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Sima Zach, Ella Shoal & Ronnie Lidor

To cite this article: Sima Zach, Ella Shoal & Ronnie Lidor (2017) Physical education and academic achievement—literature review 1997–2015, *Journal of Curriculum Studies*, 49:5, 703–721, DOI: [10.1080/00220272.2016.1234649](https://doi.org/10.1080/00220272.2016.1234649)

To link to this article: <https://doi.org/10.1080/00220272.2016.1234649>



Published online: 30 Sep 2016.



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Physical education and academic achievement—literature review 1997–2015

Sima Zach, Ella Shoval and Ronnie Lidor

School of Education, The Zinman College of Physical Education and Sport Sciences, Wingate Institute, Netanya, Israel

ABSTRACT

The purpose of this review was to organize the results of studies conducted during the last 18 years into a body of knowledge concerning the link between physical education (PE) and academic achievement (AA). Such knowledge may help in clarifying the role of PE in the schools, whose main focus is on improving the AA of the children. The term PE is used to denote those classes taught in the framework of a school curriculum in which physical activity is at the centre. The reviewed studies were divided into three categories: the 'political', in which a rationale is provided for PE in mainly achievement-oriented academic schools ($n = 10$); the 'interventionist', in which it is shown that PE given in accordance with a defined intervention programme influences AA ($n = 10$); and the 'integrative', in which it is determined how physical activity incorporated into the daily routine of academic studies contributes to AA ($n = 5$). The significance of the reviewed studies in each category is discussed, as well as the advantages and limitations of the studies. Ideas for future research on the link between PE and AA are proposed.

KEYWORDS

School; intervention programmes; integrative programmes; curriculum

Studies have shown a link between *physical fitness* and academic achievement (AA) in school-children (e.g. Chormitz et al., 2009; Haapala, 2013; Singh, Uijtendwilligen, Twisk, Van Mechelen, & Chinapaw, 2012; Wittberg, Cottrell, Davis, & Northrup, 2010), as well as a significant relationship between children's level of *physical activity* and their academic performance (e.g. Erwin, Fedewa, Beighle, & Ahn, 2012). That is to say, AAs have been found to be higher in active children than in those who are not active. Research has also shown that physical activity is likely to improve executive functions of the brain in children, such as attention, concentration, memory and space perception (see e.g. Flöel et al., 2010; Greenwood, Strong, Foley, & Fleshner, 2009; Sibley & Etnier, 2003).

In this article, our aim is to examine the existing link between *physical education* (PE) and AA. PE is the general term used for those classes taught within the framework of a school curriculum as part of the compulsory formal school programme in which physical activity is at the centre. This definition of PE differentiates the present study from previous research (e.g. the above-mentioned studies), which was carried out in well-controlled laboratory

conditions or undertaken in informal programmes taught after school. There are two reasons why we have made a distinction between formal PE taught in school and other frameworks of physical activity. First, we wanted to examine what actually occurs at school, namely in the formal education framework, where *all* children must participate. Second, PE classes have components other than pure physical activity. For example, a significant portion of the time is dedicated to aspects associated with the education process, whether by choice of the teacher who sees his or her classes as part of a the holistic educational process adopted by the school, or because of the number of different behavioural patterns demonstrated by the children during the class. These include, for example, a lack of motivation to participate or poor behaviour, which force the teacher to deal with the class's organization and management (see Bevans, Fitzpatrick, Sanchez, Riley, & Forrest, 2010; Hastie et al., 2007).

Bailey et al. (2009) critically examined the theoretical and empirical bases of claims made for the educational benefits of physical education and school sport (PESS). They reported on suggestive evidence of the distinctive role of PESS in the acquisition and development of children's movement skills and physical competence, and about positive benefits in the social domain that are mediated by environmental and contextual factors. In addition, they found a positive association for PESS with numerous dimensions of psychological and emotional development in the affective domain, but the mechanisms through which these benefits occur are less clear. Similarly, the mechanisms by which PESS might contribute to cognitive and academic developments are not fully understood. They concluded that many of the educational benefits claimed for PESS are highly dependent on contextual and pedagogic variables. Their review raises questions about whether PESS should be held accountable for claims made for educational benefits, and about the implications of accountability. These findings correspond with McNamee's (2009, p. 9) view that 'anyone attempting to argue for the educational value of physical education on the grounds that the playing of games conferred a wide-ranging cognitive perspective on the world would be barking up the wrong tree'. Therefore, we specifically concentrated on the link between PE and AA, with the aim of narrowing the existing gap of knowledge.

