Does Classroom-based Physical Activity Influence Test Results?

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Abstract

The traditional view of intelligence is based on the belief that it is static, genetically inherited and does not change much as a result of education. However, cognitive neuroscientists agree that well-balanced nutrition, nurturing environment (organized learning experiences) and exercise are critical to brain development. There have been a number of intervention techniques which could be incorporated into the curriculum, especially during the implementation of classes, in order to enhance learning and improve students' academic performance. Classroom and activity-based intervention is one of those techniques. It is based on the assumption that children need to develop specific motor skills, at critical developmental stages, for efficient neurological and intellectual development. The main purpose of the present research was to test whether or not some classroom activity-based intervention would enhance students' test results. The design of the research was based on three basic steps as pre-test, intervention/treatment and post-test. Although the students in the experimental group performed slightly better than those in the control group after the intervention, there was no statistically significant diffrence between the means of experimental and control groups on the post test. The results could have implications for pre-service and in-service teacher training curriculum developers.

Key Words: learning, physical activity, academic performance, brain energizers, curriculum

Introduction

Neuroscientists, curriculum developers and, in fact, all educators have a common goal of understanding parameters which affect learning phenomenon. Neuroscience, especially cognitive neuroscience, provides compelling evidence of brain development which has implications for education policy makers. We, as educators, would like to know the conditions for optimal brain development and brain functioning so that the learning environment can be created accordingly. The traditional view of intelligence is based on the belief that it is static, genetically inherited and does not change much as a result of education. However, cognitive neuroscientists agree that well-balanced nutrition, nurturing environment (organized learning experiences) and exercise are critical to brain development (Education Services Australia, 2010).

There is no doubt that genetic factors play an important part with regard to one's mental and physical capacity and determine many innate characteristics. However, the human brain needs stimuli to grow. It was emphasized in many scientific papers that major developments in the human brain occur after birth as a result of interactions with the environment (Shore, 2001).

Research findings reveal that if a child receives limited or low levels of sensory input like hearing few words, and receiving limited physical touch and social interaction, this could cause underdevelopment in the brain (Perry 2002, p. 92).We now know that learning is not just a behavioral change as some once claimed. In fact, when a learner learns something new, his or her brain structure physically changes. Knowing that is important since it shifts the focus dramatically from teacher to learner. There are a number of factors which influence learning processes other than genetic ones. As briefly mentioned above, some of those factors are nutrition, the way the parents interact with the child during the critical developmental stages, daily experiences, physical activity, love and nurture the child receives (Brotherson, 2005).

The human brain weighs on average 1.36 kg and comprises only 2% of the human body. However, it consumes more than 20% of the oxygen and nutrients that the body takes in. Over the last several decades a considerable amount of effort has been devoted to connecting advances in neuroscience research to educational interventions for enhanced learning. There seems to be a growing need to improve teacher instruction and student learning based on a scientific understanding of how the brain functions (Ansari, 2008; Goswami, 2006).

Developments in the field of neuroscience have enhanced our medical and psychological understanding with regard to how the brain functions (Wolfe & Brandt, 1998). In addition, recent developments in imaging technologies, like Functional Magnetic Resonance Imaging (FMRI), allow us to observe the process of brain development before and after birth. Neurons have branches or dendrites emerging from the cell body. These dendrites pick up chemical signals across a synapse and the impulse travels via axons. The electrical impulses cause the release of the neurotransmitters, which in turn, stimulates or inhibits other dendrites.

As a result of these electro-chemical signaling connections, neuron-networking occurs. A single brain cell has the potential to connect with as many as 10,000 other cells. This incredibly complex networking process is often referred to the brain's "circuitry" or "wiring." Experiences and stimuli that the brain is exposed to have a great deal of influence on the way this neuron-networking takes shape. A remarkable increase in synapses occurs during the first year of life. The brain develops a functional architecture through the development of these synapses or connections (Duman, 2009). Needless to say the brain’s primary source of energy is blood. Through blood circulation, the brain gets nutrients like glucose, protein, trace elements, and most importantly oxygen. It is estimated that the brain gets around 8 gallons of blood each hour.

