Effect of regular physical activities on working memory in school children

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Submission date: 15-Mar-2018 04:34PM (UTC+0530)
Submission ID: 930753571
File name: Paper9.docx (34.15K)
Word count: 3363
Character count: 18086

Effect of regular physical activities on working memory in school children: A comparative study

Abstract

Influence of various factors affecting scholastic performance in children has been discussed in the literature, but there appears to be limited studies reporting the relation between physical activities and working memory. The present study intends to study the difference in performance between children with and without regular physical activities.160 native Kannada speaking children within the age range of 8 to 12 years were selected for the study and were divided into 2 groups with 80 children in each group respectively. Children in group 1 regularly engaged sports/athletics for 1-2 hour per day where Group 2 children did not take part in any regular physical activities other than school physical education hour. Auditory working memory task and digit ordering task were administered on the participants. Results showed better performance by Group 1 children which indicates positive relation between physical activities and working memory. The study outcome serves as the evidence that participation in sport and other physical activity improves working memory which is vital for academic achievement. Thus children should be encouraged to involve in regular sports and physical activities.

Key Words: *Working memory, Physical activities, academic performance.*

Introduction

Cognition comprises a wide range of mental abilities such as memory, attention, reasoning, problem solving, pattern recognition, organization of knowledge, language, classification, concept and categorization (Best, 1999). These cognitive processes are interrelated with one another. Memory is an aspect of cognition that regularly intrudes into everyday activities (Owens, 2012). Specifically, cognitive psychologists have identified three common operations of memory namely encoding, storage and retrieval which represents a distinct stage in memory processing. Encoding is transformingsensory data into a form of mental representation. Encoded information is further stored in memory and information which is stored is retrieved when necessary (Baddeley, 1998, 1999, 2000; Brown & Craik, 2000).

Based on the processing, memory can be divided into three types. Shortterm memory, long-term memory and working memory. "Short term memory" is the active process of storing information for a limited period of time, while the information that has been stored and available over a long period of time is referred to "Long-term memory". Whereas "Working memory" (WM) is temporary storage and manipulation of information which is required for a wide range of complex cognitive activities (Baddeley, 2003).

Emerging literature has focused on the relation between cognition and academic achievement especially highlighting role of WM for better scholastic performance (Gathercole et al., 2003; Gathercole et al., 2004; Geary, 2004; Adams & Hitch, 1998). Children at school need WM on a daily basis for a variety of tasks such as language comprehension,reading, writing, vocabulary development, arithmetic, following simple to multiple instructions, spelling achievement, note taking and other tasks. (Alloway, 2010; Engle, Tuholski, Laughlin, and Conway, 1999). Alloway et.al (2009) investigated 308 children who were identified as having

WM impairments. Results revealed poor cognitive and behavioral profiles and as well as poor learning measures and verbal ability. Children with working memory deficitshad short attention spans, problem solving difficulties, highly distractive. Gathercole (2007), Alloway (2010), Tariq & Noor (2012) also reports academic failures in children with poor WM.

Various factors have been reported to have effects on cognition viz. emotional issues, sleep quality, developmental disorders, neuroanatomical and neurophysiological changes (Christopher & Mc Donald, 2005; Owens et.al. 2012; Steenari et.al. 2003; Achibad&Gathercole, 2007; yarrow et.al. 2009). Among various factors one factor which is attaining much attention is physical activities and its influence on cognitive abilities. Growing body of literature has acknowledged the beneficial influence of physical activity, physical fitness on cognitive functioning (Sibley &Beilock, 2007; Brisswalter, Collardeau, &Arcelin, 2002; Tomporowski, 2003; Lambourne, 2006; Kamijo et. al., 2004).

Regular physical activity during a person's childhood and adolescence is widely acknowledged as essential for healthy growth and development as well as for cognitive and neuro cognitive functioning (Hills, King, and Armstrong, 2007;Verburgh et al., 2016; Pesce&Audiffren, 2011). Intense participation in sport and other forms of physical activity/exercises enhances attention and concentration, behavior, cognitive flexibility, planning, problem solving, memory which are key factors for academic achievement (Diamond, 2013). Behavioral as well as neuro-scientific evidence support this association(Khan & Hillman, 2014; Tomporowski et al., 2011). Improved brain structural and cognitive functional levels, greater cognitive control and motor preparation, better memory and learning, and higher academic performances has been reported in children who are engaged in physical activities compared to

sedentary children (Berchicci et al., 2015; Chaddock et al., 2010; Chaddock, Hillman et al., 2011; Pontifex et al., 2011; Raine et al., 2013; Howie & Pate, 2012; Singh et al., 2012).

