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Identification of Key Therapy Ingredients for SLPs Serving on Multidisciplinary Teams Facilitating Return to Learn for Students With Prolonged Cognitive Effects After Concussion

A Retrospective Case Series Analysis

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Purpose: This retrospective case series utilized clinical data mining (CDM) to understand the potential key components in an integrated treatment approach delivered by speech–language pathologists (SLPs) treating adolescents experiencing persistent cognitive effects postconcussion. The first purpose was to describe the profiles of students treated in our clinic, how they were treated, and the nature of multidisciplinary communication. The second purpose was to generate testable hypotheses about effective intervention options for this population. **Methods:** Fifteen students aged 13–18 years experiencing prolonged concussion symptoms (PCS) were referred to our SLP graduate training clinic by a local pediatric neuropsychologist for cognitive rehabilitation services. Clinical data mining extracted clinical data in 4 main categories: (a) student characteristics, (b) SLP treatment parameters, (c) clinical outcomes following SLP treatment, and (d) the nature of multidisciplinary communication between practitioners. **Results:** Aligned with risk factors for PCS as reported in the literature, data on student characteristics revealed that the majority of students had sustained multiple previous concussions and reported a history of depression/anxiety. Data on SLP treatment parameters identified metacognitive strategy instruction and the training of assistive technology for cognition as the most frequent interventions selected to address academic goals. Data showing the frequency and type of multidisciplinary communication revealed

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that SLPs communicated most often with the pediatric neuropsychologist and educational liaison. Clinical outcome data revealed that 12 of the 15 students achieved their academic goals at the time of discharge. **Conclusions:** Overall, CDM results suggested that when working in a multidisciplinary team, SLPs can provide cognitive rehabilitation, support symptom reduction, and deliver psychoeducation potentially effective for students experiencing PCS. Key treatment and outcome measurement issues important for developing testable interventions are discussed. **Key words:** *cognitive rehabilitation*, *concussion*, *speech–language pathology*

INTRODUCTION

Mild traumatic brain injury (mTBI), more commonly referred to as concussion, occurs between an estimated 1.6–3.8 million times annually in the United States and accounts for 75% of all traumatic brain injuries (TBIs; Langlois, Rutland-Brown, & Wald, 2006). Typically, individuals who sustain a concussion may experience symptoms from 2 weeks to 3 months after the injury (Lumba-Brown et al., 2018). However, 10%–20% of concussion injuries result in prolonged concussion symptoms (PCS), sometimes termed postconcussion syndrome, defined as the presence of at least three symptoms 3 months postinjury by the diagnostic criteria of the *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition) *DSM-IV* and *International Classification of Diseases, Tenth Revision* (*ICD-10*; Babcock et al., 2013; Zemek, Farion, Sampson, & McGahern, 2013). More recent literature has defined PCS as the presence of symptoms beyond expected recovery time frames, which is beyond 10–14 days in adults and beyond 4 weeks in children (McCrory et al., 2017). Common PCS complaints include (a) somatic symptoms such as headache, dizziness, visual disturbances, sensitivity to noise and light, fatigue, and sleep disturbances; (b) cognitive concerns with attention, concentration, memory, and judgment; and (d) psychological symptoms such as irritability, depression, anxiety, or PTSD (Emery et al., 2016; Kerr et al., 2017; Towns, Silva, & Belanger, 2015).

