Tablet vs book learning: Impact on memory, attention and learning skills

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Research article

Keywords: memory; attention; learning; tablet; book; education; adolescents.

Posted Date: March 3rd, 2020

DOI: https://doi.org/10.21203/rs.3.rs-15843/v1

Abstract

Objectives : Textbooks are the major source of instruction, yet many Lebanese schools have partially introduced electronic devices, and have discreetly started to rely on them. Given the reported discrepancies between textbooks and tablets learning in international literature, it is essential to conduct a Lebanese study that compares both entities. Therefore, the objective of this paper was to assess the impact of tablet use at school on memory, attention and learning abilities among Lebanese children. Methods: This cross-sectional study, conducted between January and May 2019, enrolled 566 students aged of 11-13 years. Three schools were chosen conveniently for this study, one of them uses the Tablet and text books for students' learning whereas the second one uses text books exclusively. Students were randomly chosen from the list given by the school administration. Results : Textbook learning was significantly associated with lower episodic memory score (better episodic memory) and lower visual memory score (better visual memory), lower attention score (better attention), lower processing speed score (better processing speed), lower mathematic skills score (better mathematic skills) compared to tablets and textbook learning. Conclusion : Learning is evolving to another level and forever changing. Many studies should be conducted in order to understand the importance of merging new and old techniques to ensure that the next generations are receiving what can positively affect their cognitive skills and their performance.

Introduction

Education is must. It is a fundamental human virtue, an essentiality for society, and a firm basis for a healthy life [1]. Although education is not limited to schools, the intrinsic important aim of the expansion of human mental capacities starts in schools [2]. As a matter of fact, it is known that education improves the cognitive abilities in children: a meta-analysis done by Jennifer L. Carter et al. in 2019 points out a positive correlation between cognitive skills and education[9]. The cognitive skills of the human brain are very intriguing, yet essential in a healthy human brain to be able to manage his own decisions [3]. The main cognitive skills include memory, attention, and learning capacities, among others. It is mandatory to mention that the thread of the mental development of children depends upon the quality of education that is being transmitted, as well as the process in which the information is received. In this context, many schools have tried to shift from printed texts to electronic ones, while others held on textbooks only. Moreover, the debate whether electronic devices are more effective than textbooks in education or not is still ongoing [4]. Electronic devices are hypothesized to affect several aspects of education, such as memory, attention, learning capacities and academic performance (mathematical, reading and expression skills).

Memory can be divided into short term and long term memory. The short term is responsible of maintaining essential information for immediate purposes, accordingly, this data will be selectively relocated to long term memory [5]. Many types of memory could be highlighted such as the working memory which preserves recent acquired information and is helpful to recall data from the long term

memory needed at a specific moment, the episodic memory which is essential to recall specific events, and the semantic memory which elicits objects, facts and concepts [6]. Many previous studies have explored the effect of tablets use on children's memory in comparison to textbooks use and found contradictory results. Wagner and Sternberg determined that students reading texts on tablets were not capable of remembering the details of the text [7], while Belmore concluded that students who used electronic devices have increased reading speed and comprehension, thus a higher capacity to recall details [8].

Attention is defined as "a psychological phenomenon that interacts with all other cognitive processes, such as perception, memory, behavioral planning or actions, linguistic production, and spatial orientation" [9]. It implicates several systems of the human brain to be able first, to process all the input acquired, second, to avoid distraction and focus on the selected resources and finally, to switch the attention from one stimulus to the other successfully [10]. According to a study conducted by Kropman et al., tablets use is tiresome compared to textbooks which decreases the attention span in children trying to focus for long periods every day [11]. In addition to that, a study found that 87% of teachers believe that nowadays electronic and digital technologies are generating an easily distracted generation with short duration of attention maintenance, and that tablets in classrooms could conceivably do more harm than good.

Learning capacities largely depend on the way information is received. Many studies evaluated the impact of the electronic use on learning capacities and academic performances. Some studies revealed student's positive learning attitude towards the use of tablets and electronic devices in schooling [4]. The characteristics of tablets, such as unlimited internet access and being easy to carry were helpful [12] and made students more implicated in their learning. A study further showed that tablets' users tended to take notes directly, three times more than students using textbooks [13]. Other papers demonstrated that logical thinking and critical criticism were improved in children using tablets by enhancing their problem solving ability [14]. On the opposite side, some studies showed that tablets negatively affected academic performance and learning skills due to the eyestrain that occurs with excessive use [15].

