop & Atwell, 1980). All these FMS can be assessed in a qualitative/process-orientated, and/or a quantitative or product-orientated manner (Payne & Isaacs, 2008), thus how the skill is performed or according to skill outcomes such as time or distance (Burton & Miller, 1998).

The developmental change in a child's motor skills is influenced by many factors, which are based on the interaction between the individual, the task constraints and the surrounding environment, for example, requirements of the movement task (e.g. the size of a ball), the biology of the child (e.g. sex and heredity) and the environment (e.g. outdoor play area, resources, educators' knowledge to improve skills or socio-economic background). These subsystems can individually and mutually either encourage or discourage skill acquisition (Newell, 1986). In this regard, literature reports sex differences in the execution of FMS; however, some controversy is also found in this regard. Research conducted on primary school children between the ages of 5 and 14 years in New South Wales as well as in America indicated that girls performed less well in object control skills, involving catching, kicking and throwing, in comparison to boys (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2010; Butterfield, Angel, & Mason, 2012). Researchers also report sex differences in pre-school children. Vameghi et al. (2013) established significant sex differences in the execution of locomotor and object control skills in 4- to 6-year-old Iranian children, where girls performed better in skipping and hopping and boys in jumping skills. Amongst 3- to 5-year-old Australian children, Livesey, Coleman, and Piek (2006) report sex differences favouring girls in fine movement skills and static balance, and boys in object control skills, while Foulkes et al. (2015) report better kicking and overhand throwing skills in boys aged 3–5 years in North-west England, while girls were more competent in run, hop and gallop. Sex differences in jumping jacks and object control skills are also reported by Vandaele, Cools, De Decker, and De Martelaer (2011) where 6-year-old girls performed better in jumping jacks and boys in object control skills. Girls also outperformed boys in body and spatial awareness tasks in a study by Boyer, Carlson, and Pasnak (2012). However, despite all of these research findings, few studies have been conducted in South Africa which analyse pre-school children of different sexes regarding their fundamental gross motor and perceptual-motor skills competence. Findings from research conducted in the Potchefstroom area of South Africa on 3- to 6-year-olds have indicated that 6-year-old boys performed better than girls in standing long jumping and throwing skills (Du Toit, 2001). In addition, Du Toit (2001) found that certain FMS, such as catching, was not developed to the corresponding age standards, especially among 6-year-olds. In their analysis of qualitative and quantitative execution of one-legged balance by 3- to 6-year-olds, Du Toit and Pienaar (2001) have also found that the level of qualitative and quantitative execution can differ in 3- to 6-year-olds, where a child's qualitative execution can be above average while the quantitative execution can be below average.

Although various researchers studied the FMS of pre-school children (Du Toit, 2001; Foulkes et al., 2015; Goodway & Robinson, 2006; Livesey et al., 2006; Vameghi et al., 2013; Vandaele et al., 2011), few of these studies focused primarily on the FMS of a 6-year-old age group and more specifically on sex differences. This is considered a critical developmental period during the pre-school years because proper fundamental- and perceptual-motor skills give rise to better scholastic adjustment and social behaviour (Bart et al., 2007) in addition to the health benefits of adequate motor competence at 6 years of age as reported by Lloyd et al. (2014). In South Africa, 6-year-old children are in the grade R or reception year which is a very important preparation period for formal schooling during the following year. Pienaar et al. (2014) report a significant association between motor proficiency and basic literacy in maths, reading and writing in grade 1 in South African children. Furthermore, high percentage of grade 1 children also showing below-average motor proficiency was reported by Pienaar and Kemp (2014), while relationships between motor proficiency and body composition are also confirmed in older South African children (Kemp & Pienaar, 2013; Truter, Pienaar, & du Toit, 2012). Most other studies done on the pre-school time period focused primarily on health-related or neuro-motor fitness (Cattuzzo et al., 2014; Ortega et al., 2015) or on identifying and assessing movement problems (Vandaele et al., 2011; Venter, Pienaar, & Coetzee, 2015). The only study done in South Africa that reported on the FMS of pre-school children (Du Toit, 2001) was published more than 10 years ago, which poses the question of whether the results can still be deemed relevant, consequently identifying a gap in existing knowledge about the FMS competence of 6-year-olds boys and girls in South Africa. South Africa is also considered a low- to middle-income country with high socio-economic inequalities in a diverse population, where nutritional deficits, poor physical activity and rapid urbanization can affect the development of pre-school children and contribute to health disparities later in their lives (Pienaar, 2009). These factors might pose challenges to their fundamental movement skills development that is different to the evidence that might exist in other countries. It is also noted by researchers that at early ages, 1-year difference in age implies marked changes in fitness and development and hence assessment during the pre-school period is also recommended in 1-year age groups, for example, 5- or 6-year-olds (Ortega et al., 2015). Consequently, it was found necessary to determine the qualitative and quantitative FMS competence of 6-year-old children and specifically the influence of sex on FMS development at 6 years of age of South African children. Considering the above, we expect that sex differences will occur especially in the qualitative and quantitative execution of FMS where 6-year-old boys will generally be more proficient in object control skills and girls in locomotor and balancing skills.