Children, adolescents, and young adults are at particular risk for experiencing PCS; they represent the highest age-incidence groups and experience the most disruptive, prolonged symptoms (Cancelliere et al., 2014). A main concern regarding the development of PCS in the adolescent population is the negative effect prolonged symptom duration may have on the individual's ability to maintain academic success (Glang et al., 2019; Halstead et al., 2013; McAvoy, Eagan-Johnson, & Halstead, 2018). Academic problems following PCS may manifest as a decline in grades, reduced assignment completion, poor school attendance, or difficulty learning and processing new information (Gioia, Glang, Hooper, & Brown, 2016). Students who report multiple concussion symptoms 4 weeks following their injury demonstrate a significantly higher number of academic problems than students who report less symptoms (Ransom et al., 2016). Therefore, schools need to be equipped to provide supports through individualized, formal academic adjustments and accommodations, such as 504 Plans that are part of Tier 2 services, in order to prevent the students from falling further behind in school as they progress toward preinjury academic performance (Halstead et al., 2013; Hossler, McAvoy, Rossen, Schoessler, & Thompson, 2014; McAvoy et al., 2018). Furthermore, PCS may hinder the individual's ability to successfully regain social and athletic functioning, which are vital components of the adolescent experience and development (Green, Koshimori, & Turner, 2010). The complexity and increasing number of youths struggling to return to the classroom and extracurricular activities following concussions require that both medical and school-based speech–language pathologists (SLPs) have access to evidence-based treatments.

CONCUSSION TREATMENT IN THE LITERATURE

Speech–language pathologists play an important role in the treatment of prolonged cognitive symptoms postconcussion due to a background of clinical training in cognitive–communication disorders (Ketcham et al., 2017; Salvatore & Fjordbak, 2011; Williams-Butler & Cantu, 2019). The general knowledge and concern surrounding concussion in adolescents are increasing and provide SLPs with a growing evidence base to support their treatment of prolonged cognitive symptoms. Three primary literature sources provide direction for the assessment and treatment of students recovering from concussion or experiencing PCS: (a) position statements on school concussion management, (b) the neuropsychology treatment literature evaluating methods for symptom management, and (c) the cognitive rehabilitation literature specific to the treatment of mTBI by SLPs.

Position statements on school concussion management

Position statements on school concussion management are typically based on expert consensus and discuss the implementation of return-to-learn (RTL) guidelines, many of which specify graded and gradual return to activity in the acute recovery period of concussion (Dachtyl & Morales, 2017; Gioia, 2016; Halstead et al., 2013; Hossler et al., 2014; McAvoy et al., 2018). For example, Gioia (2016) presents a five-stage graduated RTL guideline to facilitate students' transition back to the classroom. The stages coincide with increased school engagement as symptoms reduce. The transition through the five stages signifies a greater tolerance of cognitive stimulation, class attendance and participation, test taking, and homework completion with a lessening of academic supports and rest breaks (Gioia, 2016). Several position statements also stress the importance of avoiding prolonged cognitive rest, which is believed to mediate PCS, and suggest encouraging students to return to school at a level at which they can tolerate 30–45 min of cognitive stimulation (Dachtyl & Morales, 2017; Halstead et al., 2013; Hossler et al., 2014). The RTL guidelines uniformly recommend the early identification of academic accommodations (AA) and ongoing monitoring of symptom resolution (Dachtyl & Morales, 2017; Gioia, 2016; Halstead et al., 2013; Hossler et al., 2014; McAvoy et al., 2018). The emphasis in RTL guidelines tends to be on early supports to avoid development of lingering symptoms (Gioia, 2016; Hossler et al., 2014). Earlier identification and rapid implementation of initial supports are important as typical evaluations for struggling students done as part of an individualized education plan (IEP) likely are not performed quickly enough to fully benefit the student and thus miss the window for preventing the development of PCS (Brown, O'Brien, Knollman-Porter, & Wallace, 2019).

Implementation of guidelines in the school context stresses the importance of multidisciplinary participation and communication between both medical and school personnel to ensure successful recovery and return to baseline academic performance (Brown et al., 2019; Gioia, 2016; Halstead et al., 2013; Knollman-Porter, Constantinidou, Beardslee, & Dailey, 2019; Knollman-Porter, Constantinidou, & Hutchinson Marron, 2014; McAvoy et al., 2018). A related recommendation is to educate school staff on the nature of concussion and methods to support students returning to the classroom following an injury (Dachtyl & Morales, 2017; Gioia et al., 2016; Romm et al., 2018). Speech–language pathologists have been identified as essential members of RTL concussion management teams to assess student cognitive needs, track symptom presentation, and oversee the implementation of AA (Brown et al., 2019; Dachtyl & Morales, 2017; Hardin & Kelly, 2019; Ketcham et al., 2017; Knollman-Porter et al., 2014; Knollman-Porter et al., 2019; Salvatore & Fjordbak, 2011). Although there are different models describing the roles of SLPs in concussion management in schools and clinics, there is little guidance about supporting prolonged symptoms with individualized direct

interventions. Methods to manage symptoms that last beyond 3 months are not addressed in the treatment literature.

