



A student-centered intervention program to educate and retain knowledge in stroke education and healthy habits

Leah Wormack, Leanne Brechtel, Chibueze Ubah, Amber Frazier, Chloe G. Jackson, Thomas I. Nathaniel*

University of South Carolina School of Medicine Greenville, 607 Grove Rd, Greenville, SC 29605, USA

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ABSTRACT

The goal of the stroke intervention programs was to increase knowledge in stroke awareness and healthy habits. Most of the existing school-based didactic stroke education intervention programs have not been very effective in improving learned information. We developed a student-centered or active learning educational pedagogy to improve the retention of learned knowledge on stroke issues and healthy habits. Middle school students, ages of 11 to 14 years attending a public school in the stroke belt were recruited to participate in an intervention program to raise stroke awareness and promote healthy habit. The impact of the intervention program on students' knowledge post-test and three weeks following the intervention was evaluated. Middle school students at all grade levels were aware of the cardinal symptoms of stroke, demonstrated basic knowledge of the salty foods in the post-test, and knowledge of learned information increased significantly after three weeks post intervention. The three weeks follow-up test revealed a significant increase in stroke knowledge among the 6th, 7th, and 8th grades [$F(2,109) = 134.65, P = 0.001$]. Post-hoc pair-wise comparisons analysis revealed a significant difference ($P < 0.05$) between the 6th, 7th, and 8th grades. In an active learning or a student-centered stroke and healthy life style educational program, middle school students perceived the intervention program as fun, instead of primarily educational and this allowed the learned information to be retained even three weeks after the intervention.

1. Background

The maintenance of a healthy habit and prevention of chronic diseases are associated with regular physical activity and balanced dietary intake. Among middle school students, physical inactivity and poor diet reinforce the risk of lifestyle associated non-communicable health conditions including ischemic heart disease, stroke, and overweight/obesity. Several studies have demonstrated a decreased physical activity during middle childhood (Baggett et al., 2008; Brumana et al., 2017; Hills et al., 2014; Hohensee and Nies, 2014; Pate et al., 1999; Taymoori et al., 2012). Declining physical activity in childhood contributes to the development of chronic conditions such as cardiovascular disease (Kapoor et al., 2017; O'Dwyer et al., 2017), stroke (Elsawy and Higgins, 2010; Nicholson et al., 2013; Sallar et al., 2010), and obesity (Bhupathiraju and Hu, 2016; Xu and Xue, 2016) as outcomes later in life. Several studies have identified factors that may reduce the rate of physical inactivity during childhood (Buchan et al., 2010; Ilow et al., 2017; Perez-Rodriguez et al., 2012; Rottenberg et al., 2014). Findings reveal that sedentary habits (e.g., watching television, lack of

sports participation, computer games), geographic (e.g., the ease of walking in recreational facilities or to school), cultural (e.g., race, ethnicity), and psychological factors (e.g. stress tolerance) demonstrated only weak and inconsistent linkages with physical inactivity throughout childhood. Given the significance of the decline in physical activity among middle school students, several school-based stroke education and physical health intervention programs have adopted traditional didactic health promotion strategies among elementary students (Saint-Maurice et al., 2017; Tarro et al., 2017; Toussaint et al., 2017) and middle school students (Brick et al., 2017; Frydman and Mayor, 2017; Jamerson et al., 2017) (Erfle and Gamble, 2015; Grydeland et al., 2013; Herscovici et al., 2013; Lazorick et al., 2015; Marcus et al., 2013). Whether these strategies successfully helped learners to increase or improve learned information in the short or long term is not fully understood.

Educational intervention programs that focused on didactic teaching or multi-media computer programs reveal variable results in improving knowledge about stroke and healthy habits (Hino et al., 2018; Maasland et al., 2011; Tomari et al., 2017). Unfortunately most

* Corresponding author at: University of South Carolina, School of Medicine-Greenville, Greenville, SC 29605, USA.

