Thirteen-Year Trends in Child and Adolescent Fundamental Movement Skills: 1997–2010

LOUISE L. HARDY[1], LISA BARNETT[2], PAOLA ESPINEL[1], and ANTHONY D. OKELY[3]

[1]*Physical Activity Nutrition Obesity Research Group, School of Public Health, University of Sydney, Sydney, NSW, AUSTRALIA;* [2]*Faculty of Health, School of Health and Social Development, Deakin University, Melbourne, AUSTRALIA; and* [3]*Interdisciplinary Educational Research Institute and Faculty of Education, University of Wollongong, Wollongong, NSW, AUSTRALIA*

ABSTRACT

HARDY, L. L., L. BARNETT, P. ESPINEL, and A. D. OKELY. Thirteen-Year Trends in Child and Adolescent Fundamental Movement Skills: 1997–2010. *Med. Sci. Sports Exerc.*, Vol. 45, No. 10, pp. 1965–1970, 2013. **Purpose**: The objective of this study is to describe 13-yr trends in children's fundamental movement skill (FMS) competency. **Methods**: Secondary analysis of representative, cross-sectional, Australian school-based surveys was conducted in 1997, 2004, and 2010 (n = 13,752 children age 9–15 yr). Five FMS (sprint run, vertical jump, catch, kick, and overarm throw) were assessed using process-oriented criteria at each survey and children's skills classified as competent or not competent. Covariates included sex, age, cardiorespiratory endurance (20-m shuttle run test), body mass index (kg·m^{-2}), and socioeconomic status (residential postcode). **Results**: At each survey, the children's FMS competency was low, with prevalence rarely above 50%. Between 1997 and 2004, there were significant increases in all students' competency in the sprint run, vertical jump, and catch. For boys, competency increased in the kick (primary) and the overarm throw (high school), but among high school girls, overarm throw competency decreased. Between 2004 and 2010, competency increased in the catch (all students), and in all girls, competency increased in the kick, whereas competency in the vertical jump decreased. **Conclusions**: Overall, students' FMS competency was low especially in the kick and overarm throw in girls. The observed increase in FMS competency in 2004 was attributed to changes in practice and policy to support the teaching of FMS in schools. In 2010, competency remained low, with improvements in only the catch (all) and kick (girls) and declines in vertical jump. Potentially, the current delivery of FMS programs requires stronger positioning within the school curriculum. Strategies to improve children's physical activity should consider ensuring children are taught FMS to competency level, to enjoy being physically active. **Key Words:** SCHOOLS, PRACTICE, POLICY, PHYSICAL ACTIVITY

Fundamental movement skills (FMS) are the building blocks for movement, and they form the foundation for many of the specialized skills required in popular sports and leisure activities (14). There is evidence that developing FMS during childhood may be an important step toward establishing a lifelong commitment to physical activity (3) and, importantly, that mastery, or competency, of FMS among school-age children is associated with some health benefits such as higher levels of physical activity, cardiorespiratory endurance (i.e., "fitness"), self-esteem and perceived athletic competence, and lower levels of overweight (16,21).

Globally, the proportion of children and adolescents meeting the recommended >60 min·d^{-1} of moderate-to-vigorous physical activity is unacceptably low (8,10,12). Furthermore, there is evidence that the prevalence of other health-related fitness attributes, such as cardiorespiratory endurance, is suboptimal and has declined since the 1970s (33–35). Potentially, the low prevalence of recommended daily physical activity and cardiorespiratory endurance may be associated with poor FMS ability (4,29,32,39). Historical information on children's FMS competency is unavailable; however, the available evidence indicates that few children are competent (7,16,18,36) and little is known about temporal trends in competency at a population level (31).

The purpose of this study was to examine trends in the competency in five common FMS, adjusting for sex, age, weight status, socioeconomic status (SES), and cardiorespiratory endurance, among large representative samples of Australian primary and high school students measured at three time points, 1997, 2004, and 2010.