Neuropsychology treatment literature

In spite of the implementation of RTL guidelines in schools, some students continue to present with prolonged cognitive symptoms that negatively affect their ability to learn and require direct intervention. The neuropsychology literature offers a second body of work that can guide SLP intervention in the RTL process. To provide appropriate psychoeducation (PE), track needs, and identify appropriate supports, it is critical that SLPs understand the course of concussion, including both the typical pattern of acute recovery and the development of PCS in a subset of students. The literature suggests that in most cases, prolonged cognitive symptoms result from an interaction between (a) the initial physical injury with the associated metabolic and cerebral blood flow disruptions; (b) individual preinjury risk factors including depression and anxiety, history of concussion, and previous learning disability; and (c) the individual's psychological response to the injury and symptoms (Broshek, De Marco, & Freeman, 2015; Conder & Adler Conder, 2015; Silverberg & Iverson, 2011). The concussion thus begins as a biological event, and concomitant psychological and emotional reactions to the symptoms tend to drive symptom prolongation (Broshek et al., 2015; McNally et al., 2018; Silverberg & Iverson, 2011). Several studies have suggested that PE emphasizing support and reassurance for continued recovery, behavioral health such as sleep hygiene, graded increase in activity, cognitive restructuring to mitigate negative belief patterns, and instruction in both coping skills and relaxation resulted in reduced symptom reporting and faster recovery (McNally et al., 2018; Ponsford et al., 2001; Scheenen, Visser-Keizer, Van Der Naalt, & Spikman, 2017). This body of literature also reminds practitioners of the possible iatrogenic effects of setting up expectation or context for illness through overtesting and pathologizing (Kirkwood, Peterson, Connery, Baker, & Forster, 2016). Iatrogenic effects occur as a result of treatment and may exacerbate or lengthen PCS because the patient is made more aware of potential symptoms (Bender & Matusewicz, 2013). For example, prescribing complete rest until the individual is asymptomatic may result in an iatrogenic effect by causing the individual to report more symptoms (Kirkwood et al., 2016). Iatrogenesis may also manifest by diagnosing "brain damage" as an explanation for prolonged symptoms, which for some individuals, may worsen their perception of the symptoms they are experiencing (Silverberg & Iverson, 2011).

Cognitive rehabilitation literature specific to the treatment of mTBI by SLPs

A third source of evidence useful for informing SLPs treating youth with concussions comes from the cognitive rehabilitation literature specific to mTBI. Pediatric studies have adapted interventions developed for adults to children with TBI and suggested positive effects from direct attention training (DAT) integrated with cognitive strategy training (Sohlberg, Harn, MacPherson, & Wade, 2014; Treble-Barna, Sohlberg, Harn, & Wade, 2016). In pilot studies, both Sohlberg et al. (2014) and Treble-Barna et al. (2016) identified positive outcomes in the areas of working memory and executive functioning for pediatric and adolescent individuals with a history of TBI following the implementation of DAT and strategy training. Outcome measures included the Test of Everyday Attention for Children, Delis-Kaplan Executive Function System, and both parent and self-report of the Behavior Rating Inventory Index (Sohlberg et al., 2014; Treble-Barna et al., 2016).