E-mail address: nathanit@greenvillemed.sc.edu (T.I. Nathaniel).

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of the written materials are often too complicated to be processed (Eames et al., 2003) especially by middle school students and outcomes were not associated with increase in knowledge in the short and long term (Denny et al., 2017). Active learning or students-centered educational interventions have been utilized to stimulate critical thinking (Haak et al., 2011), increase knowledge and promote the retention of learned information (Diane et al., 2012), and maybe very effective to increase knowledge on stroke issues, healthy life style choices and to promote health behaviors among middle school students. The active learning of specific healthy habits and stroke issues and the increase in the knowledge of learned information is necessary because these components are linked in a web of mutual support that needs to be maintained and constantly used to enhance healthy habits.

The objective of this study was to develop a student-centered educational intervention program to educate and retain learned knowledge on stroke issues and healthy habits among middle school students. The aims of our study were to (1) assess the impact of the program on students' knowledge in recognizing stroke signs, symptoms and healthy habits and (2) evaluate the impact of the program in changing or improving the retention of learned information 3-weeks post-intervention. Data generated in this pilot study will aid the design and implementation of active learning stroke and healthy habits education interventions in middle schools in the stroke belt.

2. Method

2.1. Participants

The program was implemented in South Carolina which falls within the "stroke belt," a region of the United States with the highest recorded incidence of stroke and other cardiovascular disease. The study population was comprised of students from various racial/ethnic backgrounds including comprises of Hispanic, African American, and Caucasian living in low to medium socioeconomic statuses in a suburban area in South Carolina. The age range of students was 11–14 years old. The population was approximately 52% girls and 48% boys. A total of 338 middle students participated in the program including 127 (6th graders), 113 7th graders and 98 8th graders. The program was implemented during physical education (PE) class; classes were 1 h long and ran from 8:00 am to 3 pm. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration concerning human rights, and correct procedures were followed concerning treatment of humans in research. Ethics clearance for the study protocol was provided by the approved by the Greenville Health System institutional committee for ethics.

2.2. Use of videos and interactive activities to prepare students for the active learning activities

To prepare students for the active learning activities, we allowed students to watch two videos, each about 10 min in duration. The first was a video from the American Heart Association/American Stroke Association (AHA/ASA) featuring NBA star Paul George and his mother who suffered a stroke (https://www.youtube.com/watch?v=_6gBPYDPx5k). This video helped to deliver a clear and simple message regarding the recognition of stroke symptoms and urged the children to readily take action via the "FAST" mnemonic—"F" (face droop), "A" (arm weakness), "S" (speech affected/slurred), and "T" (time to call 911) derived from the Cincinnati Prehospital Stroke Scale (Kothari et al., 1999). The second video demonstrated how stroke can affect individuals at any age through the story of a twenty three-year-old local resident of Greenville, South Carolina who recounted her personal experience with stroke and her journey to recovery. Information learned from the two videos are, 1) stroke is real and could affect younger and older people, 2) stroke affects the brain, 3) stroke is

preventable, 4) healthy habits can help prevent stroke. This session was immediately followed by 15 min of informal interactive overview provided by medical students. The knowledge concepts addressed by the interactive activities with medical students include 1) definition stroke and facts about stroke, 2) recognition of stroke symptoms and calling 911, 3) risk factors of stroke, 4) healthy habits and nutrition. The interactive sessions reinforced the materials in the videos. Moreover, it highlighted the importance of daily exercise as a healthy habit in the prevention of stroke. The two videos and the 15 min interactive sessions helped to prepare the students for the active learning activities at each of the stations.

2.3. Description of stations and active learning activities

Three stations were created that encompassed different themes from the two videos. Each class was divided into small groups of 8–12 students and the groups rotated through the three stations spending an average of 10 min at each station. Each station provided an opportunity for the students to interface with their peers through active learning activities that served to reinforce stroke issues and healthy habits. Activities at each station were facilitated by a medical student, and the middle school students were guided to actively learn materials individually, and by connection with their peers.