Moreover, water provides the electrolytic balance for proper functioning. Experts recommend that the brain needs 8 to 12 glasses of water per day for optimal functioning (Jensen, 1998). It is important to prevent dehydration which is a common problem in schools. Hannaford (1995) mentioned that dehydration leads to lethargy and impaired learning. The human brain has approximately 100 billion neurons at birth. Each neuron has the potential to connect to the other 10,000 neurons and this means about 1 billion potential connections. A new connection between brain cells and newly established neuron networks is called learning (Duman, 2009).

Neurons have bodies, dendrites and axons. They are responsible for information processing, sending and receiving electro- chemical signals back and forth. A normal functioning neuron fires, gets connected with other neurons and generates information continuously. Jensen (1998) stressed that the brain needs to get more oxygen and less carbon dioxide for higher levels of attention, mental functioning, and healing.

Therefore, we need to make sure that students get enough amounts of oxygen to maintain their alertness and cognitive functioning. Therefore, at schools educators need to make sure that students have plenty of opportunities to move in order to enhance blood circulation, classrooms are regularly ventilated and students have adequate daily water intake. Physical exercise is believed to be one of the most important variants that affect the learning phenomenon. One of the first parts of human brain to develop is called the cerebellum. Commands related to motor activities are given and controlled from this area. For this reason, the creation of action-oriented learning environments is especially important during childhood.

It is worth asking ourselves as educators about how much opportunity we give to our students move in a large and specious area. Jensen (1997) reported that in the 1960s children spent approximately 100 hours sitting in a car and the duration has increased to 500 hours on average in 1995. Those passive hours should be spent in wide areas where children move freely and planning should be done accordingly. For one thing, moving in large areas from infancy onwards is now known to have a positive effect on learning. A recent survey revealed that children who spend more time on physical education, regardless of their socio-economic status, exhibit superior performance in academic subjects such as maths and reading (Hillman & Erickson, 2008).

There have been a number of intervention techniques incorporated into the curriculum, especially during the implementation of classes, in order to enhance learning and improve students' academic performance. One of those intervention techniques or approaches is called "Brain Gym." This approach is based on the assumption that children need to develop specific motor skills, at critical developmental stages, for efficient neurological and intellectual development. It further claims that a lack of such motor skills developed at those specific stages could cause complex difficulties later on and could also result in learning difficulties. The main purpose of the present research was to test whether or not some classroom and activity-based intervention would enhance students' test results in the "Science Competency Test" at the 4th grade primary school level. The results have implications for pre-service and in-service teacher training curriculum developers.

Literature review & theoretical framework

Active participation in any kind of physical activity is believed to have a positive impact on children's physical and mental health (Strong and et al, 2005). Moreover, there are a number of research studies conducted in the literature claiming that increased participation in sports and/or any other forms of physical activity would enhance cognitive functioning like improvement in memory and concentration, behavior and academic performance of the students. Dexter (1999) reported a positive link between sport performance and academic ability.

Fox et al (2010) also found correlations between sports participation of middle and high school children with higher grade point averages. Also, Castelli et al (2007) conducted a research on the correlation between fitness and test scores which included 259 students in the 3rd through 5th grades. They reported a positive correlation between fitness and test results of the students in maths and reading. We need to understand how physical movement affects the human brain and have an in-depth knowledge about the internal mechanism.

New research findings suggest that the effect of exercise first occurs in the muscles (muscle contraction and relaxation) then in the brain with the protein called IGF (Insulin like Growth Factor) which is generated as a result of this.

The IGF produced in muscles reaches the brain through blood and triggers the formation of neurotransmitters.BDNF (Brain Derived Neurotrophic Factor) is one of these essential neurotransmitters in providing the communication between the two brain cells (BDNF level increases in people who do regular exercise and as a result of this dendrites occur in brain neurons). This situation sets up a substructure for the probability of neuron-network occurrence that is to establish new learning. In summary, the IGF produced in muscles triggers the formation of BDNF and BDNF forms the learning substructure and eases communication between the two brain cells (Ozdinler & Macklis, 2006).