It should be noted that PE is increasingly taking place in schools in a dual form: as a programme for the vast majority of all learners, and as an option for those learners who choose to pursue a high-stakes examination award in PE. This latter category has been written about from various perspectives worldwide. For example, from an Australian perspective, Brown and Penney (2013) critically examine the pedagogical intent inherent in the new Victorian Certificate of Education Physical Education text, and examine how teachers interpret and implement the new text. They commented that conceptual coherency from policy to assessment of student outcomes may be compromised, and that until the lack of a philosophy of practical activity within a senior study which continues to reinforce the theoretical-practical binary is challenged, it is likely that senior PE in Victoria will remain an essentially propositional/theoretical subject. From an American perspective, Rink and Mitchell (2002) explored efforts to reform PE programmes and described why they might not have been successful in the past. They claimed that the needed change must evolve from the public school personnel, who should take the lead and the responsibility for improving PE programmes. In the UK, Thorburn (2007) analysed the conceptual and curricular adequacy of three awards, and outlined the promise of phenomenology as a philosophically informed approach for assessing students' active practical experiences at the centre of learning and assessment in high-stakes school examinations. He argued that when suitably framed, such curriculum

developments could complement rather than contradict current practice, and suggested that greater conceptual and curriculum coherence in high-stakes school examinations be ensured, so that PE does not become unnecessarily constrained by developments in examination awards.

The current review focuses on PE programmes delivered to the vast majority of all learners. Its main purpose is to examine whether it is possible to bring together the results of studies carried out during the last 18 years into a body of knowledge concerning the link between PE and AA. This would help in clarifying the role of PE in the schools, whose main focus is on improving the AAs of the children.

Literature search

We searched for articles published between 1997 and 2015 that dealt with the relationships between PE and AA. We selected the year 1997 since it was our objective to continue where the review of Stone, McKenzie, Welk, and Booth (1998) left off. In their review, Stone and colleagues dealt with the impact of interventions involving physical activity, from kindergarten up to college and university. Our review focuses only on PE research from kindergarten to secondary school.

The search for articles to be reviewed included the joining together of two concepts, one independent and the other dependent. The group of independent variables included the term *PE*. In conjunction with this term, we also looked for the terms *physical activity*, *physical fitness* and *movement*, all of which were studied in school settings. We also searched the abstract of each article to ascertain whether the activity cited as an independent variable was related to the school curriculum, and was not some other kind of activity in which the study used the school population only as a research group but did not relate to PE classes. In the dependent variables group, we searched for the terms *AAs*, *academic learning*, *academic performance*, *cognitive development*, *school achievements* and *testing results*.

The search was carried out in the following databases: Academic Search Premier, SPORTDiscus, ProQuest Education Journals, Education Full Text (H. W. Wilson), ERIC and ProQuest Research Library. In addition, while reading the articles, we came across additional articles in the bibliographical sources quoted by the authors which dealt with the link between PE and AA. We located these articles—50 in number—but included only 25 of them in our review since only these fully fit the inclusion criteria. That is, they dealt with PE and AA, or with relevant research in the field, and were published in peer-reviewed journals. Other articles are quoted in this review for one of the following reasons: they deal with special population groups (Burton & VanHeest, 2007; Trudeau & Shephard, 2008), they are reviews dealing directly or indirectly with the same subject as our review (Bailey, 2006; Murray, Low, Hollis, Cross, & Davis, 2007), the research report was published on the Internet and was quoted in many studies but was not published in a periodical (Hanson & Austin, 2003) and the presentation of the research was not complete (Milosis & Papaionnou, 2007).

Results

Following classification and sorting, we found 25 articles that dealt with the link between PE and AA. We identified three distinct categories into which the articles could be divided:

- (a) The 'political' category, which attempts to justify having PE in schools where academic studies and AAs are at the centre (10 articles);
- (b) The 'interventionist' category, which attempts to prove that PE classes included in the school according to a defined intervention programme impact AAs (10 articles);
- (c) The 'integrative' category, which attempts to pinpoint the way in which PE classes integrated in the daily schedule of students contribute to academic learning (5 articles).

We provide a detailed account of the reviewed studies in each category, and attempt to answer two questions: What is the theoretical basis of the researchers' hypothesis that a link exists between PE and AA? and What are the main findings of the reviewed studies?

The 'political' category

A summary of the 10 studies which were grouped into the 'political' category is presented in Table 1.

Theoretical basis

Studies included in this category primarily attempt to respond to the policy-makers in the education system who claim that schools have to fulfil society's mandate—that is, to lead the students to attain AAs. Therefore, every subject taught in the formal school system should contribute to such achievements (see Murray et al., 2007). The premise of these policy-makers is that the more time allotted to academic studies, the greater the students' AAs. This, as far as they are concerned, justifies cutting out all other (non-academic) subjects since the latter come at the expense of academic learning. Presumably, PE is included in these non-academic subjects. The assumption made in the studies that are included in this category is that this policy is questionable because it ignores the facts about the benefits of physical activity, and therefore their research is aimed at correcting this erroneous assumption (Dollman, Boshoff, & Dodd, 2006).