Originally, textbooks were the main tool for acquiring information [12]. With time, as technology was implicated in various fields, and access to the internet or to an electronic device was easier and cheaper [16], it started to replace textbooks. In fact, the methods of instruction employed in Lebanese classrooms are mostly classic. Teachers spend a great deal of time giving lessons and homework to students, as well as reading assignments and correcting exercises finished in class. Students usually play a passive role in the education process. They listen calmly, occasionally question what is presented, and copy texts and information dictated by the teacher. Textbooks are the major source of instruction, yet many Lebanese schools have partially introduced electronic devices, and have discreetly started to rely on them [17]. Given the reported discrepancies between textbooks and tablets learning, it is essential to conduct a Lebanese study that compares both entities. In order to assess the influence of textbooks and tablets on cognition and attention, it is also essential to take the schooling age into consideration. The latter is critical to understand the human brain and cognition as one of the major skills of the mind. Therefore, the objective

of this paper was to assess the impact of tablet use at school on memory, attention and learning abilities among Lebanese children.

Methods

Participants

This study was a cross-sectional, conducted between January and May 2019. Three schools were chosen conveniently for this study, one of them uses the Tablet and text books for students' learning whereas the second one uses text books exclusively. Students were randomly chosen from the list given by the school administration. Prior to participation, parents were briefed on the study objectives and methodology, and were assured of the anonymity of their participation. Individual participants had the right to accept or refuse participation in the study, with no financial compensation provided in exchange for individual participation. All participants were parents of children aged between the age of 11 and 13 years of age were eligible to participate.

Procedure

The questionnaire was distributed to each student in the classroom to be taken home. Parents filled it within 25 minutes approximately. The completed questionnaires were collected back and sent for data entry. During the data collection process, the anonymity of the participants was guaranteed.

Questionnaire

The questionnaire used was in Arabic, the native language of Lebanon. The first part assessed the sociodemographic details of the participant's child (i.e. age, gender, grade, and father and mother education level). Questions were also asked about number of hours using the tablet for learning at home and at school, number of hours using screens for electronic use (IPad/cellphone for playing electronic games…), number of hours watching TV programs and number of hours reading books. The second part of the questionnaire included the following scales:

The Children's Memory Questionnaire (CMQ)

The CMQ is a 36-item questionnaire designed to assess parents' perceptions of their children's memory. The CMQ requires parents to assess their child's memory based on five possible options: 1 = never or almost never happens; 2 = happens less than once a week; 3 = happens once or twice in a week; 4 = happens about once a day; and 5 = happens more than once a day[1]. Three subscales derived from the total scale representing the episodic memory, visual memory and working memory and attention. The higher the scores, the greater the impairment in the cognition domain [18]. In this study, the Cronbach alpha values for the episodic memory subscale was 0.888, for the visual memory was 0.770 and for the working memory was 0.845.

The Clinical Attention Problems Scale

The scale measures the frequency of activity and attention by asking the parent and teacher to respond to a series of 12 statements and their applicability to their child in the morning and afternoon. Response options range from "not true"(0), "somewhat or sometimes true" (1), "very often" or often true (2). The higher the scores, the greater the attention problems exist [19]. In this study, the Cronbach alpha values for the clinical attention problem in the morning and in the afternoon were 0.844 and 0.839 respectively.

Learning, Executive and Attention Functioning (LEAF) Scale

The LEAF is a 55-item self-report questionnaire that assesses executive functions, related neurocognitive functions, and academic skills in children and adults. The LEAF evaluates a broad set of core cognitive abilities as well as related cognitive learning and academic abilities. Cognitive areas assessed by the LEAF include attention, processing speed (including visual-spatial organization skills), and sustained sequential processing to achieve goals (e.g., planning and executing goal-directed behavior), working memory, and novel problem-solving. Also, LEAF includes comprehension and concept formation, declarative/factual memory, and academic functioning. The LEAF contains Academic subscales assessing reading, writing, and math fluency and abilities. LEAF items are grouped by subscale, and all subscales have the same number of items.