The "FAST" station (station 1) helped to reinforce the information introduced in the videos about signs and symptoms of stroke via the "FAST" mnemonic - "F" face droop, "A" arm weakness, "S" speech affected/slurred, "T" time to call 911. At this station, students had the opportunity to share their personal family experiences and stories about stroke, including what they would have done differently based on their new knowledge. At this station, students shared their personal family experiences or stories about stroke, including what they would have done differently based on their new knowledge about FAST. In the nutrition station (station 2), students interacted among themselves to learn the differences between natural and added sugars, and the number of calories found in foods like candy, cakes, pies, and milk products. They discussed their everyday drinks including sodas, juices, sweet tea, and Gatorade. They also identified six of the saltiest foods commonly found in their diets and discussed how a high sodium content in their meals can increase the risk of hypertension, one of the leading causes of stroke. The students then consolidated their knowledge and facilitated retention through interactive matching games in which they matched sugar and salt contents to common foods and drinks. The exercise station (station 3) provided an opportunity for social interaction with both peers and medical students while engaging in motor skill acquisition. In their small groups, students practiced and discussed how engaging in about 30 min of moderate-intensity exercise at least 5 days a week in accordance with American Heart Association (AHA) recommendations can help prevent stroke (Billinger et al., 2014).

All group discussions were informal. Middle school students interacted with each other and shared new knowledge on topics discussed at each station as a simple way to increase retention of learned materials. Medical students were facilitators who redirected conversations to focus on the learning topics and responded to questions when asked. The participating medical students were trained and well educated in a standardized manner through focused lectures in clinical neuroscience, stroke etiology, control and prevention, and clinical neurology rotations. The use of medical students instead of school gym teachers served as motivation for the middle school students, giving them access to a new social group and role models. This allowed informal interactions and better communication between middle school kids and station facilitators.

2.4. Program assessment

Assessment of the program was carried out post-test and three

Table 1
Stroke education knowledge and healthy habit questions, rubrics used for scoring, and evaluation of students' performances.

Tested knowledge	Test question	Question format	Answers	Distracters	Correct response in immediate response (all class grades)	Correct response in 3 weeks testing (all class grades)
Signs of stroke and action when stroke is recognized (FAST). Body organ/System affected by stroke	What does "F", "A", "S" and "T" stands for relating to stroke? Body system for stroke: Fill in; stroke occurs when blood flow to the is interrupted.	Identify stroke symptoms associated with "F", "A", "S" and what to do at the time (T) that stroke is recognized	"F" = facial expression "A" = arm weakness "S" = slurred speech "T" = time to call 911	NA Stomach, Heart, Liver,	92.01 61.83%	99.36% 80.92%
Ability to name at least three of the six salty food them is the saltiest.	Name three salty food and which of them is the saltiest.	Open ended	Body system for stroke: Brain Bread and Rolls, Soup, Pizza, Sandwiches, Chicken, Burritos and tacos.	NA	43.20%	92.11%
Identify drinks with high levels of sugar.	Identify 2 drinks in the Rethink your drink" display had the highest level of sugar? How much time	Multiple choice	Redbull, Gatorade, Coca cola, Mountain dew, Rockstar energy.	NA	87.17%	94.38%
Number of minutes and days per week of exercise associated with lower risk of death and cardiovascular disease	How much time should you exercise every week for overall cardiovascular health?	Multiple choice	30 min at least 5 days a week.	45 min for 3 days	61.83%	80.92%
Stroke fact-that stroke is preventable	Is stroke preventable? True or false	True or false	True	True	92.01%	98.36%

