The Relationship between Physical Activity, Fitness and Educational Achievement of Rural South African Children
南非鄉鎮兒童身體活動、體適能與學業成就的關係

M J Themane[a]
[a] *Curriculum and Professional Studies, School of Education, University of Limpopo, Sovenga, SOUTH AFRICA*

L L J Koppes[b,c]
[b] *EMGO Institute, VU University Medical Center, Amsterdam, The NETHERLANDS*

H C G Kemper[b]
[c] *Department of Public and Occupational Health, VU University Medical Center, Amsterdam, The NETHERLANDS*

K D Monyeki[d]
[d] *Medical Research Council, Cape Town, SOUTH AFRICA*

J W R Twisk[b,e]
[e] *Department of Clinical Epidemiology and Biostatistics, VU University Medical Center, Amsterdam, The NETHERLANDS*

M J 菲文尼[a]
[a] *南非林布布大學教育系課程及專業學院*

LLJ 高巴斯[b,c]
[b] *荷蘭VU大學醫學研究中心*

HCG 金巴[b]
[c] *荷蘭VU大學公共及職業健康系*

KD 蒙欣基[d]
[d] *南非醫學研究局*

JWR 積斯基[b,e]
[e] *荷蘭VU大學醫學院流行病學系*

Abstract

The purpose of this study was to investigate the relationships of physical activity and physical fitness with educational achievement in rural South African school children aged 7 to 14 years (n= 212). All boys and girls underwent the following physical fitness tests: standing long jump, bent arm hang, sit ups, 10 x 5m shuttle run, 50 meter run, 1,600 meter run, flamingo balance, sit and reach, and plate tapping. All tests were performed in accordance with the European Tests of Physical Fitness (EUROFIT) and American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) protocols. A questionnaire was used to gather physical activity information concerning indoor and outdoor household activities, games and sports performed during the week days and weekend days. Educational achievement was assessed by means of the Educational Achievement Tests in Mathematics and English designed by South African Human Sciences Research Council. In contrast to what has been found in developed countries, the results of the present study did not show strong evidence for the hypothesis that physical activity and physical fitness are positively associated with educational achievement. Explanations for this finding may be that: first, the children in this population are confronted by a number of educational problems that may have confounded the relationship. Second, because all these children have high levels of physical activity it may be difficult to measure its influence on educational achievement, and third, the cross-sectional nature of this study.

摘 要

本文旨在探討南非鄉鎮地區小學生身體活動量與學業的關係.以問卷方式進行調查, 訪問了212名學童,並評估他們的體適能狀況, 結果未能顯示出兩者呈現關係,這現象可能受到文化及教育等因素影響所致.結果呈現兩種動作類，顯示對於下肢的偏向是取決於動作的。作者提出看法，認為各個不同孩童的互動、動作和環境的轉換都對下肢偏向起著影響。

Introduction

Studies have shown positive relationships between physical activity (PA), physical fitness (PF) and educational performance (EA) in school children (Dwyer et al., 1983; Dwyer et al., 2001; Linder, 1999). Indications are found that PA and PF improve children's attributes such as brain function and their energy and concentration levels and self-esteem; which may may support EA (Dwyer et al., 1983; Shephard, 1997; Tremblay et al., 2000). A growing body of literature documents the multiple physical and mental benefits of PA in young people (Flescher et al., 1992) and adults (US Department of Health and Human Services, 1996). As a result of this, promotion of PA is most prominently advocated by experts in health related sciences. Although PA programmes for children can be justified on the basis of health benefits alone (Sallis, 1994), it is important to note that PA and PF are also positively related to educational achievement of children (Dwyer et al., 2001; Linder 2002; Shephard, 1997; Tremblay et al., 2000). Despite these findings, arguments that PA harms EA by tiring the children, taking focus off education and/or taking time from learning are still heard (Linder, 1999).

Information on whether or not this relationship is also present in developing countries is not available. In South Africa for example, this information could play an important role in the choices about the amount of curricular physical education in schools, especially at this point in time where the educational system is largely being restructured. There is increasing evidence that school-aged children in both developed and developing countries are becoming less and less physically active due to a number of factors, including urbanization (Bar-Or, 2003; Mendez & Adair, 1999). This is a worrying trend that strengthens the importance of additional information on the association between PA, PF and EA. We therefore performed this study on the associations between PA, PF and EA in South African rural school children. Our hypothesis was that more physical activity and a better physical fitness are related to a better performance in English and Mathematics.