It is also assumed in these studies that physical activity should be a part of every individual's daily routine. Since children spend a long stretch of their daily lives at school, the school is responsible for providing them with the necessary physical activity to balance their lives in the present and to educate them for an active way of life in the future (Murray et al., 2007). Furthermore, there are children who have difficulty concentrating and becoming integrated into their academic studies, and therefore in the future may drop out of school altogether if they are not given an opportunity to take part in physical activities (Trudeau & Shephard, 2008).

Findings

Research concerning this issue goes back to the 1960s, but the studies essentially were not able to define any significant differences in AAs when comparing groups of students who had received more PE than other groups (see e.g. Shephard, 1996). Two studies carried out in 546 elementary schools in Canada (Shephard, 1996, 1997) examined the impact of an increased number of hours of PE on the AAs of the pupils. The experimental group was given 60 min of PE on a daily basis by PE teachers, while the control group was given their regular weekly hours of PE. In all the schools participating in the studies, part of each class was placed in the control group and part in the experimental group. The control group received

Table 1. The ‘Political’ category (*n* = 10).

Studies	<i>N</i>	Sample	Independent variable (IV)	Dependent variable (DV)	Results relationships IV and DV
Shephard (1996, 1997)	2282	1st–6th graders	Increased no. of hours of PE	Academic achievements	Unproved
Dwyer et al. (2001)	7961	7th–15th graders	Physical activity	Academic performance	Partially proved
Hanson and Austin (2003)	806,000	7th–15th graders at-risk and not at-risk	Participants in PE lessons	Academic achievements	Proved
Wilkins et al. (2003)	547	School principals	Time allocated to art, music and PE	Academic achievements	Unproved
Dollman et al. (2006)	117	1st–6th graders	Average time spent on PE	Standardized test	Partially unproved
Tremarche et al. (2007)	311	4th graders	Hours of PE per school year	Standardized test	Partially proved
Dills et al. (2011)	10,129	Kindergarten–5th graders	Increased recess and PE time	Reading test	Unproved
Simms et al. (2014)	10,210	5th graders	Once or twice a week, 45-min PE class	Reading, math and science	Proved
Telford et al. (2012)	620	3rd–5th graders	PE with specialists	Writing, numeracy and reading	Proved
Telford et al. (2014)	620	3rd graders	PE with specialists	Writing, numeracy and reading	Partially proved

13–14% more time of academic instruction. The findings did not show better AAs among the participants of either group.

Another study (Wilkins et al., 2003) collected data from 547 elementary school principals regarding teaching hours and sociocultural opportunities given by the community of each school. No connection was found between the time dedicated to art, music and PE and the schools' achievements.

The aim of Dwyer and colleagues' (Dwyer, Sallis, Blizzard, Lazarus, & Dean, 2001) study was to examine the link between physical activity and the academic performance of children in Australian schools. Performance data were obtained from assessments given by school sources. These assessments were then compared to fitness measurements made in PE classes. The findings showed a positive, albeit low, correlation between academic performance and the measurements of cardiovascular endurance, muscle strength and the level of physical activity as reported by the children.

A study by Tremarche, Robinson and Graham (2007) examined the impact of the quality of PE on a standardized achievement test. The test was administered to students from two different groups: one group had PE once a week and the other twice a week. The findings of this study showed that the group that had PE twice a week also showed better achievements in language tests, but did not do better than the other group in mathematics.

Dollman et al. (2006) conducted a survey in 117 Australian elementary schools, studying the link between curriculum time spent in PE and the schools' achievements in literacy and quantitative thinking. No data were found to support the claim that students who devoted more time to PE had lower AAs. In this study, a number of factors that made it difficult to find significant links between AAs and various education programmes that also included PE were discussed, among them the students' socio-economic status and the seniority of the teachers in the schools. The researchers stressed that social factors exert a far greater influence on the children's AAs than any school curriculum.

A systematic survey conducted by Murray and colleagues (Murray et al., 2007) concerning a variety of components of a health and PE programme revealed that PE programmes given in school to replace hours that were cut from academic studies did not exert a negative influence on the children's AAs. Similarly, Dills, Morgan, and Rotthoff (2011) reported no statistically significant impact of weekly recess or PE time on student learning for kindergarteners through fifth graders. Their data suggest that a greater amount of recess and PE does not harm student outcomes.