Most of the adult-focused experimental studies have evaluated multifaceted intervention programs including cognitive strategy training, PE, and training the use of assistive technology for cognition (ATC; Cooper et al., 2016; Tiersky et al., 2005; Twamley, Jak, Delis, Bondi, & Lohr, 2014). In what is perhaps the most rigorous efficacy study to date, the authors conducted a randomized controlled

trial to compare four different intervention approaches for adults following mTBI (Cooper et al., 2016). The results suggested that the treatment group with both individual, therapist-directed and integrated cognitive rehabilitation group sessions experienced superior outcomes on the Key Behaviors Change Inventory, an outcome measure sensitive to identifying behavioral changes following concussion (Cooper et al., 2016; Kolitz, Vanderploeg, & Curtiss, 2003). Although there are issues with scaling adult interventions to pediatric populations, it is helpful to review the studies that demonstrate positive cognitive rehabilitation outcomes for improving attention and executive functions using structured internal and external strategy training for youth and adults with prolonged cognitive symptoms following concussion (Cooper et al., 2016; Sohlberg et al., 2014; Sohlberg & Ledbetter, 2016; Tiersky et al., 2005; Twamley et al., 2014).

The limited research examining direct cognitive rehabilitation interventions designed for children with acquired impairments in attention, memory, and executive function has primarily focused on children with moderate to severe TBI or post–cancer treatment such as radiation or tumor resection. In general, systematic reviews (Laatsch et al., 2007; Limond & Leeke, 2005) provide preliminary evidence for direct bottom-up approaches using drills when combined with top-down approaches using strategy training and environmental management to address these impairments.

More recent practice-based evidence has identified that common therapy practices for concussion provided by SLPs include the use of patient education, symptom management, and cognitive retraining (Williams-Butler & Cantu, 2019). Survey results collected by the authors from practicing SLPs revealed that nearly all respondents included both patient education on the neuropathological changes following concussion and symptom management targeting the patient's optimization of function to treat PCS. According to the survey, 74% of SLPs implemented cognitive retraining comprising tasks designed to strengthen the patient's cognitive endurance using activity tolerance building and attention process training (Williams-Butler & Cantu, 2019). Interestingly, SLPs tend to treat the cognitive aspects of fatigue whereas neuropsychologists address the sleep issues often responsible for cognitive fatigue by training sleep habits and promoting melatonin (Wylie & Flashman, 2017).

Taken together, the nascent, but growing intervention literature suggests that management of prolonged cognitive effects after concussion requires an integrated approach that addresses both the cognitive symptomatology and mediating psychological and somatic factors that may be preexisting prior to the injury or a response to the injury (McCrory et al., 2017). Whether cognitive impairments are maintained by psychological or somatic issues or due to the interaction of concussion symptoms and preinjury developmental learning difficulties, adolescent students need assistance to mitigate the effects. Furthermore, contextual factors, such as school and activity demands or home environmental factors, may influence symptoms or prolong symptom duration (Ransom et al., 2015; Ransom et al., 2016). To experimentally evaluate treatments and develop best practice guidelines for SLPs working with adolescents who experience cognitive symptoms after concussion, we need to first understand the potential key components in an integrated treatment approach and develop testable treatment hypotheses. This process was first initiated by Sohlberg and Ledbetter (2016), who retrospectively reviewed the SLP treatment of PCS in 24 individuals to examine treatment options, rationale for selected treatment, and clinical outcome. This current retrospective case series builds on the work of Sohlberg and Ledbetter (2016) to answer the following clinical questions based on a group of adolescent students referred to a university speech pathology clinic for PCS affecting their return to learn:

1. What were the characteristics of the students with PCS and how did their

symptoms align with the risk factors for PCS identified in the literature?
2. What were the direct interventions implemented by SLPs to treat prolonged cognitive effects postconcussion?
3. What were the range of treatment targets and goals?
4. Did interventions appear to result in positive outcomes?
5. What was the nature of multidisciplinary communication?

The second intention of this article is to develop hypotheses about the potential active treatment components that can be empirically tested and implemented in a variety of settings.

METHODS

Retrospective case series are useful for identifying potential active treatment ingredients that foster change (Crooke & Olswang, 2015). It is helpful to first explore outcomes where therapies were individualized to student needs in order to identify trends that may be useful for developing a proceduralized approach to treatment that can be tested. With no experimental constraints placed on treatment selection, we could explore which treatments were implemented with individual adolescent students presenting with prolonged cognitive effects and develop hypotheses about the treatment ingredients that may have contributed to positive outcomes.