Method of research

Participants

This study forms part of a project which received ethical clearance from the North-West University (NWU-00040-13-A1) with the title 'The status of FMS and motor difficulties in 3- to 6-year-old children and the effect of a tailor-made intervention on identified problem areas' which is a 2-year project. As part of the first year of the study, a convenience sampling method was used to collect data of 3- to 6-year-old children ($N = 389$) in different pre-schools in the Potchefstroom and Vaalharts areas, which represent children from low- to middle-income families as well as children growing up in rural and urban areas. This study only focused on the 6-year-old children in the project; therefore, only children who were already 6 years old on the day of testing were used which included 72 children (37 girls – 24 black, 13 white – and 35 boys – 18 black, 17 white). The only exclusion criterion that was applied was when a child had any physical restrains or disabilities that could have constrained him or her in performing the assessments. Only two of the recruited 6-year-old children in the different participating schools were absent on the day of testing. The mean age of the group was 6 years and 3 months with a sex distribution of 48.61% boys and 51.38% girls. From the Potchefstroom area, 44 participants (23 boys, 21 girls) – 23 boys (17 white, 6 black) and 21 girls (13 white, 7 black, 1 coloured) – and from the Vaalharts area a total of 28 participants who were all black children (12 boys and 16 girls) participated. According to the headmasters of the different schools, the socio-economic class, based on income levels of the parents, ranged mostly between low- to middle-income families.

Measurements

The FMS performance of each participant was assessed with the predetermined protocol of the Kinderkinetics screening assessment for 3- to 6-year-old children (Pienaar, 2014). This protocol is designed to assess both the process or qualitative aspects of FMS which provides the option to rate the performance of FMS qualitatively on the basis of developmental sequences aspects, and the product or outcome of FMS competence. The assessment includes a comprehensive list of 23 items that are divided into five main components with specific quantitative criteria for each of the age groups (see Table 3 for the criteria for 6-year-olds) while body composition (body mass and stature) is also assessed with a standard procedure (Stewart, Marfell-Jones, Olds, & de Ridder, 2011) as a sixth component in the protocol. The five main FMS components that are assessed include locomotor skills (eight items), object manipulation (three items), balancing (six items), overall body coordination skills (three items) and body awareness and spatial orientation as perceptual-motor skills (three items). The locomotor skills that are assessed include running over a distance of 12 m, four sideways glides to the left and right sides of the body, four consecutive skipping jumps, jumping 10 times forward with both legs simultaneously, 10 one-legged hops with the left and right foot separately, and performing a standing long jump over a distance of 100 cm. Balancing skills include standing on the right and left foot separately, with eyes open for 10–14 sec, and standing on right and left foot separately, with eyes closed for 2–6 sec. Dynamic balance items include walking forward and backward on a 20-cm high balance beam of 1.5 m. Object control skills in the protocol include overhand throwing of a tennis ball over a distance of 7.5 m, catching a 25 cm ball four times from a distance of 2 m, and kicking a stationary ball of 25 cm three times. Overall body coordination skills that are assessed include the execution of ten star jumps consecutively, two repetitions of the caterpillar walk demonstrated to the participant with a hand-hand, foot-foot rhythm (Charlop & Atwell, 1980), and performing five rope jumps consecutively with two feet simultaneously, using a rope of different lengths based on the child's height (Pienaar, 2014). Perceptual-motor abilities that are assessed include naming 17 body parts correctly that are pointed out by the tester on the participant's body and imitating eight hand signals (Sherrill, 2004) that are showed in a specific order to the participant by the tester. Lastly, three repetitions were performed of moving the right finger with the arm stretched from the front of the body at shoulder height to touch the tip of the nose, as demonstrated by the tester standing in front of the participant. All three tests assess body awareness and spatial orientation abilities (Cheatum & Hammond, 2000; Sherrill, 2004).

The qualitative assessment criteria that assess the process or quality of execution is based on a 3-point scale that categorized the participants performance of each skill into a specific stage or sub-stage of development as described by Gallahue and Ozmun (2006) ranging from 1 to 3 (1 initial stage, 1.5 initial elementary stage, 2 elementary stage, 2.5 elementary mature stage and 3 mature stage). The criteria for each FMS are developed from the literature (Charlop & Atwell, 1980; Gallahue & Ozmun, 2006; Payne & Isaacs, 2008) that describes the main characteristics of execution in these different stages.