The subscales of the LEAF are: 1. Comprehension and Conceptual Learning (tracking and understanding information); 2. Factual Memory (memorization and retention of facts); 3. Attention (sustained focus); 4. Processing Speed (speed of completing cognitive and behavioral tasks that involve a component of focus and concentration); 5. Visual-Spatial Organization (organization and visual-constructive skills); 6. Sustained Sequential Processing (planning and sustaining effort in order to follow and complete multistep directions and sequences); 7. Working Memory (remembering and processing multiple things at the same time); and 8. Novel Problem Solving (initiating effort toward processing new or unfamiliar information); 9. Mathematics Skills (math calculation difficulty); 10. Basic Reading Skills (reading/phonics difficulty); and 11. Written Expression Skills (limited/impoverished or slow/effortful written expression). Individual items are rated on a 0–3 scale, and a raw subscale score for each of the 11 content areas is created by summing the 5 constituent items, such that higher scores indicate more cognitive problems [20]. In this study, the Cronbach alpha values for the subscales was: comprehension and conceptual learning = 0.961; factual memory = 0.792; attention = 0.901; processing speed = 0.866; visual-spatial organization = 0.729; sustained sequential processing = 0.768; working memory = 0.816; novel problem solving = 0.811; mathematics skills = 0.871; basic reading skills = 0.923 and written expression skills = 0.905.

Translation procedure

The forward and backward translation method was conducted on all the scales. The forward translation was done by one translator, whereas the backward translation was performed by a second healthcare professional. The two English versions were compared afterwards; discrepancies were resolved by consensus.

Statistical analysis

SPSS software version 23 was used to conduct data analysis. Cronbach's alpha values were recorded for reliability analysis for all the scales. A descriptive analysis was done using the counts and percentages for categorical variables and mean and standard deviation for continuous measures. A bivariate analysis using Pearson correlation coefficient served to assess the relationship between recreational use of electronic devices, TV watching and book reading.

A multivariate analysis of covariance (MANCOVA) was carried out to compare multiple measures (each scale was taken as a dependent variable) between the groups of school type (book vs. Tablet learning), taking into account potential confounding variables: age, gender, family monthly income, mother and father education level, number of hours using IPad, cellphone or playing electronic games, number of hours watching TV programs and number of hours reading books. A $p < 0.05$ was considered significant.

Results

Sample characteristics description

Out of 700 questionnaires distributed, 566 (80.86%) were completed and collected back. The sociodemographic characteristics of the participants are summarized in Table 1. The mean age was 10.77 ± 1.38 years, with 55.2% males and 48.8% females. More than half of the selected school were using book and Tablet (61.1%). Also, higher education level in parents was found in 58.9% among mothers and 39.4% among fathers. The mean number of hours per day learning on tablet at school was 0.91 ± 0.78, the mean number of hours per day spending using tablet to do homework was 0.44 ± 1.09, the mean number of hours per day using tablet or cellphone playing electronic games was 1.70 ± 2.06, the mean number of hours spending per day watching TV programs for children was 1.42 ± 1.23 and the mean number of hours spent per day reading books was 0.79 ± 1.09 (table 1).

Table 1: Sociodemographic characteristics of the study sample		
	Frequency	Percentage
Gender		
Male	286	55.2%
Female	232	44.8%
School Type		
Mixed (Book and Tablet learning)	346	61.1%
Book learning	220	38.9%
Education level father		
Illiterate	14	2.9%
Primary	34	7.0%
Complementary	111	22.9%
Secondary	135	27.8%
University	191	39.4%
Education level mother		
Illiterate	14	2.9%
Primary	11	2.2%
Complementary	58	11.9%
Secondary	118	24.1%
University	288	58.9%
	Mean	SD
Age	10.77	1.38
Number of hours per day learning on tablet at school	0.91	0.78
Number hours per day spending using tablet to do homework	0.44	1.09
Hours per day using tablet or cellphone playing electronic games	1.70	2.06
Hours spending per day watching TV programs for children	1.42	1.23
Hours spent per day reading books	.79	1.09

Bivariate analysis of electronic devices' recreational use, TV watching and books' reading with children educational aspects

Higher hours spent per day using iPad and cellphones was significantly associated with higher episodic and visual memory scores. A higher number of hours spent per day watching TV programs was significantly associated with higher working and visual memory scores, as well as higher mathematics skills scores. A higher number of hours spent per day reading books was significantly associated with higher visual memory and novel problem solving scores. A higher number of hours spent per day learning on tablet at school was significantly associated with higher episodic memory, working memory, visual memory, comprehension conceptual learning, factual memory, LEAF attention, processing speed, mathematic skills and basic reading skills scores. Finally, a higher number of hours spent per day using tablet to do homework was significantly associated with higher visual memory (Table 2).