Retrospective clinical data mining (CDM) is the extraction, analysis, and interpretation of available clinical data for practice–knowledge building, clinical decision making, and practitioner reflection (Crooke & Olswang, 2015; Epstein, 2011). Clinical data mining is conducted to not simply justify existing clinical practice but to instead provide "evidence-informed" reflection by practitioners to determine the types of treatments that may result in specific outcomes (Epstein, 2011).

Clinical setting

The purpose was to describe the types of treatments provided by SLPs and the types of communications required to integrate RTL supports in the absence of colocated multidisciplinary clinicians. There are increasing descriptive studies describing ideal implementation models that offer useful treatment protocols but may not be generalizable to a variety of settings (Knollman-Porter et al., 2014; Knollman-Porter et al., 2019). Hence, one ecological rationale for conducting this review was to examine therapeutic activities implemented by SLPs who did not have the advantage of working at a dedicated concussion clinic or of working in schools where there are committed school nurses and athletic trainers knowledgeable about concussion. The cases reviewed were all treated in a university training clinic for a communication disorders and sciences training program located in a midsized college town. Students with concussions were referred by a pediatric neuropsychologist for PCS affecting school performance and were seen in the outpatient university clinic by graduate student clinicians who had taken a dedicated cognitive rehabilitation course required by the graduate program and were supervised by one of four licensed SLPs with expertise in medical speech pathology. A total of 24 first-year graduate student clinicians were involved in the treatment of the students in the case series. The total number of clinicians was greater than the number of students included in the case series as 10 of the 15 students received treatment across multiple university terms. Graduate student clinicians in the university clinic rotate through different clinical rotations each term resulting in the 10 students to receive treatment from more than one clinician.

Multidisciplinary communication process

To follow current expert consensus guidelines (Gioia, 2016; Halstead et al., 2013; Knollman-Porter et al., 2014; Knollman-Porter et al., 2019; McAvoy et al., 2018), it was necessary to establish communication mechanisms with multidisciplinary practitioners. The principles for an integrated approach with practitioners who are not colocated or working for

the same institution were derived from the available evidence base on concussion management, emphasizing the importance of coordinated communication between multidisciplinary clinical providers, educators, and the student and family (Dachtyl & Morales, 2017; Gioia, 2016; Halstead et al., 2013; Hossler et al., 2014; McCarty et al., 2016).

The loose concussion management team was overseen by a pediatric neuropsychologist, who was colocated with a sports medicine physician. Students seeking treatment for concussion management in either the stage of acute recovery or stage of prolonged symptoms were first evaluated by the sports medicine physician. Students experiencing PCS were referred by the sports medicine physician to the pediatric neuropsychologist. The physician treated an average of 40 students each month for concussion evaluation and referred only an average of 10% to the pediatric neuropsychologist as most children and adolescents recover from concussion within 4 weeks (McCrory et al., 2017). If students were experiencing somatic symptoms such as dizziness or blurry vision at the time of their physical evaluation, a referral directly from the sports medicine physician to the physical therapist could be activated. Following the completion of an initial neuropsychological evaluation, the neuropsychologist provided PE to the students on concussion recovery and referred the students to relevant practitioners in the community based upon their symptom presentation, which included about two referrals of students with prolonged cognitive effects per month to the university outpatient clinic. The group of practitioners that were part of the multidisciplinary team included SLPs in the university clinic, a clinical psychologist, physical therapy group, sports medicine physician, pediatric neurologist, and an educational liaison, who was responsible for providing concussion education to school staff and overseeing the implementation of academic adjustments or accommodations. A referral to any practitioner was activated if the student presented with prolonged symptoms in the associated clinical domain, and students were referred to multiple practitioners if they presented with symptoms in multiple symptom categories. Figure 1 displays the referral process of our concussion management team. All team members had training and knowledge on concussion and its effects on student learning. Communication focused on reinforcement of strategies across areas to support recovery, identification of concerns, and prioritization of treatment and school goals. One student received physical therapy from a practitioner not included on the multidisciplinary team, who communicated relevant information to the pediatric neuropsychologist on the nature of the student's treatment.