Methods

Sample

The data for this study come from a sample of 212 children (112 boys and 100 girls) who participate in the ongoing Ellisras Longitudinal Study (ELS). The ELS is a ten year follow-up study that started in 1996 to investigate the growth and health patterns of children in 22 schools from the rural Ellisras areas in South Africa. Other variables were later added to the study, for example, data on PA, PF and EA were added in 2001. The sample used for the present analyses includes children from grades 4 to 8, aged 7-14 years, measured in 2001 with complete data for PA, PF and EA.

Data Collection

Physical Activity

Physical activity was assessed using a questionnaire adopted from Prista et al. (2000), which was developed to incorporate activities that are common in these areas. Subjects were asked how many times per week they performed each activity included in the questionnaire. The questionnaire included four types of activities, namely, household tasks indoor (that is, cleaning the house, washing clothes, cooking, washing the dishes) and outdoor (that is, cutting the wood, animal husbandry, fetching water, agriculture), outdoor games (that is, traditional games such as: tseretsere, banabaka, dance, diketo, katsekatse tswara legotlo, legotlo, kgati, luto, mambalobalo, maphitlaphitlwane, mmasekitlane, mmela, mokoko, morabaraba, pekwa, sekapukapu, sekonopa, sekotiwa, sepini, setimela), and unorganized sports (that is, non-curricular physical education, soccer, netball, karate, drum majorette, athletics and volleyball). The score for the four types of activities was attained by a multiplication of the number of activities reported with the number of days per week engaged in those activities. In addition, a total physical activity score was calculated through the summation of the four types of activities.

Physical Fitness

Physical fitness test items were assessed using the European Tests of Physical Fitness (EUROFIT, 1988) and American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD, 1980) test batteries. The physical fitness test items assessed were classified into the following categories: three strength items: standing long jump (cm): the best out of three trials was recorded as a score; bent arm hang (sec.): a child has to hang as long as possible with the chin above

a bar; and sit ups: a child has to sit down on a gymnasium mat with the hands behind the neck, the knees bent at 90 degrees and the feet flat on the mat. Then the child has to lie down on his/her back, shoulders touching the mat and return to sitting position with the elbows out in front so that they touch his/her knees. The total number of correctly performed sit-ups in 30 sec is the score. Three items assessed running capability: shuttle run (sec.): time taken to complete 10 x 5m shuttle run; 50 meter run (sec.): sprinting from standing start; and 1600 meter run (sec.): endurance run, time taken to run four laps of 400 meters. One item measures balance (flamingo balance): standing on one leg on a metal beam as long as possible, the total number of errors committed in one minute is the score. One item measures flexibility (sit and reach (cm)): a child has to push a bar forward with fingers of both hands together while sitting with legs stretched. Finally, plate tapping (sec.) measures speed of the arm: tapping a plate 25 times with one hand interchangeably on the left and right sides of the other hand. The test-retest reliability of the measurements was moderate to high (0.4 to 0.8) (Monyeki et al., 2003).

Educational Achievement

The measure of educational performance is based on the Educational Achievement Tests in Mathematics and English. These tests are standardized for all South African school children. For quality assurance the expertise of a qualified educational psychometrist was followed in the administration of the tests. The tests administered were those for the grade that a child had just completed. For example, the test for grade 5 was given to those children who had already passed that grade and were in grade 6. The tests were administered as early in the day as possible before the children were fatigued by other lessons. An attempt was made to motivate the children, arouse their interest, obtain their cooperation and make them feel at ease, for example by assuring them that these tests were not meant for exam purposes, in order to achieve the best results. To help the children understand, the chalkboard was used for demonstration purposes.

The English test was divided into two sections, namely subtests 1 and 2. Subtest 1 concerned vocabulary and reading comprehension, and lasted for 30 minutes. Subtest 2 concerned writing-related skills and language usage, and lasted for 23 minutes. The Mathematics test had only one section, which lasted for 60 minutes. The range of possible scores was from 0 to 60 on English, and from 0 to 30 on Mathematics, where high scores indicate good performance. For English the score of below 17 is classified as poor and above 27 as good. For Mathematics the score of below 10 is classified as poor and above 16.

Data Analysis

Because this study is carried out in schools, multilevel regression analyses are used to analyze the relationships between the four types of physical activities and total physical activity, and the nine physical fitness items on the one hand, and English and Mathematics performance on the other. In the multilevel analyses two levels are considered: subjects and schools. All multilevel analyses were corrected for age and separate analyses were performed for boys and girls. The analyses were performed with MLwIN (version 1.01).

Results

Table 1 presents descriptive information for the PA, PF and EA of the boys and girls. Games were the dominant type of PA in boys and girls. Boys performed better than girls in each PF measure, except for the flexibility test (sit and reach). Boys have slightly outperformed girls in both English and Mathematics.