Table 2. Bivariate analysis of factors (hours spent per day using iPad/cellphone, hours spent per day watching TV programs for children, hours spent per day reading books) associated with the memory, learning and attention scores.

	Hours spent per day using iPad/cellphone	Hours spent per day watching TV programs for children	Hours spent per day reading books	Hours spent per day learning on tablet at school	Hours spent per day spending using tablet to do homework
Episodic memory	0.104[c]	0.087	-0.011	0.101[c]	0.021
Working memory	0.059	0.099[c]	0.066	0.143[b]	0.031
Visual memory	0.116[c]	0.170[a]	0.200[a]	0.239[a]	0.130[b]
Clinical attention (morning)	0.014	0.012	0.008	-0.067	0.006
Clinical attention (afternoon)	0.008	0.035	0.021	-0.053	-0.029
Comprehension conceptual learning	-0.014	0.055	0.01	0.149[b]	0.024
Factual memory	0.028	0.059	0.064	0.135[b]	0.028
LEAF attention	0.009	0.065	0.012	0.145[b]	-0.005
Processing speed	0.012	0.092	0.018	0.166[a]	0.034
Visual spatial organization	0.014	0.051	-0.031	-0.082	-0.021
Sustained sequential processing	0.001	0.051	-0.027	-0.083	-0.059
LEAF working memory	-0.036	-0.034	0.03	-0.072	-0.058
Novel problem solving	0.028	-0.012	0.115[c]	-0.080	0.002
Mathematics skills	-0.015	0.098[b]	0.089	0.155[b]	0.037

[a]p<0.001; [b]p<0.01; [c]p<0.05

Table 2. Bivariate analysis of factors (hours spent per day using iPad/cellphone, hours spent per day watching TV programs for children, hours spent per day reading books) associated with the memory, learning and attention scores.

Basic reading skills	0.013	0.092	0.056	0.109[c]	-0.063
Written expression skills	-0.017	0.008	0.016	-0.060	-0.041

[a]p<0.001; [b]p<0.01; [c]p<0.05

Multivariate analysis: Educational aspects comparison between textbook and electronics use

The MANCOVA analysis was performed taking the scales as the dependent variables and the school type (Textbook vs tablets and textbook learning) as the independent variable, adjusting for the covariates (age, gender, family monthly income mother and father education level, number of hours using IPad, cellphone or playing electronic games, number of hours watching TV programs and number of hours reading books).

The means of the memory, attention and LEAF subscales between school type learning systems (tablets and textbook vs. textbook), adjusted for age, gender, family income, mother and father education level, number of hours using IPad, cellphone or playing electronic games, number of hours watching TV programs and number of hours reading books, are shown in Fig. 1.

After adjusting for all covariates, a significant difference was found for episodic memory, visual memory, LEAF-attention, LEAF- processing speed and LEAF mathematics skills. The use of electronic devices was associated with worse results: a significantly higher mean of episodic memory (8.08), visual memory (4.71), LEAF attention (3.27), LEAF processing speed (3.75) and LEAF mathematics skills (2.95) scores were found in those using tablets and textbook as compared to those using textbook exclusively.

Note
*p < 0.05 **p > 0.05
A MANCOVA models were performed taking the scales as the dependent variables and the school type (Textbook vs tablets and textbook learning) as the independent variable adjusted for age, gender, family monthly income mother and father education level, number of hours using IPad, cellphone or playing electronic games, number of hours watching TV programs and number of hours reading books.

The MANCOVA derived models showed worse results for students of schools using electronic devices for teaching: Textbook learning was significantly associated with lower episodic memory score (better episodic memory) (B=-2.62) and lower visual memory score (better visual memory) (B=-1.75), lower attention score (better attention) (B=-1.06), lower processing speed score (better processing speed)

(B=-1.41), lower mathematic skills score (better mathematic skills) (B=-1.08) compared to tablets and textbook learning (Table 3).