METHODS

There are three cross-sectional, representative school-based surveys of New South Wales (NSW) school children: 1997, NSW Schools Fitness and Physical Activity Survey (n = 5518); 2004 and 2010, NSW Schools Physical Activity and Nutrition Survey (n = 5402 and n = 8058,

Address for correspondence: Louise L. Hardy, Ph.D., Physical Activity Nutrition Obesity Research Group, School of Public Health, University of Sydney, Level 2, Medical Foundation Building K25, Sydney, NSW 2006, Australia; E-mail: louise.hardy@sydney.edu.au.
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respectively). Detailed descriptions of the surveys and sampling methods have been published elsewhere (5,6,15). Briefly, all students from participating schools were eligible to participate, and each survey collected data between February and April (late summer to early autumn in the southern hemisphere). Written informed consent from students and their parents was a requirement for participation. The University of Sydney Human Research Ethics Committee, the NSW Department of Education and Training, and the NSW Catholic Education Commission approved each survey. The study was funded by NSW Health.

The study protocol was identical for each survey. Data were collected by field teams who received 8-d training before data collection (L. L. Hardy and A. D. Okely) and were required to reach 99% interobserver agreement for anthropometric measures, and for FMS, the assessors had to attain an 85% agreement rate. These ranged from 88% to 96% agreement. Intrarater reliability, assessed 1-wk later against precoded videotape of FMS and a 90% agreement rate, was required when these two sets of results were compared. These ranged from 91% to 97% agreement. Kappa values were also calculated to take into account agreement beyond chance. These ranged from 0.68 to 0.89 for interrater reliability and from 0.81 to 0.94 from intrarater reliability.

Measurement of FMS. At each survey, the same FMS was assessed (sprint run, vertical jump, catch, overarm throw, and kick) among primary school (years 4 and 6; mean ages, 9.3 and 11.3 yr, respectively) and high school (years 8 and 10; mean ages, 13.4 and 15.3 yr, respectively) students using process-oriented checklists for each skill (13,27). These particular skills were assessed because they are foundational for popular games and sports among school-age children (e.g., ball sports, dance, and gymnastics). There were some minor differences between the 1997 and the 2004–2010 checklists. Minor adjustments were made to ensure comparability between the two assessment tools, in terms of the component description and number of components. This was important because FMS assessment assumes each component has equal value, and skills with fewer components are mathematically easier to master. The effect of these alterations on the prevalence of competency was tested (chi-square) prepost adjustment. The adjustments increased the prevalence among all students in the catch (approximately 3%) and sprint run (approximately 16%) in the 2004 and 2010 surveys and the kick (approximately 5%) in the 1997 survey (no change in overarm throw or vertical jump). Given that the direction of alterations were consistent across all students, we concluded that the adjustments were appropriate for assessing trends.

Skill proficiency was assessed by field staff scoring each skill component as present or absent across the required number of trials. If the student demonstrated the skill component consistently (e.g., four out of five trials), they were recorded as possessing that skill component. The number of components of each skill correctly demonstrated by each student was summed to give a total score for each skill, and the performance was categorized as "competent" if all components of a skill were correctly demonstrated; otherwise, the performance was classified as "noncompetent."

Other measurements. Demographic information included sex, date of birth, and postcode of residence. Postcode of residence was used as a proxy for SES, based on the Australian Bureau of Statistics' Index of Relative Socioeconomic Disadvantage (1), and was used to rank students in tertiles (low, medium, or high). Height and weight were measured and body mass index (BMI ($kg \cdot m^{-2}$)) was calculated and categorized according to international guidelines (9). Students' cardiorespiratory endurance (i.e., fitness) was assessed by the 20-m shuttle run test (19). Scores were recorded as the level and number of shuttle reached in the test, converted to the number of laps completed, and then students were categorized as "adequately fit" or "not adequately fit" using the criterion-referenced standard from Fitnessgram (37).

Analyses. Data analyses were undertaken in July 2011 using SAS version 9.2 (SAS Institute Inc., Cary, NC). Data were stratified by FMS, sex, and school level (primary and high school). Temporal trends and change in the prevalence of FMS competency between survey periods were assessed using logistic regression, adjusting for SES tertile, BMI status (not overweight/obese or overweight/obese), and cardiorespiratory endurance (adequately fit or not adequately fit). The SURVEYLOGISTIC procedure was used to allow for the stratified, clustered design of the surveys.

RESULTS

FMS data were available on a total of 13,752 students in years 4, 6, 8, and 10: 1997, n = 4363 (54% boys); 2004, n = 3720 (52% boys); 2010, n = 5669 (53% boys). Descriptive characteristics of the sample by survey year are shown in Table 1. At each survey year, the majority of students were from English-speaking backgrounds and lived in urban areas, which is reflective of the broader population; however, the proportion of rural primary school children changed over time (P = 0.02). Approximately half were boys, one-quarter were overweight or obese, and about two-thirds had adequate fitness. There were no significant changes in the proportion of students' demonstrating adequate fitness across surveys.