In parallel with the above, physical exercise is believed to be one of the most important variants that affect the learning phenomenon. One of the first parts of the human brain to develop is the part called the cerebellum. Commands related to motor activities are given and controlled from this section. For this reason, the creation of action-oriented learning environments is especially important during childhood. Teachers and parents should think about how passive hours children spend could be turned into some kind of physical activity.

We know that moving in large areas from infancy onwards has a positive effect on learning. A recent survey revealed that children who spend more time on physical education, regardless of their socio-economic status, exhibit superior performance in academic subjects such as maths and reading (Hillman & Erickson 2008). Approximately 20 years ago, scientists used to believe that the brain cells die rapidly from the age of 30 and are not renewed afterwards. However, in recent years, especially experiments conducted on animals have shown that new nerve tissue can be produced in the brain with exercise. Unfortunately, doing sports at certain times is not enough.

To maintain the positive effects of exercise on our brain we should exercise regularly. It has been scientifically proven that physical activities have a positive influence on concentration, memory and classroom behavior. Research proves the correlation between physical activities and intellectual performance. Therefore, physical activities can be added as extracurricular activities to the school curriculum by taking time from other subjects without risk of hindering student academic achievement. On the other hand, adding time to "academic" or "curricular" subjects by taking time from physical education programmes does not enhance grades in these subjects and may be detrimental to health (Trudeau, 2008)

Scientific data suggests that extra physical activities incorporated into the school curriculum could increase academic achievement even if curricular time for so-called academic subjects is curtailed. Extra physical activities are likely to increase attachment to school and self-esteem which are indirect but important factors in academic achievement. A Canadian study found that the time allocated to physical activity was positively correlated with the time that children spent in reading (Feldman and et al, 2003).

It is common sense to suggest that parents concerned with the health and academic success of their children should be focusing on the prevalence of various metabolic pathologies in which sedentary behavior plays a key etiologic role, such as obesity and diabetes, both of which appear at an ever younger age (Taras & Potts, 2005). Such pathologies have the potential to greatly deal to influence school performance of children adversely. Many questions and hypotheses remain to be researched vis-à-vis the relationship between academic performance and physical exercise. However, there is enough scientific evidence to believe that extra physical exercise incorporated into the school curriculum would have positive effects on children.

There have been some interventions and suggestions for curriculum developers to consider with regard to incorporating certain physical exercises into regular school programmes with a view to enhancing the efficiency of learning. One of those suggestions is called Brain Gym®.

According to Dennison (1981), "Brain Gym®" is the product of clinical work he conducted in 1969. It is further claimed that systematic use of specific body movements, in addition to deep breathing and a plentiful intake of water, can prepare the human brain for optimal learning regardless of age and socioeconomic status. The underlying principle of Brain Gym® is that learning can be enhanced through simple and specific movements which would in return stimulate both hemispheres of the brain to work in a balanced way.

Dennison & Dennision (1985) claimed that, when the left and right hemispheres of the brain work in harmony, one could function in a more integrated and coordinated manner. Khalsa et al (1988) and Sifft et al (1991) reported improvements in their research with students on perceptual-motor skills such as balance and visual response times after the use of Brain Gym® techniques. The underlying assumption of this approach is that there is a kind of connection between certain body movements and physical exercise with neuron-networking. It is claimed that through these physical exercises or manipulations, the brain reaches its optimal conditions for learning and acquisition of academic skills (Hyatt, 2007, p. 118).

Some researchers like Spaulding et al (2010), however, approached Brain Gym® with caution stating that "While much has been written about Brain Gym® and its applications in academic, athletic, and professional settings, the efficacy of Brain Gym® has generally not been subject to careful and rigorous investigation." (p.11). Similar comments could also be found in the literature. For instance, Hyatt (2007) stated that research articles on the same issue "clearly failed to support claims that Brain Gym® movements were effective interventions for academic learning" (p. 122).

Methodology

Research design

The main objective of the present research was to test whether or not some basic classroom-based physical activities, as the intervention, like warm-ups, stretching and some physical brain energizing exercises would improve students' test results in the science course at the 4th grade primary school level. Therefore, the null and alternative hypothesis of the present research were as follows;

Null hypothesis: There is no statistically significant difference between the means of the experimental and the control groups in the post tests in the in the "Science Competency Test (SCT) after the intervention/treatment on 4th grade primary school students. Alternative hypothesis: There is a statistically significant difference between the means of the experimental and the control groups in the post tests in the "Science Competency Test (SCT) after the intervention/treatment of 4th grade primary school students in favor of the experimental group.