Student consent and CDM

A total of 43 adolescents and clients experiencing PCS were referred to the neuropsychologist for concussion evaluation from September 2017 to February 2019. The neuropsychologist referred 88% of these clients ($N = 38$) to the university clinic. Twenty-seven of the 38 referred clients attended and

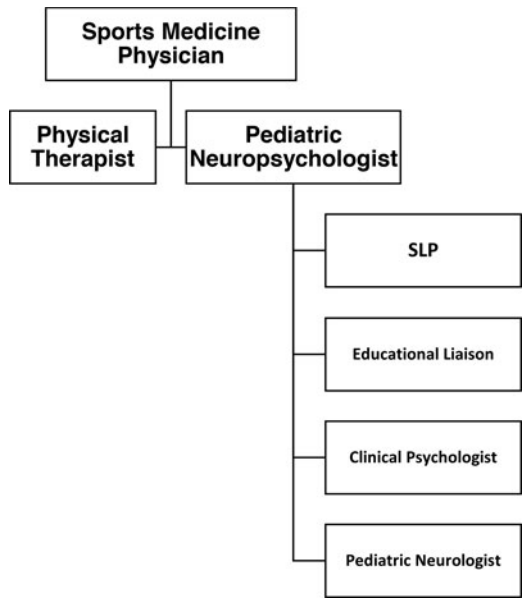

Figure 1. The referral process of the concussion management team. SLP = speech–language pathologist.

completed treatment. Only 15 students provided informed consent for this retrospective case series because of parental or individual concern about privacy. Institutional review board approval to conduct the retrospective case series was provided by the University of Oregon. Students were determined eligible for inclusion if they attended at least three clinical sessions and collaboratively developed goals with their SLP to address school-related needs (i.e., decreased academic performance, school attendance). Students who were no longer clients in the clinic were contacted by phone to discuss willingness to participate. If the students and their legal guardian agreed to participate over the phone, an informed consent form, child assent form, parent permission form, and Health Insurance Portability and Accountability Act authorization form were mailed to the students and their legal guardian to be signed and returned. Extraction of clinical data from previous students did not occur until the first author received all forms from the students and their legal guardian. Students who enrolled in the study as they were referred to our clinic were educated on the purpose of the retrospective case series during their first appointment and provided written informed consent as previously detailed to utilize their personal clinical data.

The CDM process was designed to extract clinical data representing four main categories: (a) student characteristics, (b) SLP treatment parameters, (c) the nature of multidisciplinary communication between clinical providers and educators, and (d) clinical outcomes following SLP treatment. Data extracted for the purpose of CDM were collected from the individual student's neuropsychological evaluation, SLP treatment file, and notes and/or e-mail exchanges from multidisciplinary meetings.

CDM records review

The first and second authors first identified the four main data categories of interest. The first author then reviewed each student's neuropsychological evaluation and extracted information on student characteristics. Student clinical files at the university clinic were then reviewed by the first author to extract data on treatment parameters and treatment outcomes. The second author completed reliability coding on seven of the 15 files (46%).

The university clinic files contained the following documentation written by graduate student clinicians and reviewed and signed by their SLP supervisors: initial consultation reports, session notes (using Subjective, Objective, Assessment, Plan format), and final treatment summary reports. The majority of extracted data was acquired from treatment summary reports that contained therapy goals, individual session measurements, the approach to treatment, and the outcome. The therapy goals were called long-term goals and the individual session measurements were labeled short-term objectives. Each long-term goal also contained an explanation of the treatment approach, measurement plan, and final outcome. The first author extracted these clinical data from each student file and reviewed SOAP notes as needed for further validation on the measurement of student progress.

RESULTS

Student characteristics

The participant parameters collected from file review included (a) sex, (b) age, (c) race, (d) concussion etiology, (e) the number of previous concussions the individual had sustained before receiving a neuropsychological evaluation and ensuing SLP treatment, (f) student's history of depression or anxiety, (g) the duration of time from injury to SLP treatment, (h) the student's primary prolonged symptoms, and (i) the student's academic support following the injury. The results of the extracted data on student characteristics are presented in Table 1.