The prevalence, estimated annual change in competency, and adjusted odds ratio for change in competency across surveys among primary and high school students are shown in Tables 2 and 3, respectively. At each survey time, the prevalence of FMS competency was significantly higher among boys, with the exception of the vertical jump, with competency higher among girls in 2004 and no sex difference in 1997 and 2010.

Between 1997 and 2004, there were consistent, significant increases in competency in all skills in boys, except the kick (primary school) and overarm throw (high school). The average annual increases in competency ranged between 0.6%

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TABLE 1. Sample characteristics by survey year.

Survey Year	Primary School 1997	Primary School 2004	Primary School 2010	*P* for Trend	High School 1997	High School 2004	High School 2010	*P* for Trend
Students (*n*)	2337	1949	2674	—	2026	1771	2994	—
Response rate (%)	90.8	72.9	58.8	—	80.5	56.1	51.7	—
Boys (%)	54.1	48.9	50.2	—	53.4	54.4	55.5	—
Age, mean (SD) (yr)	10.3 (1.1)	10.4 (1.1)	10.3 (1.1)	—	14.2 (1.1)	14.5 (1.1)	14.3 (1.1)	—
English-speaking background (%)	82.5	86.9	82.4	—	84.9	85.5	84.9	—
Locality (urban %)	68.7	85.7	88.7	0.02	70.2	83.9	82.5	0.19
SES (%)								
Low	32.8	27.6	27.1	0.60	34.3	29.0	23.9	0.49
Middle	33.2	34.2	46.2		34.0	36.2	33.0	
High	34.9	38.2	26.6		31.7	34.8	43.1	
Overweight/obese (%)	21.6	27.6	26.8	0.21	19.7	23.2	21.5	0.19
Adequate cardiorespiratory fitness (%)	63.3	65.4	71.8	0.06	64.0	67.3	66.3	0.67

(kick in primary school) and 4.1% (catch in high school). After adjusting for fitness, BMI, and SES, primary and high school boys were 2.0 times (95% confidence interval (CI), 1.69–2.45) as likely to improve competency in the sprint run, 1.6 times (95% CI, 1.26–1.91) in the vertical jump, 1.3 times (95% CI, 1.06–1.58) in the kick, and 3.6 times (95% CI, 2.83–4.44) in the catch in 2004 compared with that in 1997.

Similarly, among all girls, there were consistent, significant increases in competency in the sprint run, vertical jump, and catch but a 20% decrease in the overarm throw in high school girls between 1997 and 2004. The average annual increases in competency ranged between 1.1% (run in primary school) and 3.9% (catch in high school). After adjusting for fitness, BMI, and SES, primary and high school girls were 1.9 times (95% CI, 1.56–2.27) as likely to improve competency in the sprint run, 2.0 times (95% CI, 1.59–2.45) in the vertical jump, and 3.6 times (95% CI, 2.86–4.56) in the catch in 2004 compared with that in 1997.

Between 2004 and 2010, improvements in competency were less consistent among boys. The odds of competency increased only in the catch, whereas competency in the vertical jump decreased. After adjusting for fitness, BMI, and SES, the only significant change was that all boys were approximately two times (95% CI, 1.57–2.49) as likely to have mastered the catch in 2010 compared with that in 2004.

The pattern of change in competency among girls between 2004 and 2010 was different to that among the boys. Competency significantly increased for the catch and kick, whereas a significant decline was observed in competency in the vertical jump. After adjusting for fitness, BMI, and SES, girls overall were 1.7 times (95% CI, 1.38–2.14) as likely to have increased competency in the catch and 2.4 times (95% CI, 1.70–3.29) increased likelihood of competency in the kick, and the odds of competency in the vertical jump decreased 47% (adjusted odds ratio, 0.53; 95% CI, 0.44–0.64) in 2010 compared with those in 2004.

DISCUSSION

This is the first study to report 13-yr trends of school-age children's FMS competency at a population level. Our findings show that at each survey period, the prevalence of

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TABLE 2. Trends in the prevalence of FMS mastery among primary school students.

