Integrative Medicine Research 9 (2020) 100397

Contents lists available at ScienceDirect

Integrative Medicine Research

journal homepage: www.imr-journal.com

Case Study

The sensory-motor auditory visual education (SAVE) program for adults with prior concussions: a prospective case study

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ARTICLE INFO

Article history:
Received 11 September 2019
Received in revised form 20 February 2020
Accepted 20 February 2020
Available online 29 February 2020

Keywords:
SAVE program
Concussion
Multisensory integration
Symptomatology
Case series

ABSTRACT

Background: The Sensory-Motor Auditory Visual Education (SAVE) Program is an intervention that utilizes an accelerated multisensory integration process to facilitate neuroplasticity. This study aimed to determine if the SAVE Program might benefit individuals with residual symptoms from a prior concussion.
Methods: The study consists of two 1-hour sessions per day for 5 consecutive days. Five individuals were recruited and completed a symptom questionnaire, static postural assessment, auditory detection assessment, peripheral vision assessment, and a battery of computerized cognitive tests.
Results: Following the treatment program, 5 individuals showed significant ($p < 0.05$) improvements in various reported symptoms, significant ($p < 0.05$) improvements in recognizing colors further from the center of a target, and better detection of an auditory stimulus in the right ear. All tested cognitive domains improved, except for episodic memory accuracy and choice reaction time. The most notable improvements were in planning latency (29.94%), planning accuracy (19%), and working memory accuracy (34.30%). The results of the balance assessment were mixed.
Conclusion: The results suggested that the SAVE Program may be a beneficial treatment of residual symptoms from a prior concussion. However, the intrinsic caveats of a case series require more rigorous research.

1. Introduction

A concussion is a disruption of the functional process of the brain induced by trauma to the head, which can result in disturbances in behavior, emotion, cognition, coordination, fatigue, and sleep.[1–6] Most individuals recover from their concussion within 7–10 days, but 10%-40% of individuals may continue to experience deficits months and even years later.[7–9]

Given the complexity of impairments from a concussion, determining an effective course of treatment can be difficult. Integrative therapies that enhance multisensory integration may prove to be beneficial. A previous study found that individualized multi-modal programs provided improvements for individuals with persistent dizziness and debility from a prior concussion.[10] This approach is supported by evidence that neuroplastic changes from multisensory training have been observed in cortical sensory regions and in subcortical areas, such as the thalamus and basal ganglia.[11–13]

The Sensory-Motor Auditory Visual Education (SAVE) Program, developed by Dr. Mary Ann Block (The Block Center, Fort Worth, Texas), is an FDA cleared intervention that utilizes an accelerated multisensory integration process to facilitate long-term neuroplasticity. Based on clinical experience and established multisensory integration research, Dr. Block created a proprietary protocol for the SAVE Program, known as the Clarity Chair in the United States of America. This study aims to accelerate the integration of 5 senses: auditory, visual, proprioception, vestibular, and tactile. The SAVE Program was designed to be consistent and passive, allowing any person to utilize the therapy regardless of ability level. For 6 years, Dr. Block has used this therapy with individuals who suffer from cognitive and multisensory deficits and has observed great success in alleviating these deficits. Using a prospective case series design, the aim of this investigation was to determine if the SAVE Program might benefit individuals with residual symptoms from a prior concussion.

2. Methods

2.1. Participants

Five individuals were recruited from Life University's campus. Participants were all Caucasian between the ages of 25 and 69 (mean = 40.2 years; SD = 17.20 years) and were comprised of 4 males and 1 female. Concussion onset included a fall (n = 1), rafting

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https://doi.org/10.1016/j.imr.2020.02.005

accident (n = 2), and sports related injury (n = 2). Time since last concussion ranged from 1 year to 16 years (mean = 5 years; SD = 6.25 years).

2.2. Eligibility

Individuals were eligible if they were over the age of 18, self-reported a concussion, and experienced deficits remaining at least 6 months post-concussion. Individuals were excluded from the study if they could not hear, see, or were currently taking any of the following medications: methylphenidate, modafinil, or Vyvanse. All study procedures were approved by the Institutional Review Board at Life University (approval number 12_15_2016_Seckington), and all participants signed an informed consent document.

2.3. Intervention

The SAVE Program protocol consists of 1-hour sessions twice a day for 5 consecutive days, with a 3-and-a-half-hour break between sessions. In a dark room, with a computer tablet suspended 6 inches (15.24 cm) above, each participant would lie on a table that would gently rotate in a figure-8 pattern while watching various colored lights and listening to a variety of music through headphones (Supplement 1).