Sex, age, and race

Of the 15 students whose parents provided informed consent for the case series, eight were female and seven were male ranging

Table 1. Student characteristics of individuals referred for cognitive rehabilitation

Student	Sex	Age (yr)	Race	Etiology	Number of Previous Concussions	History of Depression or Anxiety	Time Postonset (months)	Primary Persistent Symptom Categories	Academic Support
1	Female	15	White	SRC	0	No	1.5	Cognitive Somatic Psychological	AA (reduced homework; postponed tests until symptoms decreased)
2	Female	18	White	Head-to-head collision	1	No	6	Cognitive Somatic Psychological	AA (reduced homework; extra time on tests and assignments)
3	Male	13	White	MVA	0	No	4	Cognitive Somatic Psychological	IEP (family opted out-of-school services)
4	Female	16	White	SRC	4	Yes	20	Cognitive Psychological	N/A
5	Female	16	White	SRC	4	Yes	2.5	Cognitive Somatic Psychological Somatic	504 Plan (rest breaks; allowed to listen to music during work time)
6	Female	12	White	Head-to-head collision	3	No	4	Cognitive Somatic	504 Plan[a] (reduced homework; preferential seating)
7	Male	15	White	Assault	3	Yes	3	Cognitive Somatic Psychological	IEP[b] (alternative school setting)
8	Male	16	LatinX	MVA	0	No	2	Cognitive Somatic Psychological	504 Plan (rest breaks; reduced homework; extra time on tests and assignments)
9	Female	15	White	SRC	0	No	4.5	Cognitive Somatic Psychological	AA (extra time on tests and assignments)

(*continues*)

Table 1. Student characteristics of individuals referred for cognitive rehabilitation (*Continued*)

Student	Sex	Age (yr)	Race	Etiology	Number of Previous Concussions	History of Depression or Anxiety	Time Postonset (months)	Primary Persistent Symptom Categories	Academic Support
10	Male	16	White	SRC	2	Yes	4	Cognitive Somatic Psychological	504 Plan[c] (rest breaks; extra time on tests and assignments; access to notes)
11	Male	14	White	SRC	4	No	3	Cognitive Somatic Psychological	504 Plan (rest breaks; reduced homework; extra time on tests and assignments)
12	Female	16	White	SRC	N/S[d]	N/S	4	Cognitive Somatic Psychological	504 Plan (reduced schedule)
13	Male	17	White	SRC	2[e]	No	9	Cognitive Somatic	504 Plan (rest breaks; extra time on tests and assignments; access to notes)
14	Female	16	LatinX	Head-to-head collision	0	Yes	5	Cognitive Somatic Psychological	504 Plan (rest breaks; extra time on tests and assignments; testing in a separate room; preferential seating)
15	Male	18	White	SRC	2	No	24	Cognitive Somatic	504 Plan (rest breaks; reduced homework; extra time on tests and assignments; access to notes)

Note. AA = academic accommodations; IEP = Individualized Education Plan; MVA = motor vehicle accident; N/A = not applicable; N/S = not specified; SRC = sports-related concussion.

[a]504 Plan eligibility established prior to the concussion based on diagnosis of central auditory processing disorder.

[b]IEP eligibility established prior to the concussion based on presence of communication disorder.

[c]504 Plan eligibility established prior to most recent concussion based on diagnosis of anxiety.

[d]Neuropsychology report cited that participant sustained multiple previous concussions but did not provide exact number.

[e]Neuropsychology report cited that participant and participant's father reported three officially diagnosed concussions and multiple undiagnosed concussions where medical treatment was not pursued.

in age from 12 to 18 years, with an average age of 15.17 across both males and females. The age of the students was identified as the age at which they received their neuropsychological evaluation. Student 2 sustained her concussion and was evaluated by the neuropsychologist prior to her 18th birthday, so her clinical data were included in the case series. Race/ethnicity mirrored the demographics in the community with 13 out the 15 students White, and two students identifying as LatinX.