Hanson and Austin (2003) analysed data on 806,000 students in California schools. Their analyses suggest that health risks and low levels of resilience inhibit the progress of schools in raising test scores. Test score gains were smaller in California schools with high percentages of students who did not routinely engage in physical activity and healthy eating; who reported ever being intoxicated, using substances at school or being offered drugs at school; who reported high levels of property theft, vandalism and weapon possession on school grounds; and who attended schools with high numbers of students who felt unsafe at school. Schools with high percentages of students who reported high levels of caring relationships at school, exposure to high expectations at school and participation in meaningful activities in the community exhibited greater subsequent gains in test scores than other schools. These relationships were evident in about 40% of the health risks and resilience measures that were examined. Telford et al. (2012) asked whether PE taught by specialists contributed to academic development and prevention of obesity in elementary school children. Their two-year

longitudinal study involved 620 boys and girls, starting when they were in grade 3, all receiving 150 min per week of PE. One group's PE included 90 min per week from visiting specialists, and the other received all their PE from generalist classroom teachers. Measurements included percentage of body fat and writing, numeracy and reading proficiency. Results demonstrated that specialist-taught PE was associated with greater improvements in numeracy and writing scores, but there was no evidence of an effect on reading.

In another study, the effect of PE taught by specialists on the literacy and numeracy development of primary school children was examined (Telford, Cunningham, Abhayaratna, Telford, & Olive, 2014). Six hundred and twenty boys and girls in 29 Australian elementary public schools received 150 min/week of PE and sport. For 312 children, the programme included an intervention of 90 min/week of PE taught by specialists, and the control group received PE from generalist classroom teachers. Government assessments of writing, numeracy and reading proficiency (NAPLAN testing) were accessed. With adjustment for socio-economic status, and an average improvement of 65 points across all children, specialist-taught PE produced a greater improvement in numeracy, writing and reading than generalist teacher-conducted PE. The researchers concluded that well-designed specialist-taught PE facilitated better academic development in elementary school children, providing strong support for the premise that the development of quality PE enhances academic progress as well.

Simms, Bock, and Hackett (2014) aimed at re-evaluating the efficacy of participation in PE through a more robust model that considers body mass index, AA, self-concept and social skills, while controlling for poor diet and out-of-school activities. The model was conducted on data derived from a sample of 10,210 fifth graders in the Early Childhood Longitudinal Study. They reported that PE was positively associated with AA (effect size = 0.10), and concluded that even at the low 'dosages' reported of one or two PE sessions/week, PE is associated with improvements in mental health, dietary choices and AA.

The studies reviewed in this section examined the existing link between increased hours of PE and an improvement in AAs. The findings of these studies do not confirm the claim that a reduction in the hours of PE raises AAs. However, it was also observed that no unique academic contribution was found following an increase in PE hours at school.

The 'interventionist' category

A summary of the 10 studies that were grouped into the 'interventionist' category is presented in Table 2.

Theoretical basis

There are two basic premises that characterize the studies that were grouped into this category. The first premise claims that there are physical components that impact AA if they are appropriately applied. The proponents of this assumption base their claim on studies that were conducted out of school in laboratory conditions. These studies examined the link between physical activity and its components, such as the duration of the physical activity (Tomprowski, Davis, Miller, & Naglieri, 2008), the level of physical fitness (London & Castrechini, 2011; Yu, Chan, Cheng, Sung, & Hau, 2006) and the intensity of the exercises (Fox, Barr-Anderson, Neumark-Sztainer, & Wall, 2010). The second premise claims that PE classes are the framework for health education, which naturally combines physical activity with theoretical knowledge, and this can impact the students' AAs (Katz et al., 2010).

Table 2. The 'Interventionist' category ($n = 10$).

Studies	N	Sample	Independent variable (IV)	Dependent variable (DV)	Results relationships IV and DV
Sallis et al. (1999)	759	4th graders	Physical activity (SPARK) taught by (a) PE specialists (90 min/week); (b) classroom teachers (90 min/week) Intensity of PE	Standardized math tests	Partially proved
Coe et al. (2006)	214	6th graders		Core class grades $\times$ 4 times + Tera-Nova Standardized tests	Proved
Ahamed et al. (2007)	287	4th–5th graders	Time allotted to the ASBC programme	CAT-3 Standardized tests	Unproved
Martin and Chalmers (2007)	5847	3rd, 5th, 6 th and 8th Graders	Fitness intervention	Academic achievements	Unproved
Carlson et al. (2008)	5316	K–5th graders	Time spent in PE	Academic achievements	Proved for girls, not for boys
Donnelly et al. (2009)	24	2nd–5th graders	PAAC Intervention (90 min/week of moderate to vigorous intensity PA)	Academic achievements	Proved
Katz et al. (2010)	1214	2nd–4th graders	The ABC programme	Academic achievements	Partially proved
Reed et al. (2013)	470	2nd–8th graders	45 min of daily PE	Fluid intelligence and perceptual speed	Partially proved
Ardoy et al. (2014)	67	12–14 years	No. of sessions and intensity	Average school grades	Proved
Ericsson and Karlsson (2014)	129	1st–3rd graders	45 min of daily PE for 9 years	Language and mathematics	Proved

Findings

Carlson et al. (2008) carried out a longitudinal investigation in which the participants were selected as a representative sample of the national school population in the US. The researchers gathered data on five occasions—in the fall in kindergarten, in the spring in kindergarten, in the first grade in the spring, in the third grade in the spring and in the fifth grade in the spring—in order to study the actual length of time allotted to PE classes, as well as to examine the children's achievements in two subjects—reading and arithmetic. It was found that girls who had longer hours of PE (from 70 to 300 min a week) showed better achievements than girls who had the least hours (0–35 min a week). The obtained findings for the boys did not show any differences. Likewise, Ahamed et al. (2007) conducted a study related to the length of instruction time allotted to a structured programme in PE. Students had at least 45 min of PE a week. Their findings showed that the time period was not a variant impacting academic attainment.