World Health Organization (2016) recommends a minimum 60 minutes of moderate to vigorous intensity physical activity daily for children and youth aged 5 to 17. Moderate tovigorous physical activity comprise a variety of activities including brisk walk, running, aerobic and strengthening exercises. But review of literature confirms the fact that in present days children are involved in more sedentary behaviors than being active. A survey was conducted by Tarun et al, (2016) to evaluate physical activity in children and youth in India. The survey was done across nationwide including children from rural as well as urban areas. To the surprise results revealed that most Indian children spend most of their day in sedentary activities.Accelerometry based ISCOLE study was done in the city of Bengaluru. According to the results, 9 to 11 years old children spent an average of 9 hours of their everyday time in sedentary activities (Denstal et.al.2015; Chaput et.al. 2015). Study by Kehoe et.al (2012) studies children aged 6 to 10 years in and around the city of Mysuru and reports an average of 5.3 hours of sedentary activities per day. Similar study bySwaminathan et al (2011) also reports sedentary behavior in the children aged 8 to 15 years in the city of New Delhi.

Though extensive research has been done on physical activities and cognitive functioning, there is a dearth of literature which highlights the relation between physical activities and WM precisely.There is a need for evidence based results that can elucidate the effect of physical activities on WM.Hence this study was planned to contribute towards the views on the physical exercises and WM performances in children.

Need for the study:

While the relation between physical activity and children's physical development is studied extensively, only lately researchers have started exploring relationship between physical activity and children's cognitive abilities. Thoughfew studies have been documented on the influence of physical activities on cognitive and neurocognitive functions, relatively few attempts have been made to support the effects of physical activities on WM. Research shows studies related to physical activities and cognitive aspects in elderly population but there is a dearth of literature on the relationship between physical activities and WM in typically growing children. Due to change of lifestyle and current school curriculum children are less engaged in physical activities which can have a negative impact on children physical and as well as mental health which in turn can affect their academic achievement. Hence there is an increasing need to study the effect of physical activities on WM in children.

Aim & Objective:

To investigate the influence of physical activity on WM in children who are regularly engaged in physical activities and children with no regular physical activities.

Method:

Participants: A total of 160 native Kannada speaking children participated in the study. The participants were from schools in the city of Dharwad. All the children were within the age range of 8 to 12 years and had no speech, language, hearing, neurological and intellectual disorders. Group 1 consisted of eighty (40 males and 40 females) children who engaged in regular physical activities for 1-2 hour per day for the past 1-2 years. (Badminton, basketball, throw-ball, volleyball, football, Taekwondo, and athletics). Group 2 consisted of eighty (40 males and 40

females) children who did not engage in any regular physical activities other than school physical education hour. Permission was taken from the school authority and also from parents through informed consents.

Table 1: *Number of participants in each age group*

Age range (years)	Group I (Children engaged in regular physical activities)			Group II (Children with no regular physical activities)		
	Males	Females	Total	Males	Females	Total
8-9	10	10	20	10	10	20
9-10	10	10	20	10	10	20
10-11	10	10	20	10	10	20
11-12	10	10	20	10	10	20
Total	40	40	80	40	40	80
Grand Total	80			80		160

Material and instructions:

Auditory working memory (AWM) task and digit ordering task (DOT) were selected from previous study done by Anjali (2010). Test material is given in appendix. The AWM stimuli consisted of 10 series. Each series consisted of randomly arranged three nouns and three digits.Subjects were instructed to listen to the stimuli and to repeat the nouns first followed by numbers in the same sequence as heard. For example in the series 3-8-vÁ¬Ä-9-HgÀÄ-ZÀªÀÄZÀ the participant was required to recall the words vÁ¬Ä, HgÀÄ, ZÀªÀÄZÀ followed by the numbers 3, 8 and 9.

In DOT, single digit numbers ranging from a series of three to eight numbers were presented to the participant. Digits were presented at a rate of about one digit per second. The participant was required to report them back immediately in ascending numerical order.

For example: Stimuli: 9 4 0 6

Correct Response: 0 4 6 9

Test stimuli were pre-recorded using Sony MP3 digital voice recorder in a sound-treated room. The nouns and digits were recorded at a rate of one per second by the examiner. Pre-recorded stimuli were transferred to dell laptop for further presentation.

Procedure:

The subject was seated comfortably on a chair facing the investigator across the table in a quiet and distraction-free room in the school. The examiner ensured that there was no interference from extraneous noise or visual distraction, so as to derive their concentration and complete attention towards the task and to control the effect of variables that would affect the subject's performance. Pre-recorded stimuli were presented to the subjects at comfortable intensity level using Sennheiser headphone. Each child was tested individually. A trial test was given for every child to confirm the understanding of instructions.