FMS	Survey Year	Boys Mastery (%)	Boys Mean Annual Change in Mastery (%)	Boys Adjusted Odds Ratio (95% CI)*	Girls Mastery (%)	Girls Mean Annual Change in Mastery (%)	Girls Adjusted Odds Ratio (95% CI)*
Sprint run	1997	31.1			27.8		
	2004	43.7	1.8	2.07 (1.68–2.55)	35.5	1.1	1.48 (1.13–1.92)
	2010	41.4	−0.4	0.83 (0.62–1.10)	38.8	0.5	1.20 (0.88–1.65)
	P for trend	0.000			0.000		
Vertical jump	1997	22.3			23.3		
	2004	29.4	1.0	1.59 (1.19–2.14)	34.2	1.6	1.73 (1.35–2.22)
	2010	21.1	−1.4	0.69 (0.52–0.91)	21.1	−2.2	0.51 (0.38–0.69)
	P for trend	0.53			0.17		
Catch	1997	20.8			10.9		
	2004	45.2	3.5	3.38 (2.57–4.45)	29.8	2.7	3.74 (2.70–5.16)
	2010	55.5	1.7	1.79 (1.28–2.50)	33.0	0.5	1.40 (1.03–1.90)
	P for trend	0.000			0.000		
Kick	1997	24.8			2.6		
	2004	27.1	0.3	1.23 (0.93–1.62)	3.4	0.1	1.19 (0.67–2.11)
	2010	30.5	0.6	1.27 (0.95–1.71)	5.2	0.3	1.77 (1.04–2.99)
	P for trend	0.001			0.001		
Overarm throw	1997	24.2			7.4		
	2004	31.0	1.0	1.45 (1.07–1.97)	6.0	−0.2	0.75 (0.44–1.26)
	2010	28.2	−0.5	0.95 (0.69–1.30)	5.0	−0.2	1.08 (0.67–1.75)
	P for trend	0.02			0.02		

*Adjusted OR = 1997 vs 2004 and 2004 vs 2010, adjusted for cardiorespiratory fitness, SES, and BMI.

TABLE 3. Trends in the prevalence of FMS mastery among high school students.

		Boys			Girls		
FMS	Survey Year	Mastery (%)	Mean Annual Change in Mastery (%)	Adjusted Odds Ratio (95% CI)*	Mastery (%)	Mean Annual Change in Mastery (%)	Adjusted Odds Ratio (95% CI)*
Sprint run	1997	39.8			30.5		
	2004	51.7	1.7	1.95 (1.46–2.60)	49.8	2.8	2.46 (1.90–3.20)
	2010	60.3	1.4	1.25 (0.96–1.61)	51.5	0.3	0.99 (0.79–1.23)
	P for trend	0.000			0.000		
Vertical jump	1997	33.0			32.5		
	2004	41.7	1.2	1.52 (1.15–2.00)	50.7	2.6	2.33 (1.66–3.25)
	2010	41.9	0.0	0.95 (0.74–1.22)	33.5	−2.9	0.44 (0.35–0.55)
	P for trend	0.000			0.99		
Catch	1997	33.4			18.3		
	2004	62.0	4.1	3.85 (2.75–5.38)	45.5	3.9	3.75 (2.74–5.14)
	2010	75.5	2.3	1.71 (1.25–2.32)	58.0	2.1	1.66 (1.27–2.17)
	P for trend	0.000			0.000		
Kick	1997	43.7			5.8		
	2004	48.1	0.6	1.32 (1.04–1.69)	6.4	0.1	1.10 (0.68–1.79)
	2010	51.8	0.6	1.05 (0.81–1.37)	13.5	1.2	2.23 (1.52–3.27)
	P for trend	0.000			0.000		
Overarm throw	1997	40.5			15.8		
	2004	46.1	0.8	1.34 (0.98–1.83)	13.0	−0.4	0.80 (0.58–1.09)
	2010	43.3	−0.5	0.84 (0.65–1.09)	12.2	−0.1	0.90 (0.66–1.24)
	P for trend	0.20			0.02		

*Adjusted OR = 1997 vs 2004 and 2004 vs 2010, adjusted for cardiorespiratory fitness, SES, and BMI.

competency in FMS was low among school-age children. A lack of historical data precludes assumptions as to what is an acceptable prevalence benchmark for competency in FMS among youth. However, the prevalence of competency in 1997, when FMS were first measured, is lower than subsequent surveys, suggesting that FMS competency among youth can be improved beyond reported levels.

Between 1997 and 2004, changes in competency were generally in a positive direction for boys and girls, with the greatest annual gains in the sprint run, vertical jump, and catch. Between 2004 and 2010, competency in the vertical jump decreased 40%–50% (except high school boys); however, significant competency gains continued for the catch and, among girls, the kick. The temporal patterns of change in FMS competency, particularly the decline in the vertical jump in 2010, are unclear but may be related to changes in children's participation in different physical activities across time.