2.4. Outcome measures

2.4.1. Symptom questionnaire

All participants completed a symptom questionnaire that was created by evaluating peer-reviewed literature and standardized medical assessments for concussion, including the review of the SCAT5 and the DSM5.[14,15] The resulting areas of assessment included concentration, balance, and other subjective symptomatology that were scored using a five-point Likert scale with options ranging from *none of the time* (0) to *all of the time* (4).

2.4.2. Balance testing

Participants completed four, ten-second assessments (eyes open and closed on flat and perturbed surface) on a force plate administered using the Bertec Workbook software (Bertec Corporation, Columbus, Ohio, USA).

2.4.3. Auditory testing

Participants wore noise cancelling headphones to test auditory detection at varying frequencies: 1000 Hz, 2000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz (Cadwell Industries, Kennewick, Washington, USA). Each trial began at 25 decibels and decreased by 5 decibels until a stimulus could no longer be detected. Testing was repeated for each ear separately.

2.4.4. Visual testing

Participants were asked to focus on the center of a chart that included eight concentric circles, divided into eight sections. Using a four-color pointer (red, green, blue, and white) the investigator randomly moved the pointer from the outermost circle towards the inner circles, stopping when the participant recognized the color. This was done for each section and color, resulting in a total of thirty-two trials. The testing was repeated separately for each eye with a patch covering the opposite eye to obscure vision.

2.4.5. Computerized cognitive testing

Designed specifically to assess cognitive dysfunction following a traumatic brain injury, The Cambridge Neuropsychological Testing Automated Battery was used to measure cognitive performance (CANTABeclipse 5 on a Microsoft Surface Pro with Windows 10 Pro, Cambridge Cognition, Cambridge, UK). Using a response pad and touch screen technology, the tests included attention switching task, one touch stockings of Cambridge, paired associates learning, reaction time, and spatial working memory.

Table 1
Changes in symptom score in adults with prior concussions (n = 5).

Symptom	Pre	Week-Post	Month-Post	P Value[a]
Headache	1 (0–1)	0 (0–1)	1 (0–1)	.156
Dizziness	1 (1–4)	0 (0)	0 (0)	.018
Depression	1 (0–2)	0 (0–1)	0 (0–1)	.050
Anxiety	2 (0–2)	0 (0–1)	0 (0–1)	.032
Irritability	2 (1–2)	0 (0–1)[b]	1 (0–1)	.035
Vertigo	0 (0–1)	0 (0–1)	0 (0–1)	.368
Tinnitus	1 (0–2)	0 (0–1)	0 (0)[c]	.023
Hearing Impairment	1 (0–4)	0 (0–4)	0 (0–4)	.135
Blurred Vision	1 (0–4)	0 (0–4)	0 (0–4)	.050
Diplopia	0 (0–1)	0 (0)	0 (0)	.368
Sensitivity to Light	2 (1–2)	1 (0–1)[b]	1 (0–1)[c]	.007
Sensitivity to Noise	2 (1–3)	0 (0–1)	0 (0–4)	.128
Fatigue	2 (1–3)	1 (0–1)[b]	1 (0–1)[c]	.009
Sleep Disturbances	3 (1–3)	1 (0k1)	0 (0–1)[c]	.024
Impaired Attention	2 (0–4)	0 (0–1)	0 (0–1)[c]	.023
Slow Reaction Time	1 (1–2)	0 (0–1)	0 (0–1)[c]	.015
Slow Speed of Information Processing	2 (0–3)	0 (0–1)[b]	0 (0–2)	.023

Data is represented as median (range).
[a] Within-group repeated measures p values for the Friedman's test.
[b] P < 0.05, Pre vs. Week-Post.
[c] P < 0.05, Pre vs. Month-Post.

2.5. Analysis

Assessments were conducted one-week pre, immediate pre, immediate post, one-week post, and one-month post SAVE protocol. One-week pre data was not included in the analysis due to equipment malfunction, and immediate post data was not included due to participant fatigue. Descriptive statistics, percent change, and within-group repeated measures Friedman's tests with post hoc analysis were calculated to test for significant differences (SPSS v25, IBM Corporation, Armonk, New York).

3. Results

3.1. Symptom questionnaire

Table 1 shows the median and range of responses from the questionnaire. Post hoc analysis of significant Friedman's test results showed significant improvements ($p < 0.05$) in irritability, sensitivity to light, fatigue, and slow speed of information processing pre to week-post and in tinnitus, sensitivity to light, sleep disturbances, impaired attention, and slow reaction time pre to month-post.