The screening instrument has good construct and content validity as it is already in use for more than 15 years by Kinderkineticists in practice to assess the FMS of children and to design developmentally appropriate perceptual-motor development programmes accordingly for different aged pre-school children. Taking into account the challenging nature of assessing pre-school children, we in general found moderate test–retest reliability for the different FMS in the screening protocol, based on the results obtained from 60 children with the strongest reliability found for the process-orientated or qualitative assessments (>.75) and body composition measurements (>.98). In this regard, caution is reported by researchers (Malina, 2010; Molenaar et al., 2010; Ortega et al., 2015) regarding the challenges to reliably measure children as young as 3 years.

Criterion-related validity, measured against golden standard tests such as the Test of Gross Motor Development and the Movement Assessment Battery of Children produced moderate validity (0.5–0.7) for most of the variables (Pienaar, 2014). As the contexts of the different tests are not identical to our protocol, we consider these values as satisfactorily. Other studies (Ortega et al., 2015) also indicated acceptable reliability for the different versions of the one-leg stance and standing long jump in pre-school children and the testing of balance is also recommended by Ortega et al. (2015) at this period of life.

Research procedure

All the 6-year-old children ($N = 72$) in the project that included 385 3- to 6-year-old participants (89 = 3-year-olds, 113 = 4-year-olds, 111 = 5-year-olds) were evaluated for the specific purposes of this study. Separate papers are also in preparation for the other age groups, because of the comprehensive nature of the assessments and different criteria that have to be met at different ages for specific FMS. The research literature on pre-school-aged children also recommends that children in these age groups should be studied by 1-year age increments because of large improvements that are seen in their development in short periods of times (Ortega et al., 2015). Participants (all children in the schools in the age groups 3–6 years) were invited to participate in the study after ethical approval was obtained from the North-West University (NWU-00040-13-A1) and the headmasters gave permission for their schools to take part in the study. Only children who obtained written consent from their parents or a legal guardian and who gave verbal assent were assessed on the day of testing. The assessments took place during school hours. The researchers are all senior researchers and well-trained postgraduate students in Human Movement Science specializing in the field of Kinderkinetics. All underwent thorough theoretical training in the protocol and a practical examination of the test beforehand to rule out any uncertainties before the testing took place. Each child was also assessed by two testers independently to improve the accuracy of the assessments. Pre-planning sessions were also done to determine the order of execution of the various test items in the form of a circuit on the day of testing.

Statistical procedure

Descriptive statistics were used to analyse means (*M*), standard deviations (SD), frequencies and percentages using STATISTICA for windows (Statsoft, 2013). Independent *t*-testing was used to analyse sex differences. Statistical significance was set at a p value of ≤ 0.05, the practical significance was used to practical effect of differences, based on effect size cut-off points set by Cohen (1988) (small: 0.2, medium: 0.5 and large: 0.8).

Results

Table 1 provides detailed descriptive percentages of the qualitative mastery of the group ($N = 72$) in each sub-component of the pre-school screening assessment. This table displays the number and percentages of participants who were categorized in each of the different stages of mastery of the different FMS ranging from 1, 1.5, 2, 2.5 or 3, where 1 indicates mastery in the initial stage and 3, full mastery. The descriptive mastery categories of the test items that showed significant sex differences are also included in the table for boys and girls separately. Table 2 presents the summarized percentages for the group and each sex separately for each of the five main FMS components. This summary in Table 2 only displays the proportion (percentages) of children who were classified in the mature phase, as this study is primarily focused on the percentage of children who are in the mature phase of development of FMS and for each test item. Table 3 presents the quantitative characteristics of the group and significant sex differences. The criteria that the participants had to adhere to are also presented in this table.

Eight locomotor skills were assessed and mastery in these skills ranged between 71% for skipping and 96% for running in the group (Table 1). Mastery of locomotor skills was the highest of all five main FMS components that were assessed where a high percentage of the group was in the mature phase according to a summarized percentage for the eight locomotor skills (84.3%, Table 2). Only 71% of the group showed mastery in the mature phase of skipping which was the most difficult locomotor skill to master. A slight difference of only 1.6% was found between the sexes in mature mastery of locomotor skills where 82.5% of boys showed mature mastery, compared to 84.6% of the girls. The highest differences in the percentages of boys and girls who showed mastery were found in skipping (Table 2).

Balancing skills were less well mastered qualitatively as locomotor skills as only 74% of the group was categorized in the mature stage with a difference of 12% in the percentage mastery of boys and girls (Table 2). Girls also showed higher mean percentages mastery in all six balancing items. Up to 17% of the group displayed mastery of balancing skills that was still in the elementary stage of development (Table 1). Static balance as assessed by one-legged standing with eyes open and walking forward on a beam showed the highest percentage participants reflecting characteristics of the mature stage of development. Standing on one leg with eyes closed was the most difficult task of

Table 1. Qualitative mastery of the fundamental movement skills and significant sex differences ($N = 72$).