Table 1. Descriptive Data of Age, Physical Activity and Physical Fitness in Boys and Girls.

	Boys (N = 112)		Girls (N = 100)	
	Mean	SD	Mean	SD
Age (years)	11.35	1.49	11.15	1.73
Physical activity				
Games	28.90	16.65	27.20	15.22
Sport	7.35	4.52	6.24	4.79
Indoor	6.03	4.72	7.55	5.58
Outdoor	8.54	4.81	8.86	5.63
Total Physical Activity	50.81	22.86	49.97	24.01
Physical fitness				
10x5m Shuttle run (sec.)	22.03	1.72	22.26	1.69
Sit and reach (cm)	15.97	4.09	17.08	4.16
Flamingo balance (number of failures)	9.99	5.27	10.59	5.39
Long jump (cm)	131.72	16.69	126.41	17.92
Bent and arm hang(sec.)	8.52	8.80	4.80	6.84
Sit ups (number)	16.04	7.01	15.17	6.71
Plate tapping (sec.)	18.97	4.18	19.03	3.68
Mile run (sec.)	434.57	110.66	475.23	154.11
Sprint (sec.)	8.96	1.70	9.09	2.52
Educational achievement				
English	17.68	5.13	16.19	5.98
Mathematics	5.13	3.64	4.92	3.10

Regarding the relationship between physical activity and physical fitness on the one hand and English performance on the other (Table 2), for boys a significant positive relationship was found for outdoor activities. For girls, significant inverse relationships with English performance were found for Games, Sport and Total Activity. Boys with a better performance on the long jump and plate tapping had a better English performance. For girls, no significant relationships between the physical fitness items and English performance were observed.

Table 2. Regression Coefficients and 95% Confidence Intervals (CI) for Physical Activity, Fitness and English Performance in Boys and Girls, Controlled for Age.

	Boys (N = 63)		Girls (N = 64)	
	B	95% CI	B	95% CI
Physical activity				
Games	-0.02	-0.10 ; 0.06	-0.11	-0.19 ; -0.02
Sport	0.06	-0.19 ; 0.32	-0.36	-0.62; .-0.09
Indoor	0.00	-0.24 ; 0.25	-0.03	-0.28 ; 0.21
Outdoor	0.26	0.04 ; 0.48	-0.16	-0.42 ; 0.10
Total Activity	0.01	-0.05 ; 0.06	-0.07	-0.13 ; -0.01
Physical fitness				
Shuttle run[1]	-0.28	-1.03 ; 0.47	0.66	-0.17 ; 1.49
Sit and reach	-0.12	-0.40 ; 0.16	-0.05	-0.38 ; 0.28
Flamingo balance[1]	-0.07	-0.29 ; 0.15	-0.02	-0.31 ; 0.26
Long jump	0.08	0.01 ; 0.15	-0.07	-0.14 ; 0.00
Bent and arm hang	0.09	-0.05 ; 0.23	-0.09	-0.34 ; 0.16
Sit ups	0.12	-0.05 ; 0.29	-0.22	-0.44 ; 0.01
Plate tapping[1]	-0.31	-0.59 ; -0.04	0.12	-0.24 ; 0.48
Mile run[1]	-0.19	-0.86 ; 0.48	0.10	-0.38 ; 0.57
Sprint[1]	0.06	-0.81 ; 0.94	0.05	-0.47 ; 0.57

[1] lower score on these fitness items indicates a better performance

Boys who played more games and were able to hang longer with bent arms were found to have a worse Mathematics performance (Table 3). In boys no other significant relationships were observed. In girls, doing more outdoor activities was significantly related with a better Mathematics performance. In addition, a better score on the balance test and a worse score on the mile run and 50m sprint were related to a better Mathematics performance.

Table 3. Regression Coefficients (b) and 95% Confidence Intervals (CI) for Physical Activity and Fitness and Mathematics Performance in Boys and Girls, Controlled for Age.