3.2. Balance testing

Displacement of the center of pressure (COP) was analyzed to examine changes in postural control. Changes in COP displacement were mixed with no significant differences found (Supplement 2).

3.3. Auditory testing

From pre to month-post, all participants demonstrated improvements in stimulus detection in the right ear, and post hoc analysis of significant Friedman's test results showed a significant improvement ($p < 0.05$) at 4000 Hz. A decline in detection was noted for the left ear pre to month-post across all frequencies (Supplement 3).

3.4. Visual testing

Trials were averaged for each eye to give a mean distance from the center of the target for stimulus detection. Post hoc analysis of significant Friedman's test results demonstrated significant ($p < 0.05$) improvements in the ability to recognize colors further from the center of the target from pre to week-post testing in both eyes. A significant ($p < 0.05$) improvement from pre to month-post in the right eye was also demonstrated (Supplement 4).

3.5. Computerized cognitive testing

Although no significant differences were observed following cognitive testing, percent change calculations showed improvements from pre to month-post, except for episodic memory accuracy (−21.72%) and choice reaction time (−1.72%). The most notable improvements were in planning latency (29.94%), planning accuracy (19%) and working memory accuracy (34.30%) (Supplement 5).

4. Discussion

This study aimed to determine whether the SAVE Program's proprietary multi-sensory integration protocol might be a beneficial treatment for residual concussion symptoms. Following treatment, individuals showed notable improvements in reported symptoms, color-related peripheral vision, hearing, mental planning, and working memory. Further, most improvements were still noted at the one-month follow up assessment.

Emerging research regarding concussion rehabilitation reveals the importance of incorporating multisensory integration. A systematic review by Königs and colleagues reported that early onset neurorehabilitation programs that demonstrated better functional outcomes for traumatic brain injury patients utilized multisensory stimulation.[16] Adams and Moore found significant improvements in individuals who had suffered a concussion at least nine months prior by using a multi-modal intervention program including vestibular and visual components.[10]

There are several limitations to this preliminary study, with the most prominent limitation being sample size. To fully investigate the impact the SAVE Program may have on individuals with concussion, a larger sample and comparison groups would be needed. Students were utilized as a convenience sample, so study time commitment was difficult to manage with already busy academic schedules. Future studies would benefit by utilizing a larger sample size and recruiting through a clinic or rehabilitation facility. Additionally, future studies might also benefit from the addition of neurophysiological measures, such as event-related potentials, or more rigorous sensory assessment methods. These measures might provide further insight into the mechanisms of action underlying observed clinical improvement.

In conclusion, the results of this case series may show the potential effects of the SAVE Program for individuals with residual symptoms from a previous concussion. However, the evidence is limited because of the intrinsic nature of a case series. Further rigorous investigation is needed regarding the efficacy of the SAVE Program.

Acknowledgements

The authors thank Dr. Mary Ann Block for consignment of the SAVE Program to the Dr. Sid E Williams Center for Chiropractic Research at Life University for this study.

Author contribution

AS and SS conceptualized the study idea. All authors contributed to data collection. ED analyzed and visualized the data. ED and SS wrote the manuscript. All authors contributed to manuscript review and editing.

Conflict of interest

The authors declare no conflict of interest.

Funding

No external funding was received.

Ethical statement

This study was approved by the Institutional Review Board at Life University (approval number 12_15_2016_Seckington), and all participants signed an informed consent document.

Data availability

Data will be available upon request.

CRediT authorship contribution statement

Emily D. Drake: Investigation, Formal analysis, Visualization, Writing - original draft, Writing - review & editing. **Angela S. Seckington:** Conceptualization, Investigation, Writing - review & editing. **Stephanie G.B. Sullivan:** Conceptualization, Investigation, Writing - original draft, Writing - review & editing. **Shannan Behrens:** Investigation, Writing - review & editing.

Appendix A. Supplementary material

Suppl. 1. Depiction of an individual on the table used in the SAVE Program; Suppl. 2. Mean center of pressure displacement for anterior/posterior and medial/lateral directions; Suppl.3. Mean results for the decibel level at which an auditory stimulus was detected by the left and right ear at each of the tested frequencies; Suppl. 4. Mean distance from the center of the target for stimulus detection of the left and right eye; and Suppl. 5. Mean percent change of each of the cognitive domains assessed, can be found in the online version, at doi:https://doi.org/10.1016/j.imr.2020.02.005.

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