Coe, Pivarnik, Womack, Reeves, and Malina (2006) dealt with the intensity aspect of physical activity, as measured by System for Observing Fitness Instruction Time, and how it affects AAs. In their study, the school curriculum enabled the students to select the level of activity intensity. The results showed that the pupils who performed at more intensive levels reached higher levels of AAs. However, since they selected the level of activity independently, one cannot discount the possibility that other variables, such as motivation and socio-economic status, interfered with the examined variables.

Martin and Chalmers (2007) study focused on a physical fitness intervention programme called 'Healthy Children Learn Better', and they assessed the connection between achievements in a physical fitness test and achievement in an academic performance test of children from a Seattle school that participated in this programme. It was found that the physical fitness components that were improved through the intervention programme explain only 3.6% of the AAs' variance.

An additional study (Katz et al., 2010) examined the relationships between AAs and an intervention programme focusing on physical fitness, based on a significant change in the curriculum—Active Bursts in the Classroom (ABC). This programme calls for physical activity to be performed for several minutes at a time in the classroom, in addition to regular PE classes. The programme added at least 30 min of physical activity a day at the expense of the other subjects. This study, carried out in Missouri, encompassed 1214 schoolchildren—655 in an experimental group and 559 in a control group, and was based on significant changes in the curriculum. In accordance with the ABC programme, in addition to regular PE classes, short 'bursts' of physical activity lasting several minutes each were inserted into the academic classes. The findings showed a significant improvement in physical fitness components in the experimental group, such as flexibility and strength. However, no significant differences were found between the two groups in a number of other variables, among them behaviour in class, attitude towards physical activity and test scores in reading comprehension and mathematics. On the other hand, teachers in the control group, where lessons went on uninterrupted, reported better student achievements (Katz et al., 2010).

In another study (Sallis et al., 1999), the Sports, Play, and Active Recreation for Kids programme was used as an interventional framework in which emphasis was given to two variables—duration of activity and a self-management programme. The intervention was administered by the PE teachers and regular homeroom class teachers. Concerning the duration of activity, the programme included three 30-min weekly interventions. The control

group was given half as much time as the experimental group, namely three 15-min weekly interventions. Although the added physical activity was at the expense of academic classes, the academic examination scores of the experimental group did not lag behind the control group. Regarding the variable 'self-management' in the course of PE classes, it was found that the groups that were taught this subject by the homeroom teacher did significantly better in reading, language skills and a whole range of learning fundamentals.

Donnelly et al. (2009) conducted a three-year study aimed at promoting physical activity and decreasing overweight in elementary school children. Physical Activity across the Curriculum (PAAC) promoted 90 min/week of moderate- to vigorous-intensity physically active academic classes delivered by classroom teachers. Results indicated that the PAAC approach promoted daily physical activity and AAs in elementary school children.

In another study, Reed, Maslow, Long, and Hughey (2013) examined the impact of 45 min of daily PE on second-grade to eighth-grade participants, implemented by a PE teacher, on cognitive (e.g. fluid intelligence; perceptual speed) and physical fitness (e.g. aerobic capacity, muscular strength, muscular endurance and body composition) measures. The researchers used a pre-/post-test design with a control group. Their findings demonstrated that the experimental group had significantly greater improvement compared with the control group on 8 of 26 cognitive measures, and on 7 of 16 fitness and body composition measures. These results were more evident among females.

Arday et al. (2014) analysed the effects of an intervention focused on increasing the time and intensity of PE and its effect on adolescents' cognitive performance and AAs. A four-month group-randomized controlled trial was conducted on 67 adolescents. The control group received two PE sessions per week. One experimental group received four PE sessions per week of regular intensity, and a second experimental group had four PE sessions per week of high intensity. Results showed that overall, the experimental group that received four PE sessions per week of high intensity improved more than the other two groups. The authors of this study concluded that an increased intensity of PE classes might play a role in the positive effect of physical activity on cognition and academic success.