Table 3: Multivariate analysis of covariance (MANCOVA) models taking the scales as the dependent variables and the school type (Textbook vs tablets and textbook learning) as the independent variable, adjusting for the covariates (age, gender, family monthly income mother and father education level, number of hours using IPad, cellphone or playing electronic games, number of hours watching TV programs and number of hours reading books)

	Beta	p-value	95% Confidence Interval	
			Lower Bound	Upper Bound
Episodic memory				
School type (Textbook vs tablets and textbook* learning)	-2.62	0.013	-4.69	-0.55
Working memory				
School type (Textbook vs tablets and textbook* learning)	-1.34	0.078	-2.84	0.15
Visual memory				
School type (Textbook vs tablets and textbook* learning)	-1.75	< 0.001	-2.59	-0.91
Mother secondary compared to illiteracy/primary level*	-2.26	0.009	-3.97	-0.56
Clinical attention in the morning				
School type (Textbook vs tablets and textbook* learning)	-0.55	0.431	-1.94	0.82
Clinical attention in the afternoon				
School type (Textbook vs tablets and textbook* learning)	-0.64	0.393	-2.12	0.83
Gender (females vs males*)	-1.59	0.006	-2.74	-0.45
LEAF comprehension and conceptual learning				
School type (Textbook vs tablets and textbook* learning)	-0.38	0.336	-1.17	0.40
Father university compared to illiteracy/primary level*	-1.16	0.042	-2.28	-0.04
LEAF factual memory				
Mother secondary compared to illiteracy/primary level*	-1.59	0.024	-2.98	-0.21
Mother university compared to illiteracy/primary level*	-1.58	0.020	-2.90	-0.25
School type (Textbook vs tablets and textbook* learning)	-0.58	0.094	-1.25	0.100
LEAF attention				
School type (Textbook vs tablets and textbook* learning)	-1.06	0.034	-2.04	-0.07

Table 3: Multivariate analysis of covariance (MANCOVA) models taking the scales as the dependent variables and the school type (Textbook vs tablets and textbook learning) as the independent variable, adjusting for the covariates (age, gender, family monthly income mother and father education level, number of hours using IPad, cellphone or playing electronic games, number of hours watching TV programs and number of hours reading books)

Father university compared to illiteracy/primary level*	-1.62	0.023	-3.02	-0.22
LEAF processing speed				
School type (Textbook vs tablets and textbook* learning)	-1.41	0.005	-2.40	-0.42
LEAF visual spatial organization				
School type (Textbook vs tablets and textbook* learning)	-0.70	0.09	-1.53	0.11
Gender (females vs males*)	-0.70	0.029	-1.34	-0.07
LEAF sustained sequential processing				
School type (Textbook vs tablets and textbook* learning)	-0.37	0.385	-1.22	0.47
LEAF working memory				
School type (Textbook vs tablets and textbook* learning)	-0.70	0.097	-1.54	0.12
LEAF novel problem solving				
School type (Textbook vs tablets and textbook* learning)	-0.36	0.364	-1.15	0.42
LEAF academic: mathematic skills				
School type (Textbook vs tablets and textbook* learning)	-1.08	0.018	-1.97	-0.18
Father university level of education compared to illiteracy/primary level*	-1.37	0.035	-2.64	-0.09
LEAF Basic reading skills				
School type (Textbook vs tablets and textbook* learning)	-0.85	0.091	-1.83	0.13
Father university level of education compared to illiteracy/primary level*	-1.76	0.014	-3.17	-0.35
LEAF written expression skills				
School type (Textbook vs tablets and textbook* learning)	-0.91	0.104	-2.02	0.18
Father university level of education compared to illiteracy/primary level*	-1.77	0.028	-3.35	-0.19
*Reference group				

Discussion

This pilot study is the first of its kind in Lebanon that aims to evaluate the association between tablet vs book learning on memory, attention and learning. Overall, the major finding from the study is that the use of textbooks was associated with better results in many aspects that can influence the learning process. The findings elicit that the students that used textbooks had better memory function, which contradicts the study that showed improvement in cognitive learning in people using tablets [13]. Another study concluded that learning from a tablet made the person involved in the process of learning. Many e-texts provide the option to highlight text, present with high resolution graphics and not to forget that many e-texts can be saved on the same tablet [12]. Despite these advantages, tablets can cause eyestrain and are a major source of distraction to the learner. Thus, a person reading a book will be focused on the material presented in front of him. On the other hand, a tablet especially connected to the internet can provide endless information that can affect the ability of the learner to retrieve the needed information [12].