			Stage of mastery										
			Initial (1)		Initial elementary (1.5)		Elementary (2)		Elementary mature (2.5)		Mature (3)		Sex diff.
	Mean	SD	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*p*
Locomotor skills													
Running	2.99	0.06	0	0.00	1	1.39	1	1.39	1	1.39	69	95.83	
Two-legged jumping	2.89	0.38	0	0.00	1	1.39	6	8.33	1	1.39	64	88.88	
Hopping one-leg(left)	2.88	0.40	3	4.17	1	1.39	8	11.11	0	0.00	60	83.33	
Hopping one-leg (right)	2.87	0.38	1	1.39	2	2.78	9	12.5	0	0.00	60	83.33	
Gliding to the left	2.99	0.98	3	4.17	0	0.00	9	12.50	1	1.39	59	81.94	
Gliding to the right	2.86	0.39	2	2.78	0	0.00	9	12.50	1	1.39	60	83.33	
Standing long jump	2.81	0.53	2	2.78	0	0.00	10	13.89	1	1.39	59	81.94	
Skipping	2.72	0.57	6	8.33	1	1.39	7	9.72	7	9.72	51	70.83	
Balance													
One-leg standing (left) eyes open	2.88	0.38	2	2.78	3	4.17	5	6.94	1	1.39	61	84.72	.02*
Boys	2.67	0.62	2	5.71	2	5.71	4	11.42	1	2.85	26	74.28	
Girls	2.93	0.29	0	0.00	1	2.70	1	2.70	0	0.00	35	94.59	
One-leg standing (left) eyes closed	2.51	0.73	12	16.67	1	1.39	13	18.06	1	1.39	45	62.50	
One-leg standing (right) eyes open	2.83	0.42	3	4.17	1	1.39	10	13.89	2	2.78	56	77.77	
One-leg standing (right) eyes closed	2.54	0.70	11	15.23	1	1.39	12	16.67	3	4.17	45	62.50	
Walking forward on a 20 cm beam	2.84	0.40	2	2.28	0	0.00	4	5.56	3	4.17	62	86.11	
Walking backward on a 20 cm beam	2.73	0.53	6	8.33	0	0.00	10	13.89	5	6.94	50	69.44	
Object control													
Catching a ball	2.82	0.45	3	4.17	0	0.00	5	6.94	4	5.55	60	83.33	
Kicking a stationary ball	2.86	0.36	0	0.00	1	1.39	11	15.23	3	4.17	57	79.16	.04*
Boys	2.90	0.29	0	0.00	0	0.00	3	8.57	1	2.85	31	88.57	
Girls	2.72	0.46	0	0.00	1	2.70	8	21.62	2	5.40	26	70.27	
Throwing an overhand ball	2.30	0.78	14	19.44	1	1.39	21	29.17	1	1.39	35	48.61	
Body awareness													
Identifying body parts	2.67	0.57	4	5.56	0	0.00	18	25.00	0	0.00	50	69.44	
Copying of hand signs	2.86	0.39	1	1.39	0	0.00	8	11.11	3	4.17	60	83.33	.04*
Boys	2.77	0.24	1	2.85	0.	0.00	6	17.14	2	5.71	25	71.43	
Girls	2.93	0.53	0	0.00	0	.00	2	5.40	1	2.70	34	91.89	
Finger to nose	2.90	0.40	2	2.78	0	0.00	3	4.17	2	2.78	65	90.28	
Overall coordination													
Jumping jacks	2.50	0.72	9	12.50	1	1.39	17	23.61	3	4.17	42	58.33	
Caterpillar walk	2.30	0.79	12	16.67	3	4.17	19	26.39	4	5.56	34	47.22	
Rope skipping	1.82	2.42	33	45.83	0	0.00	16	22.22	0	0.00	17	23.61	<.01*
Boys	1.51	0.72	20	57.14	0	0.00	9	25.71	0	0.00	4	11.43	
Girls	2.0	1.51	13	35.13	0	0.00	7	18.91	0	0.00	13	35.14	

*$p < .05$.

Table 2. Percentage mastery of the main FMS components in the mature phase in the group and by sex.