weeks after initial intervention study design. All data was collected without personal identifiers and drawn from 6th, 7th, and 8th graders. All data was collected without personal identifiers and drawn from 6th, 7th, and 8th graders. The evaluation questions were modified from validated American Heart Association/American Stroke Association Stroke Toolkits for Kids. Questions were printed onto small cards given to the students and referred to as "passports". Only the professor and medical students were involved in the development of the test questions and the grading. Questions examined stroke knowledge and healthy habits related to the active learning activities. Table 1 summarizes stroke education knowledge and healthy habits questions, rubrics used for scoring, and evaluation of students' performances. The rubrics have been validated in our previous study (Johnson et al., 2017). Questions covered basic knowledge of signs of stroke, actions to take when stroke is recognized, body organs/systems affected by stroke, and knowledge of the fact that stroke is preventable. For the healthy habit questions, students were tested on their ability to identify at least three of the six most salty foods, and drinks with high levels of sugar. Our goal was to determine the impact of the program on students' knowledge and recognition of stroke symptoms, and healthy habits and to evaluate the impact of the program in the retention of learned information at 3-weeks post-intervention. Therefore, we collected for post-test and 3-weeks follow-up post intervention. The 3-weeks follow-up post intervention was given without warning so that the measure would reflect the retention or improvement due to the program, and conversations sparked by the students' new knowledge, and not possible interim studying by the students. After completing the three weeks follow-up, a debriefing session was conducted to provide correct answers and reinforce key healthy habit and stroke awareness issues. The debriefing session was conducted in the gym by physical education instructors, and the middle school students were not evaluated after the debriefing session. The three weeks follow-up timeframe was chosen to adhere to time constraints set by the release of middle school students for summer break. All components of the intervention program were implemented in English, and all test questions and responses were provided in English. We summed all data and correlated to a validated number scale for summative assessment ranging from 0 to 5 where "outstanding" is "5", excellent is 4, very good is 3, good is, 2, "fair" is "1" and poor is "0". Data are represented as mean ± standard error of the mean or expressed in percentages.

2.5. Data analysis

All statistical analyses were performed utilizing SPSS Statistics Software version 25.0 (Chicago, IL) and P < 0.05 was used to establish statistical significance in all comparisons between groups. The results of the post-test were compared against the 3-weeks post intervention test using Students t-test for each of the 6th, 7th, and 8th grade tests. Scores are represented as Mean ± S.D. We summed all data and correlated to a validated number scale for summative assessment ranging from 0 to 5 where "outstanding" is "5", excellent is 4, very good is 3, good is, 2, "fair" is "1" and poor is "0". Data are represented as mean ± standard deviation of the mean or expressed in percentages. The effect size was calculated for any statistically significant values using Cohen's d value to quantify the effect of size between post-test and the three weeks post intervention. Comparison between the 6th, 7th, and 8th grades was done using a 3 × 2 mixed analysis of variance (ANOVA) with grade (6th vs. 7th vs. 8th) as between factor and intervention (post-test vs. 3-weeks post intervention) as within factor during the baseline and post-intervention tests. Post hoc analysis was used to determine significant differences between the grade levels in the post-test and the 3-week post-intervention. In using ANOVA, we considered the independence of the groups being compared. Mauchly's test was used to test for sphericity to support the assumption that the relationships between pairs are equal in parametric test. We tested for the normal distribution of our data using exploratory data analysis (EDA) before use of the

Table 2

The post-test and the three weeks follow-up evaluation of knowledge of 6th grade student's for stroke and healthy habits. Scores are represented as Mean ± S.D. P values were determined using a Student's *t*-test, and the effect size was calculated for any statistically significant values using Cohen's *d* value to quantify the effect of size between post-test and the three weeks post intervention test. The effect size for FAST (*d* = 1.0.3) was found to be small as it was lower than Cohen's *d* value for a medium effect (*d* = 0.50), while the effect size for the salty six (*d* = 1.35) reflect a large size, and it was larger than Cohen's *d* value for large size effect (*d* = 0.8).