The research approach and procedure

The design of the present research followed 3 basic steps "pre-test, intervention/treatment, and post-test."

With regard to population and sample of the present study; The research was conducted in a k-12 school based in Istanbul in Turkey. In that school there were a total number of 8 4th grade primary school classes which were considered as the population. 4 out of 8 of those classes were involved in the research as the sample. Details are provided further in this section of the paper.

Below is the description of the brain energizers and physical exercises used in the present research as the activity-based intervention/treatment:

The following pool of activities was performed and repeated several times together with the science teacher and the students in the Experimental Group (EG). Both the science teacher and the students in the EG were trained by one of the physical education teachers who received extensive training from the researcher.

The teacher was free to form any 5-minute combinations of physical activity out of the exercises given below. A special video was developed by the physical education teacher, led by the researcher, together with a theoretical information pack prepared for the science teacher and the students in the EG. In addition the pictures of the movements of those brain energizers and physical exercises were found from the internet, cut out, framed and displayed on the walls of the EG's classrooms as additional visual guides.

The following are the classroom and activity-based physical exercises, considered as the intervention:

- Basic warm up exercises
- Basic stretching exercises
- Pressing on brain buttons (Using thumb and forefinger of one hand, vigorously massaging soft spots beneath clavicle for about one minute. Hold other hand flat against navel).
- Cross movements (touching the left knee with the right elbow and vice versa, turning the head looking right while touching the shoulder with the right hand and the like).
- Drawing an imaginary shape of a square or a triangle in the air with the right index finger while moving the left index finger up and down.
- Deep breathing

Students in the EG were also encouraged to drink water before and during the class. It has to be stressed that the present research was not designed to test the effectiveness of "Brain Gym®" commonly referred to in the literature, on academic performance. However, it is true that some of the activities of Brain Gym® were part of the intervention of the present research.

The research was conducted in a K-12 foundation (non-profit) school based in Istanbul. There were altogether 8 classes studying at the 4th grade in that school. 8 primary school classes at the 4th grade were given a test called the "Competency Diagnosis Test in Science" (CDTS). Table 1 below shows the class numbers, means, number of students in each class, standard deviations and variances of 4th Graders in the CDTS of all the 8 classes.

Table 1: Class number, Means, Ns, Standard Deviation and Variance of 4th Graders on CDTS

Class Number	Mean	N	Std.Dev.	Variance
4-A	69,13	23	13,112	171,937
4-B	71,36	22	9,902	98,052
4-C	75,42	24	10,624	112,862
4-D	73,18	22	11,291	127,489
4-E	65,42	24	13,507	182,428
4-F	72,80	25	9,798	96,000
4-G	68,40	25	11,431	130,667
4-H	70,42	24	12,329	151,993
Total	70,74	189	11,737	137,746

Findings and data analysis

On the basis of the above data, One-way ANOVA was performed using SPSS to see the homogeneity of the 8 classes with regard to their test results in the CDTS. Table 2 below shows One-way ANOVA results of the 8 classes of the 4th graders on CDTS

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Table 2
ANOVA of 8 classes on CDTS

Scores	Sum of Squares	df	Mean Squares	F	P
Between Groups	1649,824	7	235,689	1,759	,098
Within Groups	24246,472	181	133,958		
Total	25896,296	188			

As can be seen from Table 2 above, there is no statistically significant difference between the means of the 8 classes in the CDTS (p= 0,098 against predetermined alpha level of p< 0,05). Therefore, it can be stated that in terms of the test results of 8 classes in the Competency Diagnosis Test on Science (CDTS), all of the 8 classes of 4th graders are homogeneous. Because of the homogeneity observed, 4 out of 8 classes were selected randomly. Out of these selected 4 classes, 2 of them were assigned as the "Experimental Group" symbolized as "EG" and the other two groups assigned as the "Control Group" symbolized as "CG".