Scoring:

AWM task: Live scoring was done by the investigator on a score sheet. A score of one was assigned to each series for a correct recall of digits and nouns in the same sequence of presentation. When the participant was not able to recall the digits and nouns separately in the

sequence of presentation, then a score of zero was assigned and the next series was presented to the participant. The task was continued until all the ten series of noun and digit combinations were presented to the participant. The scores for each of the series were summed to provide the total score out of ten which represented the participant's performance for the auditory working memory task.

DOT task: The participant was assigned a score of three when the participant was able to recall a series of three digits correctly in the ascending order. The investigator presented the next series of four numbers and when the participant recalled the digits correctly in the ascending order a score of four was assigned. Similarly, the scoring was done for other levels until the participant was able to recall the last series of eight numbers. When the participant made an error at any of the levels the test was terminated and the participant was assigned a score that corresponded to the previous correct level. Thus, all the 6 series were presented to the participant and the responses were obtained and were subjected to statistical analysis using IBM SPSS software (version 20).

Results:

The Mean and standard deviation (SD) were calculated for the scores obtained by both the groups for each task. Univariate Analysis of variance (UNIANOVA) was carried out to find the differences between both the groups followed by Bonferroni post hoc test.Table 2 and 3 depict the results for the AWM task and DOT in both the groups.

Table 2: Mean scores and SD values for AWM and DOT task for group 1 and group 2

Groups	**AWM task**	**DOT task**
	Mean (SD)	**Mean (SD)**
Group 1	3.54 (1.19)	15.85 (4.2)
Group 2	0.84 (1.17)	10.45 (6.1)

Table 3: Mean scores and SD values for AWM and DOT task for group 1 and group 2 across age groups

Age range	**Group**	**AWM Task** Mean (SD)	**DOT Task** Mean (SD)
8-9	Group 1	3.40(0.94)	13.15(1.75)
	Group 2	0.15(0.36)	5.60(4.45)
9-10	Group 1	3.55(1.23)	15.80(4.15)
	Group 2	0.60(0.94)	9.75(5.03)
10-11	Group 1	4.55 (1.46)	5.80 (1.29)
	Group 2	1.05 (1.14)	4.98 (1.11)
11-12	Group 1	7.13 (0.25)	17.60 (4.14)
	Group 2	1.55 (1.50)	11.90 (4.15)

From table 2 it can be inferred that among both the groups group 1 had better scores compare to group 2 for both AWM and DOT task. It is also clearly evident that both the groups

performed better in DOT task compared to AWM task in all the age groups. For both the tasks no gender difference was observed.

Further, multivariate ANOVA was done to find the effect of physical activity, gender and age for WM tasks. The results showed significant difference across age ($F=3.67$, $p<0.05$; $F=14.47$, $p<0.05$) and between both the groups ($F=220.0$, $p<0.05$; $F=53.98$, $p<0.05$) for both the tasks. Combined effect of age and groups also showed significant difference ($F=4.67$, $p<0.05$; $F=15.34$, $p<0.05$) for both the tasks.

Table 4: *Results of MANOVA for AWM and DOT task between the groups across the age*

Source of variations	***AWM task***		***DOT task***	
	F	***Significance***	***F***	***Significance***
AGE	**3.67**	**0.01**	**14.47**	**0.00**
GENDER	0.30	0.58	1.26	0.26
GROUPS	**220.0**	**0.00**	**53.98**	**0.00**
AGE* GENDER	0.66	0.57	1.07	0.36
AGE*GROUP	**4.67**	**0.02**	**15.34**	**0.00**
GENDER*GROUP	0.01	0.89	0.84	0.36
AGE*GENDER*GROUP	1.16	0.32	1.75	0.15

As there was significant interaction between age and groups, UNIANOVAwas carried out as a part of statistical analysis to check the effect of age on both the tasks and across the groups. UNIANOVA results revealed significant difference in performance between age groups

for both AWM and DOT tasks (F= 10.48, p<0.05 & F = 6.28, p<0.05) and compared to group II, group I children outperformed in both the tasks.

Table 5: *UNIANOVA results of*effect of age on AWM task and DOT task in group I and group II

Group	***Task***	***F***	***Significance***
Group-I Children engaged in Physical activities	AWM	6.28	0.00
	DOT	10.09	0.00
Group-II Children with no physical activities	AWM	0.14	0.03
	DOT	4.85	0.00

To compare the performance of children in AWM and DOT task between all the four age groups, Bonferroni post hoc test was done. Significant difference was found between 8-9 years and older age groups, whereas children between age group 9-10 years, and other older groups showed no difference (p<0.05) for both the tasks.