Subsection	Post-test	Three weeks post-intervention test		
	(n = 127)	(n = 109)	P-value	Cohen's D
F.A.S.T.	94.9 ± 19.2	99.1 ± 4.7	0.019*	0.300
Area affected by stroke	78 ± 28.6	78.9 ^a ± 31.4	0.809	
Salty six	59.8 ± 17.3	88.1 ± 24.0	< 0.001*	1.353
Drinks and sugar levels	91.9 ± 27.0	95.3 ± 20.3	0.091	
Stroke is preventable	89.9 ± 23.4	93.7 ^b ± 22.7	0.209	

* P < 0.05

parametric test.

3. Results

From the 6th grade, 127 students participated in the intervention and took the healthy habit and stroke education exam immediately following the intervention, and 109 students participated in the delayed test (Table 2). Knowledge was low in the post-test for all parameters except knowledge of whether stroke is preventable. There was a significant increase in the retention of knowledge of stroke signs (FAST; P = 0.019) and the salty six (P = 0.001) as most students were able to retain and improve knowledge about basic information about signs of stroke and salty foods three weeks after the intervention. Knowledge of organs/systems in the body affected by stroke, drinks with highest levels of sugar, and whether stroke is preventable or not were not significantly different (P > 0.05) when comparing post-test to the three weeks follow-up.

A total of 113 students in the 7th grade participated in the post-test, while 108 students completed the three weeks follow-up test (Table 3). The increase in retention of knowledge of basic information about stroke signs via the FAST acronym (P = 0.002), knowledge that stroke occurs in the brain (P = 0.001), and basic knowledge of salty foods (P = 0.001) significantly increased during the three weeks post intervention test. There was no significant difference (P > 0.05) in post-test and follow-up post intervention of the fact that stroke is preventable and knowledge of the sugar content of various drinks.

In the 8th grade class, 98 students participated in the post-test, while 87 students participated in the three weeks follow-up post intervention (Table 4). There was a significant increase (P < 0.05) in the retention of knowledge for all parameters except for knowledge of whether stroke is preventable (P > 0.05) in the three-weeks follow-up when compared to the post-test, and there was no change in the knowledge of drinks with high sugar content in the post-test and three-weeks follow-up post intervention test. The greatest increase in knowledge was observed in the six salty foods (P < 0.001), followed by the knowledge that stroke occurs when blood flow to the brain is obstructed (P < 0.001), and the fact that stroke is preventable (P = 0.04).

As shown in Table 5, ANOVA found a significant difference in knowledge for signs of stroke (FAST) between the 6th, 7th, and 8th grades [F (2,109) = 279.67, P = 0.05] in post-test. Post-hoc pair-wise comparisons analysis revealed a significantly higher performance

Table 3

The post-test and the three weeks follow-up evaluation of knowledge of 7th grade student's for stroke and healthy habits. Scores are represented as Mean ± S.D., P-values were determined using a Student's *t*-test, and the effect size was calculated for any statistically significant values using Cohen's *d* value to quantify the effect of size between post-test and three weeks post intervention test. As shown in the table, effect size for this analysis for the salty six (*d* = 1.18) was found to exceed Cohen's *d* value for a large effect (*d* = 0.80), while the effect size for FAST (*d* = 0.429) and knowledge of the area affected by stroke in the body (*d* = 0.431) reflect a small size because it is lower than Cohens' *d* value for medium size effect (*d* = 0.5).

Subsection	Post-test	Three weeks post-intervention test		
	(n = 113)	(n = 108)	P-value	Cohen's D
F.A.S.T.	87.8 ± 24.3	96.3 ± 14	0.002*	0.429
Area affected by stroke	78.8 ± 29	90.3 ± 24.1	0.001*	0.431
Salty Six	57.5 ± 17.3	85 ± 28.0	< 0.001*	1.182
Drinks and sugar levels	95.6 ± 20.7	92.6 ± 21.4	0.293	
Stroke is preventable	93.8 ± 22.3	93.5 ± 19.4	0.919	