	Boys (N = 41)		Girls (N = 50)	
	b	95% CI	b	95% CI
Physical activity				
Games	-0.08	-0.15 ; -0.01	-0.04	-0.09 ; 0.02
Sport	-0.06	-0.31 ; 0.18	0.10	-0.08 ; 0.29
Indoor	0.07	-0.15 ; 0.30	-0.11	-0.27 ; 0.04
Outdoor	-0.14	-0.33 ; 0.05	0.24	0.08 ; 0.40
Total Activity	-0.05	-0.09 ; 0.00	-0.01	-0.05 ; 0.03
Physical fitness				
Shuttle run[1]	0.51	-0.12; 1.13	0.17	-0.32 ; 0.65
Sit and reach	0.11	-0.13 ; 0.35	0.02	-0.19 ; 0.22
Flamingo balance[1]	-0.05	-0.24 ; 0.15	-0.22	-0.40 ; -0.05
Long jump	0.01	-0.06 ; 0.07	0.02	-0.03 ; 0.06
Bent arm hang	0.14	0.00 ; 0.28	-0.06	-0.20 ; 0.08
Sit ups	-0.02	-0.17 ; 0.13	0.04	-0.10 ; 0.17
Plate tapping[1]	0.15	-0.09 ; 0.40	-0.08	-0.30 ; 0.15
Mile run[1]	0.38	-0.15 ; 0.91	0.30	0.03 ; 0.57
Sprint[1]	0.27	-0.42 ; 0.96	0.34	0.07 ; 0.62

[1]lower score on these fitness items indicates a better performance

Discussion

This study examined the relationships between physical activity, physical fitness and the educational achievement for the sample of rural South African boys and girls aged 7-14 years, who participate in the Ellisras Longitudinal Study. In general, the results do not support our hypothesis that physical activity and physical fitness are positively associated with educational achievement. Six significant associations were found that support our hypothesis, whereas six others were in the unexpected direction.

Most studies earlier performed on this topic found that physical activity and physical fitness are associated with educational achievement. Shephard (1997) found significant positive relationships, where the educational achievement was gauged by grade point averages, report card results and IQ scores. Another cross-sectional study by the California Department of Education (CDE) (2002) found strong associations between physical fitness and Mathematics and Reading. In addition Dwyer et al. (2001) completed a study on 7961 Australian school children and showed that academic ratings were significantly and consistently correlated with physical fitness across age and sex groups.

There may be some explanations as to why we have not found consistent associations between physical activity and physical fitness on the one hand and educational achievement on the other. The studies mentioned above were conducted in developed countries and among urban children which have a completely different socio-economic conditions compared to the children who participated in the present study. Unfortunately, it is likely that children in these areas are beset by myriad educational problems such as low nutritional status. Monyeki et al., (2003) in a study of the same population revealed that there was a high prevalence of malnutrition and that most children were stunted. Themane et al. (2003) revealed that malnutrition was related to poor educational achievement of children. The relationship between short stature and late enrolment in school is likely for children in our population as it is for primary school children in Ghana and Tanzania, where short stature (height for age Z score) was strongly

associated with late enrolment in school (Doherty,1997). Mendez and Adair (1999) found stunting in the first two years of life to be strongly associated with lower test scores in school age children (age 8-11) and deficits in cognitive ability later in life. Another study by Walker et al., (2000) on the effects malnutrition on growth, IQ and cognition at ages 8 to 11 years found that nutritional status affected educational achievement. To investigate the influence of malnutrition on the present observed relationships an additional analysis was done, where we corrected for malnutrition (i.e. height for age and weight for age). This additional correction however did not influence the observed results.

It is also important to consider the fact that physical activity levels in this population are very high, unlike in developed countries. For example, children in these areas travel by foot for about 80 minutes daily to and from school. Besides this, when they arrive home they are faced with activities such as fetching water, collecting wood, cooking etc. Even during the weekend the children perform some of these activities. The relatively low active children are therefore highly active in absolute terms. Since they are this active, there may be a small distinction between children that are highly active and extremely active, and a ceiling effect is likely.

The last point to consider is the difficulties in measuring physical activity variables. In the physical activity questionnaire only the number of physical activities is asked, not the time because children of this age have problems in estimating time properly (Hussey, et al., 2001). It may be as Tremblay et al. (2000) allude, that any increased time on physical activity is associated with academic improvement, up to a certain optimal level, but that too much time on physical activity detracts academic pursuits.

Although this is the first study that investigated the relationship between physical activity and physical fitness in a population from a rural situation in a developing country, the study has some limitations. The first limitation to consider is the cross-sectional nature of the design which we used in this study. In the above studies a longitudinal design was used. The cross-sectional design might have limited the extent to which long term effects of the relationship could be inferred. It is possible, that children with the lower educational performance were less physically active or vice versa. Only a longitudinal study following these children to higher grades could clarify this relationship. Most studies, which were longitudinal in nature, found strong associations between physical activity, physical fitness and educational achievement after several sets of data were collected over time (Shephard, 1997). It could be concluded then that a longitudinal study that takes other factors such as continuous assessment of educational achievement and make use of other qualitative assessment tools, is necessary for a better understanding of the topic of this study.