Main FMS components	Mature phase group (%)	Boys (%)	Girls (%)	% difference between sexes
Locomotor skills (8)	84.3	82.85	84.45	1.60
Running		97.14	94.59	
Two-leg jumping		91.43	86.48	
Hopping right leg		82.85	83.78	
Hopping left leg		80.0	86.48	
Gliding left		77.14	86.48	
Gliding right		85.71	81.08	
Standing long jump		85.71	78.37	
Skipping		62.85	78.37	
Balancing skills (6)	73.84	67.61	79.62	12.11
One leg open eyes left		74.28	94.59	
One leg closed eyes left		54.28	70.27	
One leg open eyes right		71.42	83.78	
One leg closed eyes right		57.14	67.56	
Walking forward 20 cm beam		82.85	89.18	
Walking backward 20 cm beam		65.71	72.97	
Object manipulation (3)	70.36	75.23	65.76	9.5
Catching		85.71	81.08	
Kicking		88.57	70.27	
Throwing		51.42	45.94	
Overall body coordination (3)	43.05	36.15	49.54	13.3
Jumping Jacks		51.42	64.86	
Caterpillar walk		45.71	48.64	
Rope jumping		11.42	35.13	
Body awareness (3)	80.93	77.14	84.68	8.5
Identifying body parts		65.71	72.97	
Copying hand signs		74.29	91.90	
Finger to nose		91.42	89.18	

the balancing items to master, where only 65% of the group was in the mature stage. One significant sex difference was found in balancing skills, where a much higher percentage of girls (94.6%) displayed the qualitative criteria of the one-leg standing with eyes open which categorized them in the mature phase compared to boys (74.3%). No significant quantitative differences were found in balancing skills of boys and girls.

Mature mastery of object control skills was found in 70.4% of the group with a 9.5% difference in the percentage of mature mastery of boys and girls where boys showed the highest percentage of mastery and also in all three object control skills. Throwing a ball overhand was the most difficult object control skill to master compared to kicking and catching, as only 48.6% of the group showed full mastery of this skill with a high percentage (29.0%) of group still in the elementary stage of development. Catching a ball showed the highest percentage of mastery (83%) of object control skills. Kicking a stationary ball produced significant sex differences favouring boys ($p < .05$), where 88.6% of the boys compared to 70% of the girls showed mature mastery characteristics of this skill (Table 1). No significant quantitative differences were found in object control skills of boys and girls.

Overall body coordination skills were the most difficult main FMS to master in this 6-year-old group, where only 43.1% of them were already in the mature stage of development (Table 2). A difference of 13.3% were found in the number of boys (36.2%) and girls (49.5%) who were classified in the mature phase with girls showing superior qualitative and quantitative mastery of rope jumping which also showed practical significance ($p < .01$, $d = 0.7$, Tables 1 and 3). Only 11.4% of the boys were competent in rope jumping compared to 35% of girls. Walking like a caterpillar (47.2%) and rope jumping (23.61%) were also the skills that showed the poorest mastery of all the FMS skills that were assessed. These results indicate that these skills are mainly mastered up to the elementary level in the group.

No sex differences were found in the qualitative mastery of the three body awareness skills, although Table 2 indicates an 8.5% difference between the sexes showing mature mastery with girls displaying a higher summarized mastery percentage (84.7% vs. 76.2%, Table 2) and also superior

Table 3. Sex differences in the quantitative mastery of FMS criteria.

		Quantitative						
Activity	Criteria	Group $M \pm SD$	Girls $M \pm SD$	Boys $M \pm SD$	t	df	p	d
Locomotor skills								
Running+	12 m						–	
Two-legged jumping	10 jumps	10.14 (0.75)	10.0 (0.00)	10.28 (1.07)		58	–	
Hopping on one-leg (left)	10 jumps	9.75 (1.72)	10.13 (0.82)	9.34 (2.26)	1.03	58	.04*	.5**
Hopping on one-leg (right)	10 jumps	10.03 (1.83)	10.41 (1.82)	9.63 (1.78)	1.03	58	.31	
Gliding to the left+	4 glides	4.18 (1.18)	4.00 (0.00)	4.37 (1.68)	–	58	–	
Gliding to the right+	4 glides	4.18 (1.18)	3.97 (0.16)	4.40 (1.67)	–	58	–	
Standing long jump	100 cm	96.49 (24.14)	95.41 (23.94)	97.63 (24.65)	−1.07	58	.07	
Skipping	4 skips	4.11 (1.35)	4.05 (1.20)	4.17 (1.50)	−0.69	58	.70	
Balance								
Standing on one leg (left) with eyes open	10–15 sec	15.41 (10.95)	16.19 (11.60)	14.57 (10.33)	0.48	58	.53	
Standing on one leg (left) with eyes closed	2–6 sec	5.07 (4.66)	4.74 (4.22)	5.42 (5.13)	−1.11	58	.17	
Standing on one leg (right) with eyes open	10–15 sec	14.97 (3.00)	14.58 (8.02)	15.39 (9.69)	−0.54	58	.70	
Standing on one leg (right) with eyes closed	2–6 sec	4.39 (1.00)	4.99 (4.08)	3.74 (2.29)	0.97	58	.12	
Walking forward on a 20 cm beam+	1.5 m	1.50 (0.00)	1.50 (0.00)	1.50 (0.00)	–	58	–	
Walking backward on a 20 cm beam+	1.5 m	1.50 (0.00)	1.50 (0.00)	1.50 (0.00)	–	58	–	
Object control								
Catching a ball	4 catches	3.99 (3.00)	0.00 (0.16)	4.00 (0.00)	−0.97	58	.33	
Kicking a stationary ball+	3 kicks	3.00 (3.00)	0.29 (0.00)	3.00 (0.00)	−1.03	58	–	
Throwing an overhand ball	3 throws	10.39 (0.55)	7.42 (0.48)	7.58 (0.77)	0.97	58	.23	
Body awareness								
Identifying body parts	17 body parts	15.21 (9.00)	15.89 (1.31)	14.49 (2.17)	3.15	58	.00*	.6**
Copying of hand signs	8 signs	7.64 (3.00)	7.86 (0.54)	7.4 (1.26)	1.52	58	.04*	.4*
Finger to nose	3 times	3.10 (1.00)	3.00 (0.47)	3.2 (1.18)	−0.97	58	.59	
Overall coordination								
Jumping jacks	10 jumps	8.88 (0.00)	9.13 (2.90)	8.60 (3.24)	0.02	58	.46	
Caterpillar walk	2 times	1.96 (0.00)	1.92 (1.38)	2.0 (1.19)	−0.18	58	.79	
Rope skipping	5 times	3.41 (0.00)	4.50 (2.64)	2.57 (1.88)	2.88	44	.01*	.7**