* P < 0.05

Table 4

The post-test and the three weeks follow-up evaluation of knowledge of 8th grade student's for stroke and healthy habits. Scores are represented as Mean ± S.D., P-values were determined using a Student's *t*-test, and the effect size was calculated for any statistically significant values using Cohen's *d* value to quantify the effect of size between post-test and the three weeks post intervention test. The effect size for FAST (*d* = 0.348), and the fact that stroke is preventable (*d* = 0.422) were lower than Cohen's *d* value for a medium size effect (*d* = 0.5), while the effect size for the knowledge of the area affected by stroke (*d* = 0.796) was of medium size. The effect size for knowledge of the salty six (*d* = 1.353) was larger than Cohen's *d* value for a large size effect (*d* = 0.8).

Subsection	Post-test	Three weeks post-intervention test		
	(n = 98)	(n = 87)	P-value	Cohen's D
F.A.S.T.	92.1 ± 21.7	98 ± 10.2	0.018*	0.348
Area affected by stroke	79.1 ± 30.4	97.7 ± 13	< 0.001*	0.796
Salty six	60.7 ± 21.5	87.4 ± 17.8	< 0.001*	1.353
Drinks and sugar levels	92.9 ± 25.9	92 ± 22.7	0.802	
Stroke is preventable	87.8 ± 30.5	97.7 ± 13	0.004*	0.422

* P < 0.05

(P < 0.05) among 6th grade when compared with the 7th grade, but the performance between the 6th and 8th grades were not significantly different, while the difference between 7th and 8th grade was significant (P < 0.05). There were no significant differences between 6th, 7th, and 8th grades in the three weeks follow-up test [F (2,109) = 0.67 P = 0.120] for all parameters. In post-test following the intervention, knowledge that stroke occurs in the brain was generally low across the grades and was not significantly different between the three grades [F (2,109) = 0.89, P = 0.96]. The three weeks follow-up test revealed a significant increase in stroke knowledge among the 6th, 7th, and 8th grades [F (2,109) = 134.65, P = 0.001]. Post-hoc pair-wise comparisons analysis revealed a significant difference (P < 0.05) between the 6th, 7th, and 8th grades. Basic knowledge of the salty foods was generally low and not significantly different [F (2,144) = 0.053, P = 0.428] between the 6th, 7th, and 8th grades. There was a general increase in the three-weeks follow-up test compared with the post-test, but the difference was not significant [F (2,109) = 0.82, P = 0.609].

Table 5

Students performance by grade levels. Scores are represented as Mean \pm S.D. P-values were determined using ANOVA with repeated measures with a post hoc test for each variable.

Subsection	Post-test				Three weeks post-intervention test			
	6th grade	7th grade	8th grade	P values	6th grade	7th grade	8th grade	P values
F.A.S.T.	94.9 ^{bc} \pm 19.2	87.8 ^a \pm 24.3	92.1 ^b \pm 21.7	0.050*	99.1 \pm 4.7	96.3 \pm 14.0	98 \pm 10.2	0.120
Area affected by stroke	78 \pm 28.6	78.8 \pm 29	79.1 \pm 30.4	0.955	78.9 ^a \pm 31.4	90.3 ^b \pm 24.1	97.7 ^c \pm 13.0	< 0.001*
Salty six	59.8 \pm 17.3	57.5 \pm 17.3	60.7 \pm 21.5	0.428	88.1 \pm 24.0	85.0 \pm 28.0	87.4 \pm 17.8	0.609
Drinks and sugar levels	91.9 \pm 27.0	95.6 \pm 20.7	92.9 \pm 25.9	0.626	95.3 \pm 20.3	92.6 \pm 21.4	92.0 \pm 22.7	0.692
Stroke is preventable	89.9 \pm 23.4	93.8 \pm 22.3	87.8 \pm 30.5	0.216	93.7 ^b \pm 22.7	93.5 ^b \pm 19.4	97.7 ^b \pm 13	0.010*

Notes:

Asterisks (*, **, ***, P values) indicate results for post hoc comparison following repeated measure analysis. Numbers with the same alphabets are not significantly different but different from others with different alphabets of post hoc pairwise comparison evaluations differentiating all grades in the immediate and three-weeks delayed posttest.