Science classes for both the EG and the CG were held by the same science teacher and the topic was "The Nature of Substances." Under this topic students studied the following subtopics: Object, substance, materials, transparent materials, opacity, process of freezing, melting & evaporation, natural & artificial materials, pure & processed materials, solution, homogeneous and heterogeneous blends. This specific topic was selected in consultation with the teacher on the basis of the principle that it was regarded as one of the most difficult subjects to be grasped by the students. The teacher also expressed that most students find this topic boring. It was thought that if an easy topic had been selected, the effect of the intervention could not have been observed.

Both the EG and the CG took the same pre-test in the selected subject of "The Nature of Substances". Table 3 and Table 4 below show means of both the EG (70.60) and the CG (71.11) and also results of the Independent Samples Test (t-test) applied to see if there is a statistically significant difference between the means of EG and CG on the pre-test.

Table3
Pre-Test Results of EG and CG on The Nature of Substances

Scores	N	Mean	Std.Deviation	Std. Error Mean
EG	50	70,60	10,768	1,523
CG	45	71,11	12,289	1,832

Table 4 : Independent Samples Test / Pre-Test on SCT

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Dif.	Std.Err.Dif	Lower	Upper
Equal variances assumed	0,227	0,635	0,216	93	0,829	-,511	2,366	-5,209	4,187
Equal variances not assumed			0,215	88,063	0,831	-5,11	2,382	-5,245	4,223

Table 4 above shows that the mean differences between the EG and the CG in the pre-test in the SCT. As can be seen above, the mean differences are not statistically significant (p=0,829>0,05) in the pre-test.

The science teacher received around 10-hours training on the physical exercises used as an intervention in the present study. In addition to the practical aspect, the science teacher was also given the theoretical support explaining the effect of physical exercise and brain energizers on concentration and brain activity. The students in the EG also received the same training from the same physical education teacher. In addition to 10-hours training, the students in the EG were asked to repeat those exercises during their regular physical education classes. Students in the CG received no training and no intervention was applied during the classes held on the selected science topic.

The selected topic was studied by all the students both in the experimental and control groups with the same science teacher. It took 8 sessions/classes to cover all the sub-topics. Each class took 40 minutes. In other words, it took 320 minutes to cover the entire topic by both the EG and the CG. 40 minutes were allocated for each lesson. Students in the EG were asked to do the brain energizers and physical exercises as described above for 5 minutes as an intervention at the beginning of each lesson and after 20 minutes of each lesson's commencement.

Students in the CG studied the same topic with the same amount of time allocated and with the same science teacher like any other regular classes without the intervention. The hypothesis of the present study was based on the understanding that such intervention could help students send more oxygen to their brains, increase their concentration level and stimulate their brain function in a hemi-spherically integrated way (balance between the right and the left hemisphere of the brain).

In return, this would create an optimum learning state of mind. Table 5 below shows the means of both the EG and the CG in the post-test in the SCT.

Table 5: Post-Test Results of EG and CG on SCT

Scores	N	Mean	Std.Deviation	Std. Error Mean
EG	50	86,20	8,781	1,242
CG	44	85,00	10,675	1,609

Table 6 below shows differences between the means of EG and CG on the post test of SCT.

Table 6: Independent Samples Test /Post-Test on SCT

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Dif.	Std.Err.Dif	Lower	Upper
Equal variances assumed	2,250	0,137	0,598	92	0,551	1,200	2,088	-2,787	5,187
Equal variances not assumed			0,590	83,479	0,557	1,200	2,033	-2,843	5,243

As can be seen from Table 6 above there is no statistically significant difference between the means of the EG and the CG in terms of post test results in the SCT (p=0,551>0,05). Therefore, the findings of this study fail to support the alternative hypothesis.

Discussion

On the basis of the results presented above, the intervention applied in this research did not cause a statistically significant difference in the post test results of both the EG and the CG in the “Science Competency Test” for the selected 4 classes in the 4th grader. However, even if 10 minutes were spent for the intervention for each lesson (5 minutes at the beginning and 5 minutes after the commencement of each lesson) an increase in the means of the EG in the post test results was observed as illustrated on Table 5. This is in line with some similar research findings showing that even if curricular time for academic subjects is curtailed and additional time is allocated for physical activity, this did not affect the academic performance of the students negatively (Trudeau & Shephard, 2008). Although no significant effect of the intervention was found, the science teacher expressed the view that “students in the EG and myself included enjoyed using the classroom-based physical exercises and brain energizers and we really had fun.”