In another study, Ericsson and Karlsson (2014) studied the long-term effect of PE over a nine-year period on motor skills and school performance. All pupils born in the years 1990–1992 from one school were included in a longitudinal study over nine years. An intervention group received 45 min of PE daily, and the control group had 45 min of PE twice a week. After nine years, 96% of the pupils in the intervention group compared to 89% in the control group qualified for upper secondary school. The sum of their marks was higher among boys in the intervention group than in the control group. The researchers concluded that daily PE during compulsory school years is a feasible way to improve motor skills and school performance, as well as to increase the proportion of pupils who qualify for upper secondary school.

The findings of the 'interventionist' category are not unequivocal. Rather, intervention programmes differ in many aspects—their content, intensity, duration, frequency and the amount of physical activity that they offer. These intervention programmes have no common denominator that enables us to reach any firm conclusions regarding the relationships between physical activity and AAs. Furthermore, the reporting in these articles is essentially about the level, time and intensity of physical activity, which is one part of being physically educated, but not the only part. Lacking in the literature are the cognitive, social and affective claims that could be made for PE and for PE's claim of fostering AA.

Table 3. The ‘Integrative’ category ($n = 5$).

Studies	<i>N</i>	Sample	Independent variable (IV)	Dependent variable (DV)	Results relationships IV and DV
Caterino and Polak (1999)	177	2nd–4th graders	Physical activity integrated into the academic classes	Concentration	Proved
Reed et al. (2010)	155	3rd graders	Physical activity integrated into the academic classes	Fluid intelligence and academic achievements	Partially proved
Shoval and Shulruf (2010)	364	2nd–3rd graders	Mindful movement in the academic classes	Academic achievements	Proved
Lynch (2005)	3 primary schools	1000+ students and their teachers	Implementation of Health and PE programmes in schools	Academic performance	Proved
Lynch (2013, 2015a)	376	Principals/head teachers	Health and PE programmes in schools	Principals’ perception of academic performance	Proved

The ‘integrative’ category

A summary of the five studies that were grouped into the ‘integrative’ category is presented in Table 3.

Theoretical basis

The integrative category is actually derived from two different theoretical sources that share the claim that physical activity has a direct and immediate impact on learning ability, and therefore that settings in which physical activity is combined with academic learning, or in which both occur simultaneously, should be studied.

The first source is physiological: intensive movement increases the pulse and blood circulation in the body, supplies oxygen to the brain and improves learning performance. It was observed that physical activity influences a number of factors associated with the development of the nervous system (e.g. Vaynman & Gomez-Pinilla, 2006; Vaynman, Ying, & Gomez-Pinilla, 2004). Although the exact impact of physical activity on the brain is still unknown, a number of researchers claim that systematic and consistent physical activity generates general changes in the function of children’s brains (e.g. Jensen, 2000). Some of the functions that were investigated are attention, concentration and memory, but opinions remained mixed regarding the impact of PE classes on children’s memory. Research has shown that physical activity reduces anxiety and heightens positive attitudes, helping children concentrate better (Caterino & Polak, 1999). Pellegrini and Bohn’s (2005) study on the relationship between schoolchildren’s behaviour during recess and concentration during classes showed that moderate physical activity and social activity improve concentration, whereas lack of activity or the opposite—performing intensive activity—diminishes it. These results are in line with Jensen’s (2000) claims about the importance of recess in learning: taking a break from class enables children to shape and organize their memory, and movement during the break from classes also affects memory in these respects.

The second source is connected to active learning or ‘mindful movement’ (Shoval & Shulruf, 2010), in which children have movement-aided learning of academic subjects. According to this source, movement enables children to experience their learning environment, which activates their kinesthetic perception (Jeannerod, 2005), supplying unique

information that cannot be provided by movement-less learning. This information concerns the location of the body in its environment, the place of each one of the limbs, changes in the whole body's location or in one or more of the limbs, the weight of objects in relation to the body and the assessment of the size of objects compared to the body. Movement also enables visual and kinesthetic demonstrations that turn abstract concepts into concrete processes (Shoval & Shulruf, 2010). In addition, movement enables children to learn through social interaction, which naturally involves movement; children imitate each other's movements and observe how others deal with (movement) challenges and physical contact, again helping them learn from one another. These processes are part of learning, and furthermore they enable children to spend longer stretches of time in learning activities and encourage them to persevere.

Findings

In one study (Caterino & Polak, 1999), 117 young students were divided into two groups: one group continued to study in their classroom, while the other did 15 min of physical activity in a gym, which included stretching and walking. Immediately following the activities, the schoolchildren were tested for concentration. The results showed that of all the fourth graders who were given the concentration test, the group that had performed physical activities achieved better than the others.

In another study, Reed et al. (2010) aimed at examining the impact of PE integration in academic curricula on schoolchildren's fluid intelligence and AAs. Teachers who participated in the experiment inserted physical activities into the research group's classes, which included a total of 80 children. They required the children to walk approximately 1200 steps for 30 min a day, three times a week, for 4 months. The experimental group achieved significantly better results than the control group on the fluid intelligence test and on standard social studies tests. The researchers came to the conclusion that movement can have an impact on fluid intelligence, and that this kind of activity seems to influence the cognitive development of elementary school children. In their review regarding the impact of physical activity on cognitive functioning, Tomporowski et al. (2008) reported similar findings.