Basic knowledge of the drinks with the highest sugar levels was generally high across all three grade levels but was not significantly different in the post-test [F (2,109) = 0.73, P = 0.626], and the three weeks follow-up test [F (2,109) = 0.53, P = 0.692]. Although the mean performances in knowledge of whether stroke is preventable or not was generally high for all grades, there was no significant difference between the three grades [F (2,109) = 0.35, P = 0.216] in the post-test. Repeated measures reveal a significant difference between grades in a three weeks follow-up test [F (2,109) = 56.08, P = 0.01]. Although post-hoc pair-wise comparisons analysis revealed no significant difference (P > 0.05) between the mean performance for the 6th and 7th grades, there was a significant higher performance (P < 0.05) when the 8th grade is compared with the 6th and 7th grades (Table 5).

4. Discussion

The current program was designed to provide an opportunity for middle school students where they can socially interact and take active roles in their own learning process in order to recognize stroke signs and symptoms including healthy habits and as well retain the learned information three weeks post-intervention. In this program, the student-centered active or learning activities varied from allowing students to clarify and organize their thoughts and ideas on their own or with peers, solve problems on their own by quizzing themselves, providing answers to solidify new learning, and confirming answers with medical students as facilitators. They shared personal family stories about stroke and healthy habits as a motivation and a starting point to learn more about stroke issues and healthy life styles choices. In this way, they built their own knowledge-base by connecting new ideas and experiences to current mental models in order to form new or enhanced knowledge and concepts about stroke and healthy habits.

Irrespective of the grade level, middle school students were aware of the cardinal symptoms of stroke and indicated that they would call 911 in a timely manner. They demonstrated basic knowledge of the salty foods in the post-test, and their knowledge in this area increased significantly after the three weeks post intervention. One would expect that students might forget information over time and that a 3-week post intervention testing would show decreases in knowledge. However, our finding reveals that the reverse was the case as there was a general increase in knowledge from directly after the intervention to three weeks later. It is possible that this could be due to the intervention that stimulated productive conversations about stroke and healthy habits both among peers and at home allowing learned information to be better retained and recalled even in a three-week post-intervention.

During the intervention, Students participated in physical activities of their choice including dancing, weightlifting, core body exercises, golf putting, hula hooping, jumping rope, and basketball. In their small groups, they shared information among themselves on how they embarked on different physical activities at home through everyday

activities including climbing stairs, walking pets, swimming, running errands, and common home tasks like sweeping or cleaning chores. They discussed physical activity as a strategy to lower the risk of stroke and then engaged in fun-related physical activity to solidify the discussion with examples of healthy habits that can help prevent stroke. They enjoyed the different fun activities that kept them entertained and were motivated to learn more physical activities that can prevent stroke as well promote a healthy habit. In this way, our program provided many fun and enjoyable activities with long lasting, memorable experiences to assist with measures to develop healthy habits even at home. The experience as a whole may have helped in increasing retention of learned information rather than a decrease in knowledge overtime. It is also possible that the students practiced some of the different activities after the program and this may have contributed to their ability to retain and improve on learned information three weeks following the intervention. Therefore, when students are encouraged to take ownership of their own learning with interactive activities, they perceive the entire educational program as fun, instead of primarily educational.

The 8th grade outperformed other grades in the basic knowledge that stroke is a preventable disease, while the 7th and 8th grades gained a significant increase in the knowledge that stroke occurs when blood flow to the brain is disrupted. This finding suggests that the ability to improve learned knowledge about stroke is not dependent on grade levels. Although the reason for the low performance of the 6th grade when compared with other grades is not clear, the increased performance for most of the parameters in the three weeks post-intervention indicate that middle school students can rapidly learn stroke information and retain the knowledge for at least three weeks. A major finding of this study is that the ability to retain such information is irrespective of stratifications in academic grade levels.