Furthermore, the low prevalence of competency overall among girls in the kick and overarm throw may reflect the actual skills assessed or that activities associated with these skills do not resonate with girls. For example, overarm throwing is typically associated with smaller ball sports (baseball, softball, cricket, etc.) rather than larger ball throwing, such as the throw required for netball (Australia's most popular female ball sport) (2). Similarly, the kick is most strongly associated with soccer, which until recently has low participation among girls compared with boys. The improvement in girls' competency in the kick over time may reflect the growing investment in girls' soccer, with participation increasing between 2003 and 2012 among girls (2).

Our study has several strengths, including the large sample of children from three methodologically comparable, cross-sectional, representative school-based monitoring surveys spanning 13 yr. Importantly, we used objective measures of FMS, cardiorespiratory endurance, and BMI. FMS competency was determined by process-oriented criteria to assess the technique in performing components of a skill. That is, the assessment is "how the ball is thrown," not "how far the ball is thrown." Boys demonstrated higher competency in the majority of FMS; however, this may reflect a sex bias in the skills assessed, which may be more common to sport and games boys play.

There are some limitations to consider when interpreting the current findings. First, there were some minor differences in skill components of the 1997 and the 2004–2010 FMS instruments. The components of both checklists were, however, adjusted to be as similar as possible in terms of the components and number of components. This is important because FMS assessment assumes each component has equal value, and skills with fewer components are mathematically easier to master. The declining response rate, which is the result of active rather than an "opt-off" consent processes, was another limitation. Although this was of concern, the participation rates were comparable with other population surveys (11,25).

The evidence shows that investment in FMS programs during early childhood is effective in improving FMS ability (17,20,22,40). Similarly, the generally positive findings reported here between 1997 and 2004 are likely to have resulted from a planned, sequential, and sustained focus on the development of FMS. After the 1997 survey, a resource was developed to support the teaching of FMS (i.e., *Get Skilled: Get Active* (27)), which was distributed among government schools. Potentially, its implementation through long-term professional development of teachers and the employment of specialist physical education (PE) consultants in government schools from 1998 to 2001 helped to make FMS a focus of school PE. The implementation of this resource potentially had a flow on effect to the levels of competency in high school children. The children who received this focus in primary school after 1997 would have been, in many cases, the same cohort assessed in the 2004 survey (i.e., those in grade 2 in 1998 would be in grade 8 in the 2004 survey).

It was concerning that the current findings suggest that many youths are underskilled, and FMS programs need to remain a key component of PE curriculum. The low competency in the kick and throw among girls also suggests that the underlying pedagogy of these skills was not successful or did not resonate for girls. There is good evidence of strong associations between FMS and health benefits (21), including a link to physical activity participation. A lack of FMS may be one of the causal factors related to children's growing inactivity; however, few jurisdictions routinely monitor FMS (32). Continuing support is required to scale up professional development programs for nonspecialist early childhood and primary school teachers (26,28,38), which would be of great value to instilling teacher confidence in the delivery of PE and FMS programs (23,24).

Foremost, it is critical that the learning process for FMS be fun so that children and teachers are motivated to participate. By identifying specific components of skills that children are lacking, teachers can guide and develop implementation programs that focus on addressing the underdeveloped components of a skill. Most important is that children are provided with opportunities for active play and participation in organized games and sports to practice FMS.

CONCLUSIONS

Our findings indicated that the prevalence of FMS competency in 1997 was low; however, after dissemination of a specific FMS teaching resource in schools, the prevalence of competency was associated with an increase in FMS competency. The 2010 prevalence of FMS competency still appear low, and on-going investment could increase the current rates of competency. Surveillance of children's physical activity typically focuses on the proportion meeting daily recommendations; however, children who have not mastered basic FMS are more likely to not participate in organized sports and play experiences because of a lack of basic physical skills (30). Potentially, strategies to improve children's physical activity may need to first consider ensuring children have competency in the necessary FMS to be physically active.

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L. L. Hardy, L. Barnett, P. Espinel, and A. D. Okely helped to plan the research and took part in the writing of the final article. L. L. Hardy undertook the statistical analyses. L. L. Hardy has full access to all the data in the study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

The results of the present study do not constitute endorsement by the American College of Sports Medicine.

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