The science teacher went on to say that “At the beginning I was afraid of wasting time on the intervention and therefore not to having enough time to cover all the sub topics. However, although 10 minutes were allocated for the intervention, this didn’t have any negative influence on the test results at all.”

Therefore, curriculum developers could think about incorporating classroom and activity-based exercises into the regular curricula at all levels so that both teachers and students have fun while learning. Considering the fact that children, especially at a young age, lose their concentration easily, it is strongly believed that similar classroom-based activities could be part of pre-school teacher training curricula so that prospective teachers have innovative techniques to use as and when required.

The findings of the present study could be partially attributed to the way the science teacher implemented the classroom and activity-based intervention/treatment. If the same intervention/treatment had been implemented by the physical education teacher, who trained the science teacher, the results could have been different. It should also be discussed that a number of research findings, as presented in the section titled “Literature Review and Theoretical Framework” of this paper, show correlations between physical activity and improved school performance.

However, almost all of those research designs relied on relatively longer periods of time allocated to physical activities than the time spent on classroom-based physical activities within the scope of this paper.

As explained in the design section of this study, the present research was based on the effect of classroom-based physical activity. It could be argued that maybe the allocated time for those classroom-based activities was not long enough to trigger IGF and BDNF mechanisms to create the optimal learning state in the brain, as explained in the theoretical framework section of this paper. It is worth reemphasizing that the present study was not designed to see the influence of “Brain Gym®.”

In the Brain Gym® programme, there are about 26 simple and specific movements which are claimed to stimulate both hemispheres of the brain to work in harmony and in a synchronized fashion and therefore learning is enhanced. Dennison (1981) mentioned about four categories of Brain Gym® exercises; midline movements, lengthening activities, energy exercises, and deepening attitudes. Dennison & Dennision (1985) also claimed that when the two hemispheres of the brain are working in harmony, individuals could function in a more integrated and coordinated manner. In the present study, the teacher was free to form classroom and activity-based physical activities which are not necessarily included in the Brain Gym®.

It is obvious that the possible relationship between the physical activity, at different lengths of physical activity and enhanced learning is to be further examined. It seems that more empirical data is required to substantiate the claims about the relationship between physical activity and learning which improves by various degrees according to the time allocated.

Recommendations

- 4th graders were included in this study. It is recommended that the present research study be repeated involving all grades in a k-12 school setting. This would allow us to see if the intervention could be influential for younger or older students.
- The intervention was applied covering only one selected topic which took 8 sessions/classes (320 minutes). It is worth testing the same hypothesis with a longer period of say with 2 or more topics to cover.
- It is recommended that the intervention described above be revised to extend the scope of it and go beyond classroom-based physical activities. Therefore, it is highly recommended that increased time for regular physical education lessons together with classroom-based physical activity be used as the intervention.
- The design of the present study be shared with teachers, curriculum developers and decision-makers in the field of education so that the effect of classroom and activity-based physical exercises could be tested on learning on a larger scale.
- In similar future research, it is
- recommended that the intervention/ treatment be implemented by an expert rather than a class teacher or any subject matter teacher.

Limitations

The interpretation of the results from this study may be limited in several ways. First of all, the low number of students involved both in the EG and CG was an issue. It seems implausible to generalize the findings of the present study due to the limited total number of students involved (n=94).

Secondly, insignificant findings of the present study could be attributed to the selection of exercises used as the intervention/treatment.

The present study was designed to see if the classroom and activity-based intervention would have an influence on the test results of the 4th grade primary school children.

Therefore, the present study is limited to a specific age group (9 or 10 years old). Moreover, gender differences were not examined. It is also worth mentioning that reliability and validity of the tool or exam, developed by the science teacher, used as the pre and post-test called the Science Competency Test in the selected topic, were not performed.

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