Our program revealed a stratification in class grade levels such that 8th and 7th grade students demonstrated greater understanding of the fact that stroke occurs when blood flow to the brain is disrupted when compared with 6th grades students. We also found that 8th grade middle school students are more knowledgeable of the fact that stroke is a preventable disease when compared with the 6th or 7th grade students. Based on the success of this program, it is possible that our active learning activities may serve as a novel medium for the implementation of a stroke and healthy life style educational intervention program that encompasses multiple content areas of stroke and healthy habit, including nutrition, physical activity, and stroke awareness and prevention. This approach may represent an ideal intervention template that (1) allows middle school students to actively take responsibility for their own learning of stroke and healthy habit topics and (2) enhances the learning of knowledge about key stroke concepts such as the FAST acronym, stroke symptoms, localization of stroke to the brain, and stroke prevention through avoidance of salty foods and high sugar drinks.

The impact of utilizing active learning in a stroke educational program has become evident due to several studies which demonstrated that peer interactive activities significantly improved learning outcomes (Nishikawa et al., 2016). We developed a student-centered program that provided the opportunity for students to socially interact and actively learn stroke knowledge both individually and with their peers through small groups' activities. In this setting, middle school students first "see" the evidence that stroke is real (videos), and then learn facts about stroke and its prevention, followed by putting those facts into action by "actively implementing" exercise as part of a healthy habit. Moreover, individuals discussed and shared personal family experiences involving stroke and the consequences of unhealthy habits. By employing this method, we created a diverse experience and provided an engaging learning environment that facilitated self-efficacy in the ability to actively learn information in a socially interactive session. It is possible that allowing the students to actively learn and practice exercises of their choices enhanced cognitive constructs that facilitated daily and regular practice (Fishbein, 2008) of healthy habits, as well as improved the retention of learned positive behaviors that increased the motivation to learn, remember, and engage in desired healthy behaviors (Allen, 2004).

Although there are some limitations, our study shows that a student-centered or active learning activities can be used as a tool to recognize stroke signs, symptoms and healthy habits and also retain learned information following the three weeks post-intervention. Collecting the data at a post-intervention time of only 3 weeks following the interventional program did not allow for a strong extrapolation on long-term retention of knowledge. This was because the program was implemented 3 weeks before the end of the academic year. Another limitation in our study is the lack of a pre-test measure as we only collected data for post-test and three weeks post intervention. Future studies should focus on implementing the program in multiple middle schools to obtain a control group and scheduling delayed testing after a period longer than three weeks.

5. Conclusion

This study found that active learning activities allow middle school students to take responsibility for their own learning of stroke and healthy habit topics and enhances learning and increase in retention of learned information. Intervention strategies need to consider active learning activities to better enhance the retention of basic knowledge of stroke and healthy habits among middle school students.

Abbreviations

"FAST"	mnemonic—"F" (face droop)
"A"	(arm weakness)
"S"	(speech affected/slurred)
ANOVA	Analysis of Variance
AHA	American Heart Association
PE	physical education
NBA	National Basket Ball Association
EDA	exploratory data analysis
GHS	Greenville Health System

Ethics approval and consent to participate

This study was performed with the approval of the Institutional Review Board of Greenville Health System and the institutional Committee for Ethics. We did not obtain individual consent to participate, as it was not feasible to obtain consent. Written consent to participate was obtained from the parents/guardians of all students included in this study.

Consent to publish

Not applicable.

Availability of data and materials

All materials are available for use from the corresponding author.

Competing interests

Authors report no conflict of interest.

Funding

Not applicable.

Authors' contribution

LW, LB, CU, AF and TIN designed the concept, experimental design and data analysis and critically revised the drafts read and approved the last version of this manuscript.

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