Note: +, No variation was found in the outcome of the skill between the sexes.
df = degrees of freedom, $d > .3$ small*, .5 medium**, .8 large**.

performance in two of the three skills. Two statistical and practical significant quantitative sex differences were found in body awareness skills, namely in the number of correctly copied hand signs and the number of correctly named body parts, where girls showed superior performance in both these skills ($p < .05$, $d = 0.4$, 0.6). The quality of copying of hand signs was also superior in girls ($p = .04$, Table 1).

Discussion

The aim of this study was to examine FMS competence of 6-year-old children, and specific sex differences in FMS competence at this age. Various FMS were assessed across five main components and the performance was compared to studies worldwide to determine how South African children compare to them.

Generally, we found FMS competence in the five main components that ranged from adequately to well mastered (84%) to poorly mastered (46.1%), depending on the nature of the FMS skills which generally agrees with other literature findings (Barnett et al., 2010; Butterfield et al., 2012; Foulkes et al., 2015; Gallahue & Ozmun, 2006; Malina, 2004; Vandaele et al., 2011). Locomotor skills showed improved mastery over object control skills which is also consistent with other studies (Foulkes et al., 2015; Lubans et al., 2010) while competence in overall body coordination skills was the lowest and is also considered to be poor. Few sex differences were found in the group and girls were in general the sex that showed improved competence over boys except in kicking skills. These differences favouring girls were, however, in agreement with the nature of FMS skills that are also reported by other studies to be better in girls (Foulkes et al., 2015; Spessato, Gabbard, Valantini, & Rudisill, 2012). Of the eight sex differences that were found across the five main components, four indicate differences in the quality of FMS competence, namely in one-leg standing (locomotor), kicking (object control), rope jumping (body coordination) and copying of hand signs (body awareness). These differences that were also of practical significance agree with other literature findings where boys were only superior to girls in kicking skills as reported in a review paper by Lubans et al. (2010). On a quantitative level, girls also showed superior competence in the number of one-legged hops, identified body parts and copied hand signs and the number of rope jumps that they could perform. Literature generally indicates improved object control skills in boys, while controversy still exists regarding the influence of sex on locomotor skills (Lubans et al., 2010). Few studies report on overall body coordination and body awareness differences, but girls are generally indicated to be more proficient in these skills at a young age (Boyer et al., 2012; Vandaele et al., 2011).

Seven of the eight locomotor skills that were assessed were well mastered except for skipping (71%). Balancing skills that are performed with the eyes open showed higher mastery than balancing skills where vision could not be used (standing with eyes closed and walking backwards). Although body awareness skills showed adequate mastery in the group, this mastery percentage was most probably influenced by improved body awareness among girls as boys experienced significantly more difficulty than girls with the naming of body parts and the copying of hand signs which is both considered to be indicators of body awareness (Cheatum & Hammand, 2000).

Mastery of object control skills ranged between good (catching and kicking) and poor especially in the throwing skill (48.6%) which is in line with other studies reporting the greater complexity of learning object control skills, which require more sophisticated visual-motor requirements, as well as enhanced coordination and stability of the limb and trunk (Hardy, King, Farrell, Macniven, & Howlett, 2010). FMS that requires complex body coordination were the poorly mastered of all the FMS, especially rope jumping. These skills require even more coordination of different body subsystems; therefore, this result is not surprising.