Table 6: *Bonferroni post hoc test results across age for AWM task*

Age in years	8-9	9-10	10-11	11-12
8-9		S	S	S
9-10			NS	NS
10-11				NS

*Note: S= significant NS= No Significant

***Table 7**: Bonferroni post hoc test results across age for DOT task*

Age in years	8-9	9-10	10-11	11-12
8-9		S	S	S
9-10			NS	NS
10-11				NS

Bonferroni test results for AWMand DOT task between all the four age groups for group I and II have been presented in Table. Unexpectedly diverse performance has been noted for AWM and DOT tasks by both the groups. For AWM task difference was seen between younger and older children only in group 1 children whereas for DOT task significant difference was seen between younger and older children among both the groups.

***Table 8**: Bonferroni post hoc test results across age for Group I children for AWM task*

Age in years	8-9	9-10	10-11	11-12
8-9		NS	S	S
9-10			NS	S
10-11				NS

***Table 9**: Bonferroni post hoc test results across age for Group I children for DOT task*

Age in years	8-9	9-10	10-11	11-12
8-9		S	S	S
9-10			S	NS
10-11				NS

***Table 10**: Bonferroni post hoc test results across age for Group II children for AWM task*

Age in years	8-9	9-10	10-11	11-12
8-9		NS	NS	NS
9-10			NS	NS
10-11				NS

***Table 11**: Bonferroni post hoc test results across age for Group II children for DOT task*

Age in years	8-9	9-10	10-11	11-12
8-9		NS	S	S
9-10			NS	NS
10-11				NS

Discussions:

The present study aimed to investigate the effect of regular physical activities on WM in children. AWM and DOT were administered to the selected group of children. While AWM task reflects the storage and processing functions to measure each individual's WM capacity, DOT comprises simultaneous coordination of storage and retrieval. Both the tasks tap verbal and auditory short-term storage WM.Results showed that children engaged in physical activities performed better in both the tasks compared to the other group.Hillman et al (2017), Kasper et al (2012), Pesce et al (2009), Ahamed et al (2007) and Lambourne (2006) also reports positive relation between physical activities and cognitive functions including WM and academic achievement.Children from both the groups performed better in DOT task compared to AWM task. This can be attributed to the task complexity. DOT task involves recalling only digits while AWM task involves recalling words as well as digits in an orderly fashion which requires complex processing.

With respect to the age related performance elder children performed better compared to younger children in both the tasks. This age- related progress in WM is supported from previous studies by Linda, Siegel & Ryan (1989), Vuontela et.al (2003), Gathercole (2004), Anjali (2010), Cowan et al, (2010), Finn et al., (2010) who also reports better performance for WM as age increases. Contrary to these findings no statistically significant changes was seen across age in auditory working memory task for Group II children in our study.

No significant difference in performance were seen between males and females for both AWM and DOT tasks ($F=0.302$, $p>0.05$; $F=1.260$, $p>0.05$). Results of previous studies by Tende et al (2010), Harness et al (2008), and Tariq & Noor (2012) also reports no gender differences for WM tasks.

Thus our results clearly indicate that regular physical activities have a positive impact on WM which is important for learning and better academic performance in children. The outcome of the present study is expected to contribute towards creating awareness about the importance of physical activities for children. Recent research evidence shows more sedentary behaviors in children and leading cause is attributed to technology such as television, computer and mobile phones (Katapally&Muhajarine, 2015; Tremblay et.al. 2011; Biddle et.al. 2010). Sedentary behaviors are associated with greater risk of physiological and as well as psychological problems including negative effects on various cognitive abilities.

A longitudinal survey by CentersforDiseaseControl and Prevention (2003, 2007 & 2008) reports reduced participation in physical activity by children at schools. Due to growing demand for higher academic scores children are refused by parents to engage in sports activities after school hours with the concern of decrease in academic performance. In contrary to above notion research shows that children and youth who spent more time in physicaleducation class did not havelowertestscores compared to individuals whospendlesstimeinphysicaleducationclass (Sallis et.al. 1999; Shephard, 1997; Carlson et.al. 2008).

Further studies exploring the association between physical activities and WM aspects in children will strengthen the present areaof research. The study could be extended toinclude a larger sample and as well as different WM tasks as a comparison of performance between individual sports/physical activities.

Summary and conclusion

Though research has proven the benefits of physical activities on individual's health, comparatively less attention is devoted to the association between physical fitness and cognitive aspects in children. Present study is an attempt to provide insight into the relationships between regular physical activity and WM in children. Children who engaged in sports and athletics performed better in WM tasks compared to children with no regular physical activities. The present study results support the fact that regular physical activities have positive impact on WM which is crucial for academic achievement. Thus children should be encouraged to involve in regular physical activities and further attempts should be made to create awareness among parents and school about positive effects of regular physical activities.

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