In another study (Shoval & Shulruf, 2010), 262 schoolchildren were divided equally into two groups: an experimental group that learned in cooperative sub-groups about angles in a geometry class, and a control group that maintained its regular learning (no cooperative activities). The researchers observed several learning behaviours in both groups: physical contact with the learning environment, use of visual-kinesthetic demonstrations, socio-kinesthetic interaction, verbal interaction and the length of time the children spent in movement-aided learning activities. It was found that the experimental group had higher achievements than those in the control group, and that the more the learners exhibited the aforementioned learning behaviours, the higher their achievements. In this same study, it was found that weak learners in the experimental group improved significantly more than their peers who had started at a higher learning point.

Lynch (2005) conducted an evaluation of school responses to the introduction of the Queensland 1999 health and physical education (HPE) syllabus, and of policy documents, in three Brisbane Catholic primary schools. He reported that students linked quality HPE to improved academic performance: 'They thought that physical activities enhanced their enjoyment of learning within the classroom in other key learning areas through relieving stress, enhancing motivation and increasing concentration' (p. 220). In two other studies

(2013, 2015a), Lynch examined 376 primary school principals/head teachers from a cross section of Australian Government schools representing every state and territory, region and size, regarding their perceptions about the implementation and outcomes of this programme. This series of studies led to the conclusion that a monitored, well-designed, nationwide programme enhances students' all-around performance.

Although the body of research concerning the integrative relationship is still limited in scope, the direct and immediate associations are promising about such relationships and warrant further research.

Discussion

Following our review of the theoretical basis and the findings of the studies in each designated category, we will discuss each category with regard to the following two questions: What is the significance of the findings for the understanding of the relationships between PE and AA? and What are the advantages and the limitations in each of the categories?

The 'political' category

Significance of the findings

Based on the findings discussed in this category, it cannot be argued that a limited reduction in the hours in the academic curriculum lowers AAs, and therefore there is no point in cutting PE hours from the school's curriculum (Murray et al., 2007). Moreover, it is important to form good health habits among pupils by providing them with PE classes on a daily basis, starting in elementary school (Wilkins et al., 2003).

Advantages and limitations of the reviewed studies

The studies we describe in this category focus on a large sample of participants, and therefore allow us to consider this sample as a valid generalization. There is general agreement among the researchers that PE classes do not detract from the AAs of the children, even in the instances where they are provided at the expense of the academic instruction. These studies present data that can be taken into account by policy-makers, showing that academic learning cannot be made more effective simply by cutting PE hours.

The main difficulty with these studies is that there are no data on the content taught in PE classes, or on the way it was taught. The reasons behind the findings remain largely unknown, and they may have nothing to do with the advantages or disadvantages of PE, but instead may relate to other variables, such as a change in the learning routine. If this is the case, then it makes no difference if children have PE classes or art classes in addition to their academic classes (Wilkins et al., 2003). Another explanation of the findings might be that the teachers were well organized when handling their workload. Those teachers who taught academic subjects might have been better focused in their classes due to the reduced hours, or may have organized their teaching in such a way as to cover all the learning material. The results might also be explained by the possibility that forces stronger than the teaching process were at play, such as the socio-economic background of the children, the parents' level of education and the children's extra-curricular learning activities, which could have had a stronger impact than the teachers' efforts at school.

The 'interventionist' category

Significance of the findings

The current research has not been able to comprehensively pinpoint what variations in PE may affect AA (see Martin & Chalmers, 2007). The length of PE classes and the level of the physical fitness of the children were not found to affect AAs (Ahamed et al., 2007). However, the intensity of physical activity is a new variable that seems to be more promising in the attempt to determine the relationships between PE and AAs, and therefore is worthy of exploration (Coe et al., 2006). In this respect, Wittberg et al. (2010) succeeded in defining in fifth graders the point at which AAs of the individual rise, showing that achievements of running one mile in 9 min for boys and 12 and 30 running cycles on the Progressive Aerobic Cardiovascular Endurance Run for girls were positively correlated with AAs. The disparities that emerged between boys and girls may stem from the fact that boys are a priori more active and more physically fit than girls, and therefore the additional PE time the boys receive may not impact their AAs (Carlson et al., 2008). Another finding revealed that when in the course of PE classes other learning-aided contents are added, such as learning-managing skills, the transition from PE to academic subjects is likely to improve (Sallis et al., 1999).