The mastery of different FMS across the main components at the age of 6 years was generally in line with literature findings that describe the complexity and hence the difficulty in mastering of different FMS skills (Hardy, et al., 2010; Malina, 2004). Skipping is reported as a difficult locomotor skill to fully master by the age of 6 years (Malina, 2004) which agrees with the competence of 71% who were found in our study for this skill. According to Malina (2004), only 60% of girls and boys are able to reach stage 3 of five stages of skipping development by 70 and 78 months (5.8 and 6.5 years), respectively. Girls also performed hopping on one leg qualitatively (also referred to as hopping in the literature) significantly better than boys which is also in agreement with findings reported by Malina (2004) namely that girls attain each stage of hopping development earlier than boys. Vameghi et al. (2013) and Hardy et al. (2010) also confirmed better competence in hopping skills among pre-school girls. However, Lubans et al. (2010) still report controversy in the literature regarding sex differences in locomotor skills.

Object control skills especially overhand throwing are described by researchers as complex object control skills to master (Booth et al., 2006; Butterfield et al., 2012; Malina, 2004; Pienaar et al., 2015) which is also substantiated by our findings of low mastery (48.6%). Overhand throwing requires coordinative skills involving the upper and lower body and bilaterally, especially shoulder and hip rotation which are still challenging to master at the age of 6 years (Pienaar et al., 2015). Throwing skills did not differ between the sexes which is different compared to other studies reporting on 6-year-olds (Du Toit, 2001; Vandaele et al., 2011), and 3- to 5-year-olds (Foulkes et al., 2015; Livesey et al., 2006) and older children (Barnett et al., 2010; Butterfield, et al., 2012; Pienaar et al., 2015). It might happen that differences between the sexes only emerge at an older age as a widening in the distance that boys and girls can throw a ball is reported at later ages as well as improved shoulder and hip rotation during the throwing action (Barnett et al., 2010; Pienaar et al., 2015). The quality of kicking skills competence was significantly higher in boys compared to girls in our study which is also substantiated by other studies on 6-year-old and younger children (Foulkes et al., 2015; Vandaele et al., 2011). A literature review by Lubans et al. (2010) reports a general higher competence in object control skills among boys compared to girls. Although our study only confirmed sex differences in the quality of kicking competence of boys, a trend of higher mean scores was observed in our findings of all three object control skills favouring boys.

Mastery of balancing skills was poorer in standing on one leg with eyes closed and walking backwards than in standing on one leg with open eyes and walking forward on a balance beam. Similarly, backward balance was also most difficult to master in Flemish 6-year-olds (Vandaele et al., 2011) compared to walking forward and balancing on one leg. The researchers report that the transition towards adult-like balance responses is not yet fully complete by the age six for all sensory conditions where the majority of 6 year-old children still rely on visual perception than on proprioceptive skills, which can be provided as a possible reason for the difficulties that are experienced in performing these skills. Girls showed superior performance to boys in the one-leg standing on the left leg. Livesey et al. (2006) also report sex differences amongst 3- to 5-year-old Australian children, where girls performed better in static balance skills. The significantly better quality of one-leg hopping which was found in the girls on the left leg might have a relationship with their improved standing on this leg as balancing on one leg is a precursor of one-leg hopping.

Overall body coordination showed the poorest full mastery of all the FMS in our study (23.6–58.3%), which is also consistent with other researchers who also report poor mastery of these skills at this level, indicating that skills of this nature still pose a challenge to 6-year-olds (Charlop & Atwell, 1980; Livesey et al., 2006; Spessato et al., 2012; Vandaele et al., 2011). Rope jumping showed mature mastery in only 23.6% of the group with significant qualitative and quantitative differences favouring girls which is consistent with other literature findings (Micallef, Calleja, & Decelis, 2010). As girls in our study could perform hopping on one leg significantly better than boys, and also showed superior body awareness over boys which is both required in rope skipping, it could have contributed to these sex differences, although play preferences might also have played a role as rope jumping is a favourite pastime activity among girls (Ha, Wong, Chan, & Fishburne, 2006). Rope skipping is also a good example of a skill where the process or how the skill is performed influences the outcome, for example, the number of jumps that can be performed consecutively. Children who struggle to hold the rope correctly or to swing it appropriately, especially the backswing part of the swing, compensate with their bodies by moving the upper body and especially the head forward and out of alignment with the rest of the body which influences their body control and timing with the forward swing of the rope and the child ends up jumping too early or too late over the rope or they compensate by reverting to one-legged walking or jumping over the rope. The result is poor rhythm and timing with the rope and the child consequently battles to perform more than one jump consecutively over the rope with both legs. Evidence is also found in the literature, supporting the view that it is easier to conceptualize the dimensions of your own body than the dimensions of an external object (Crescentini, Fabbro, & Urgesi, 2014); therefore, it is not strange that 6-year-old children still find it difficult to coordinate their body with external stimuli, like swinging a rope, as these children are still in a developing phase, where this kind of coordination skills is still difficult to master. Vandaele et al. (2011) also report poor mastery of tasks such as jumping jacks and indicate that these tasks require body tension and coordinative skills that are still a challenge at this age. Poor mastery of these skills can thus be ascribed to developmental lags at the age of six and development that still has to take place at this age.