A positive correlation is found between the use of textbooks and the episodic, working, visual and factual memory, which is confirmed in the literature [21]. To be able to understand a textbook or an e-book, the long term and short term memory need to be involved [21]. A previous study conducted in 2012, implied that it is easier to recall information read in books than in tablets due to many factors [22]. For example, tablets present fewer spatial landmarks, smaller screens that can cause eyestrain. In addition to that, scrolling along text can cause distraction [21]. All of that can negatively influence the memory and eventually affect the comprehension. Another study done in 2012 found a better reading comprehension in books compared to e-books [23], and people noted that e-books were not clear enough because of the screen and text size, which affects their ability to comprehend the text and the way they perceived the e-book [23].

As for attention, the results were inconclusive in accordance to other studies that could not find a difference between tablets and books regarding many aspects such as comprehension [12], and reading skills [4,24]. Books learning was correlated with better cognitive skills especially in memory but did not seem to directly affect the attention: attention was found to be similar in books and in tablets learning. Meaning that people were able to focus on the text and the data regardless of the way it was presented to them. The media used to read and to learn did not seem to affect attention. A study done in 2019 that compared comprehension in reading text in printed books and on a tablet showed that there is no difference in the attention paid in both cases [21].

Moreover, learning in books was associated with an improved processing speed compared to tablets learning. In a study done by A. Lynne Beal et al in 2016 showed that processing speed is correlated with the improvement of reading and mathematical skills [25]. This paper also showed a positive impact for learning in books on mathematical skills and reading abilities that is in favor of the positive impact on the processing speed in learning: children learning in books will depend more on their basic skills and knowledge to be able to develop their mathematical, reading and writing abilities. They have to memorize the multiplication table to be able to do calculation. In addition to that, they need to be creative in order to write a good sentence. Oppositely, tablets have a “built-in calculator” which is able to do all the complex calculation in a fraction of second. At the same time, there is a reading option dedicated to read a whole

text so the child is only passively receiving information, without him trying to improve his reading skills. Furthermore, tablets also provide “predictions” when writing which can negatively affect the creativity of the child compared to books.

Additionally, the level of education of the parents, especially the father influenced on the results. Children with educated fathers showed better scores in reading and written expression skills, mathematic subscale and comprehension and conceptual learning which is a finding not discussed in other studies. According to these findings, we hypothesize that educated parents will be more involved in helping their children learn and be more involved in education [26].

Limitations

There are some limitations in our study. Since this is a one-time measurement of exposure, it is difficult to derive causal relationships from a cross-sectional analysis. This study type is also prone to certain biases. An under or over estimation of a question could be experienced by the parent, leading to a non-differential information bias; this is expected to drive the results towards the null hypothesis. Selection bias and misclassification due to recall bias could may have also occurred. More than that, attrition bias could have happened when participants don’t respond to certain questions. Furthermore, although the multivariate analysis took into account several potential confounding factors, a residual confounding is still possible. Nevertheless, the overall results are consistent with the study hypothesis and the majority of literature findings, which can be considered as a strength of this study.

Conclusion

The results suggest that tablet learning was significantly associated with worse memory, attention, processing speed, mathematic skills, as well as, worse writing skills, compared to book learning. Education and technology are merging in societies. Learning is evolving to another level and forever changing. Many studies should be conducted in order to understand the importance of merging new and old techniques to ensure that the next generations are receiving what can positively affect their cognitive skills and their performance.

Declarations

Ethics Approval and Consent to Participate

The Psychiatric Hospital of the Cross Ethics and Research Committee approved this study protocol (HPC-012-2018). A written consent was obtained from the students’ parents prior to starting the data collection.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are not publicly available to maintain the privacy of the individuals' identities. The dataset supporting the conclusions is available upon request to the corresponding author.

Competing interests

The authors have nothing to disclose.

Funding

None.

Author contributions

DM, GAK and NK were responsible for the data collection and entry. SH and PS designed the study and drafted the manuscript; SH, CH and PS carried out the analysis and interpreted the results; HS, RH and AH assisted in drafting and reviewing the manuscript; All authors reviewed the final manuscript and gave their consent; PS and RH were the project supervisors.

Acknowledgements

The authors would like to thank Mr Jihad Gerges, Mr Joseph Chahine and the following persons of College Central des Moines Libanais Maronites- Jounieh: Father Superior Antoine Salame, General Director Father Dr. Wadih Al Skayem, Mrs Hélène Chbeir- Director of the kindergarten, Mr Joseph Rassi- Director of the primary cycle as well as the teachers of the primary cycle for their help in the data collection. Special thanks to the parents who participated in this study and for Ms Marine Arisdakessian for her help in the data entry.

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