Advantages and limitations of the reviewed studies

The search for variables in PE that are likely to impact academic learning is important in the light of the data that emerged from the 'political' category, which show that PE, even when given to schoolchildren on a daily basis, does not ensure academic improvements. When researchers examine the impact of PE on a population by taking a large horizontal slice, they find it difficult to control confounders that exert a stronger influence than any educational curriculum. One such variable might be the children's socio-economic status, which is a strong predictor of AAs and of participation in physical activity (Trudeau & Shephard, 2008), and therefore it is not surprising that the results of the reviewed studies are not uniform. Bailey (2006) concluded that contributions to social processes can be either positive or negative, and if they are to be positive, they should be purposefully structured with a goal in mind. This may very well be true in the case of achieving academic scores. When comparing the findings of the different studies included in the 'interventionist' category, a number of aspects should be taken into account, among them the differences in the duration of the interventions, the contents of the PE programmes and the teachers' skill level.

The 'integrative' category

Significance of the findings

PE can exert a positive influence on AAs when PE and academic instruction are integrated into the education system (Myotin, 1992). This integration would require significant changes in both the curriculum and the school system, as well as a transition from a strict division of defined subjects to a new system in which students would be taught with an integrative approach.

Advantages and limitations of the reviewed studies

The advantage of the studies included in this category is that the examined physical activity was used as a teaching strategy for attaining higher AAs, and consequently the influence on AA could be established on a direct theoretical foundation. Moreover, the reviewed

studies allow us to examine the links between behaviour in the course of instruction, learning and the pupil's achievements. A drawback of these studies is that they require setting up a special, albeit temporary, research environment in the schools due to the fact that integrative curricula that integrate subjects as diverse as PE and geometry, for example, are rare in the current education system.

One general limitation that should be addressed is that a greater appreciation of focal points in this area, such as cognitive value, assessment and evaluation, might have helped in the literature search, and could have yielded a broader range of articles. However, since we were interested in concentrating on the terms *physical activity*, *physical fitness* and *movement*, and not on a broader set of associated terms such as social benefits and emotional benefits of PE, we decided on narrowing the search.

Conclusions

Our classification of the reviewed studies into three categories—the 'political' category, the 'interventionist' category and the 'integrative' category—enables us to reach a number of conclusions. The studies we reviewed in the 'political' category show that PE classes do not hinder schoolchildren's AAs. The studies included in the 'interventionist' category focused on a number of variables, such as the length of the physical activity, the intensity of the physical activity and the strengthening of children's physical fitness, which are only a few of the possibilities to consider when attempting to determine the link between PE and AAs. The studies in the 'integrative' category suggest that if we want that PE will positively influence academic, then PE and academic instruction should be integrated and significant changes in both the curriculum and the school system are needed.

Our results are in line with the conclusion presented by others (e.g. Bailey et al., 2009; Brown & Penney, 2013; Rink & Mitchell, 2002; Thorburn, 2007) that it might be beneficial to integrate PE with cognitive variables such as problem-solving and planning, or personal variables such as self-esteem, self-concept and focusing on goals, and then to examine their link to AAs. The findings of the current review encourage expansion of the reviewed studies in two main directions. First, future studies should be extended to other subjects and populations. Second, research should also be focused on the way learning is acquired. For example, the cooperation of PE teachers with the other class teachers will most likely enable physical activity to exert a positive effect on the learners. An example of this is the GEAR (Geocoaching for Exercise and Activity Research; Maeda & Murata, 2004) programme, in which PE teachers and the other class teachers cooperate on a daily basis. Lynch (2015b) also addressed this issue. His study's findings suggested that PE is best implemented when teachers work together—both specialist PE teachers and classroom teachers. Such an approach involves a programme for each of the HPE strands, and enables opportunities for the staff to communicate openly about implementation of the HPE curriculum. He claimed that addressing these issues can promote and strengthen the school's implementation of the HPE curriculum.

It should be noted that qualitative research in this area is lacking. This void should be filled since it would then be possible to question teachers and learners about the actual link between PE and academic learning, extending from Lynch (2005). One of the questions that should be asked is whether the link between the two is positive and whether this matter should be pursued further.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Sima Zach is the head of the School of Education in the Zinman College of Physical Education and Sport Sciences at the Wingate Institute, Israel. She is also the director of Teacher Education Program. Her research interests are in sport psychology, physical education psychology, sport pedagogy and psychology of leisure-time physical activity.

Ella Shoval is a senior lecturer and until her retirement in 2013 served as the head of the Early Childhood Physical Education Department at the Zinman College of Physical Education and Sport Sciences at the Wingate Institute and coordinator of the MEd Program of Physical Education at The Washington College of Education, Israel. Her areas of interest include curriculum theory, teaching education and learning through the movement of the body.

Ronnie Lidor is a professor of Motor Behavior and is the director of the Zinman College of Physical Education and Sport Sciences at the Wingate Institute (Israel). His main areas of research are cognitive and learning strategies, talent detection and early development in sport, and sport development.

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