The body awareness of girls was generally superior to boys as two of the three items showed significant sex differences. A significant quantitative difference was found between boys and girls in their body awareness, where girls were able to identify more body parts than boys. This result confirms the findings by Boyer et al. (2012) who reported that girls outperformed boys in body and spatial awareness tasks which are usually associated with each other (Fregonesi et al., 2014).

Copying of hand signs also showed a significant quantitative sex differences, where more girls were in the mature phase than boys. Fregonesi et al. (2014) describe copying of hand signs as a sub-component of body awareness which is associated with spatial awareness.

Limitations

The small sample based on a convenience sample is a limitation of the study that is acknowledged and which should be kept in mind in the generalization of the results. Further investigation on bigger and random groups of 6-year-old children is thus recommended because of this limitation to further substantiate the findings.

Conclusion

It is concluded that full mastery of specific FMS especially those that are considered to be complex FMS was still not achieved by a high percentage of this group of South African 6-year-old children with specific sex differences across different FMS. Although our results could not be compared directly to other studies, mainly because of methodological differences, our findings generally agree with most studies worldwide. As researchers emphasize that improved motor competency represents increased functional capacity that may promote positive lifespan trajectories of functional capability which may contribute to long-term health outcomes (Cattuzzo et al., 2014; Faigenbaum et al., 2011), capability in FMS should be promoted in children to allow them to pursue many different types of physical activities that are health enhancing and developmentally appropriate. Teachers or motor developmentalists can use the findings to develop targeted interventions to improve developmental lags in this age group which is a key developmental stage for the acquisition and development of FMS. The potential effects of sex differences as indicated in our findings are also worth to be investigated further by researchers especially with regard to future health implications. It is also the opinion of the researchers that a more thorough knowledge of the child's development of different spatial transformation systems may also help scholars and educators to promote effective spatial and body awareness required for optimal learning in school. Further research in this area as well as regarding overall body coordination skills of 6-year-old children is thus recommended as very little knowledge is also available regarding these skills and abilities of pre-school children.

Taking into consideration the limitations of this study, the findings of our study not only add to the findings of other researchers that studied FMS competence and sex-related FMS differences among pre-school children, but also add new knowledge regarding the qualitative and quantitative FMS competence of specifically 6-year-old children in a wide range of FMS. To our knowledge, very few studies on FMS competence studied both the product and process of FMS performance specifically in 6-year-olds which adds further value to our study as it provide advantages of the use of both assessment methods in the understanding of FMS competence. Our findings also make a contribution to existing knowledge regarding skills that provide knowledge regarding body coordination and especially body awareness skills of which very little is known or reported on. The results of this study also shed light on possible differences and subsequently developmental lags in the qualitative and quantitative fundamental skills development of boys and girls, and consequently allow for the development of guidelines for appropriate FMS development at 6 years of age which can be used to effectively assess and develop 6-year-olds, based on relevant norms.

Proficiency in a range of FMS provides the foundation for an active lifestyle; therefore, we also support the view from other researchers in this field that from a health surveillance systems point of view, the inclusion of motor competence and neuro-motor fitness assessments is recommended from an early age and that pre-schools may be ideal settings for monitoring these health markers. Knowledge of shortcomings in the developmental repertoire of FMS obtained by developmentally appropriate assessments can contribute to timeously but also targeted intervention should it be found necessary to put a child on a healthier trajectory early in his life.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Prof. Anita E. Pienaar is a professor within the School of Biokinetics, Sport en Recreation, and programme leader within the Kinderkinetics programme in this School at the North-West University (NWU), Potchefstroom Campus. She obtained her PhD degree in 1994 at the former PU vir CHO. Her training responsibilities at the NWU include modules on undergraduate and postgraduate levels, as well as guidance to several masters and doctoral students in the field of Kinderkinetics and Sport Science. She plays a leading role in several research projects with regard to the growth, perceptual-motor and physical development of children and the influence of different factors within the context of the South African population on children's school- and sport performance, as well as the improvement thereof. She was bestowed an honorary award in 2012 by the South African Academy for Science and Art for her contribution to the expansion of subject-specific knowledge in this field.

Irma van Reenen obtained her B.Sc. MBW & Physiology degree in 2013 at the North-West University (NWU) and specialized in Kinderkinetics in the following Honours year. She is a full-time Kinderkineticist practising in Potchefstroom at different settings and is currently enrolled for a part time M.Sc. thesis.

Angelique Weber obtained her BA MBW & Psychology degree in 2013 at the North-West University (NWU) and specialized in Kinderkinetics in the following Honours year. She is now a full-time Kinderkineticist practising in a private practice in Carletonville.

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