In conclusion, in contrast to what has been found in developed countries, the results of the present study did not show strong evidence for the hypothesis that physical activity and physical fitness are positively associated with educational achievement in a population of rural South African children.

Acknowledgements

The authors are very much thankful to the children and field workers for the wonderful support they gave this study. The MRC (Medical Research Council of South Africa), NRF (National Research Council of South Africa), University of the North (presently University of Limpopo) and VU (Vrije University, Amsterdam, The Nertherland).

References

American Alliance for Health, Physical Education, Recreation and Dance. (1980). *Lifetime health-related physical fitness test manual.* Reston. VA: AAHPERD.

Bar-Or, O. (2003). The Juvenile Obesity Epidemic: Strike Back with Physical Activity. *Sport Sci. Exchange*, *89*, 1-15.

California Department of Education (CDE). (2002). California State-wide Study of Physically Fitness. USA, Sacramento, California. California Department of Education.

Doherty, G. (1997). *Zero to Six: The Basis for School Readiness.* Hull, QC: Human Resources Development Canada

Dwyer, T., Coonan, W., Leitch, D., Hetzel, B., & Baghurst, R. (1983). An investigation of the effects of daily physical activity on the health of primary school students in South Australia. *Int. J. Epidemiol.*, *12*, 308-313.

Dwyer, T., Sallis, J. F., Blizzard, L., Lazarus, R., & Dean, K. (2001). Relation on academic performance to Physical Activity and Fitness in Children. *Paediatr. Exerc.*, *13*, 225-237.

EUROFIT (1988). *Handbook for the European Test of Physical Fitness*. Council of Europe, Committee for Development of Sport, Rome.

Fletcher, G.F., Blair, S.N., & Blumenthal, L. (1992). Statement on exercice. Benefits and recommendations for physical activity programs for all American. A statement for healthy professionals by the Committee on Exercise and Cardiac Rehabilitation of the Council of Clinical Cardiology, American Health Association. *Circulat., 86*, 340-344.

Human Sciences Research Council. (1995). *Educational Achievement Tests*. Pretoria: HSRC.

Hussey, J., Gormley, J., & Bell, C (2001).Physical Activity in Dublin children, aged 7-9 years. *British J. Sports Med. 35, 268-272.*

Linder, K.J. (1999). Sport Participation and Perceived Academic Performance of School Children and Youth. *Paediatr. Exerc., 11*, 129-144.

Linder, K.J. (2002). The Physical Activity participation- Academic Performance Relationship Revisited: Perceived and Actual performance and the Effect of Banding (Academic Tracking). *Paediatr. Exerc., 14*, 155-169.

Mendez, M.A., & Adair, L. S. (1999). Severity and Timing of Stunting in the First Two Years of life Affect Performance on Cognitive Tests in Late Childhood. *J of Nutr, 129, 1555-1562.*

Monyeki, M. A., Kemper, H.C.G., Twisk, J.W.R., Monyeki, K. D., Toriola, A. L., & Steyn, N. P. (2003). Anthropometric indicators of nutritional status and physical fitness of Ellisras rural primary school children, South Africa. *Med. Sportiva.*, E93-102.

Prista, A. (2000). Growth, physical fitness and their relationship with physical activity and nutritional status in Mozambican children and youth: Summary of findings. *African J. Phys., Health Educ., Recr. Dance (AJHPHERD).* Supplement. 77-79.

Sallis, J.F. (Ed.). (1994). Physical activity guideline for adolescents. *Paediatr. Exerc., 6*,4.

Shephard, R.J. (1997). Curricular physical activity and academic performance. *Paediatr. Exerc., 9*, 11-126.

Themane, M.J., Monyeki, K.D., Nthangeni, M.E., Kemper, H.C.G., & Twisk, J.W.R.(2003). The relationship between health (malnutrition) and educational achievement (Maths and English) in the rural children of South Africa. *Inter. J. of* Educ. Dev.23, 637-643.

Tremblay, M. S., Inman, J. W., & Willms, J. D. (2000). The Relationship Between Physical Activity, Self-Esteem, and Academic Achievement in 12-Year-Old Children. *Pediatr. Exerc. Sci., 12*, 312-324.

US Department of Health and Human Services, (1996). *Physical Activity and Health: A report of the Surgeon General.* GA: Atlanta.

Walker, S.P., McGregor, S.M., Powel, C.A., & Chang, S. M. (2000). *J. Pediatr., 137*, 36-41.

Correspondence:

Mahlapahlapana J Themane
School of Education, University of Limpopo,
Private Bag 1106, Sovenga, South Africa.
E-mail : mahlapat@unorth.ac.za
Fax : +27 15 268 2965
Tel : +27 15 268 2928