Injury etiology

The most common injury etiology was sports-related concussion, occurring in nine of the 15 students. Two students sustained their concussion in motor vehicle accidents, three sustained their concussion from an accidental head-to-head collision with a friend, and one student sustained his concussion from a physical assault.

Number of previous concussions

The number of previous concussions sustained by each student was identified in their individual neuropsychological report. Ten of the 15 students and/or parents reported at least one concussion prior to the present injury that led them to be referred by the physician to the neuropsychologist for an evaluation. Nine of these 10 students reported an exact number of previous concussions, whereas one student reported "multiple" previous concussions without providing an exact number. Of the nine students who reported an exact number of previous concussions, the average number of previous concussions was identified to be 1.79. Five students reported no previous concussions prior to their current injury.

Psychological history

Student history of depression or anxiety was obtained through the neuropsychological evaluation. Of the 15 students, a history of depression or anxiety was reported for five students.

Duration of time from injury to treatment

The duration of time from injury to initiating SLP intervention ranged from 1.5 months to 24 months with an average of 6.43 months. Four months was identified to be the modal duration of time from injury to SLP treatment. The duration of time from injury to treatment was measured as the length of time between the date of the student's injury and the date of the first appointment in the university clinic.

Primary symptoms

The students' primary concussion symptoms were categorized into the acute symptom clusters outlined by both Eisenberg, Meehan, and Mannix (2014) and Teel, Marshall, Shankar, McCrea, and Guskiewicz (2017). Those symptom clusters were Cognitive, Somatic, and Psychological. For the purpose of this retrospective case series, symptoms related to sleep disturbances were categorized under the somatic domain. Symptoms were assessed at the time of the student's neuropsychological evaluation through administration of the Post-Concussion Symptom Scale (Lovell et al., 2006). Of the 15 students, 12 reported symptoms in all three of the symptom domains. The remaining three students reported symptoms in the cognitive and somatic domains.

Primary academic supports

Fourteen of 15 students received some form of academic support following their concussion. Nine students were placed on 504 Plans, two students were placed on IEP, and three students received informal AA. Of note, two of the students with 504 Plans were determined eligible prior to their concussion based on other diagnoses, one for a diagnosis of central auditory processing disorder (CAPD) and the other student for a diagnosis of depression/anxiety. In addition, one student was previously determined eligible for his IEP based on the presence of a communication disorder. This student's IEP was adjusted following his injury to provide him the academic modification of attending school online through

a local charter school. Following the concussion, the student with the existing 504 Plan to address CAPD was provided the additional accommodation of reduced homework, whereas the student with the existing 504 Plan to address depression/anxiety was provided the additional accommodation of extra time on tests and assignments.

SLP treatment

Speech–language pathology treatment parameters were identified from the students' individual university clinic file where they received cognitive rehabilitation services and included the following: the number of sessions attended and scheduled, the students' primary functional goal, and the therapeutic approach to symptom management. The results of CDM on SLP treatment are presented in Table 2.

Dosage

The university clinic operates on an academic schedule with three 9-week clinic terms during the Fall, Winter, and Spring terms, and one 6-week clinic term during the Summer term. Students seeking services in the clinic attended weekly, 50-min sessions. For the 15 students of this case series, the average number of sessions attended was observed to be 8.87 sessions, and the average number of sessions scheduled was observed to be 11.33. The longest duration of treatment for one student was observed to be 19 sessions attended out of 28 sessions scheduled, whereas the shortest duration of treatment for one student was observed to be four sessions attended out of four sessions scheduled.

SLP therapy goal(s)

Every student and at least one parent or guardian collaborated with the SLP to develop a primary therapy goal(s) related to the cognitive or academic concerns for which they had been referred. As displayed in Table 2, the cognitive target represents the specific cognitive domain targeted in treatment, whereas the academic goal was the primary functional outcome and represented the desired impact by addressing the cognitive target. Goals were developed through the use of motivational interviewing to identify student priorities by asking initial questions such as: "What do you want to change about school right now?" "What do you think is getting in the way?" "What aspects of school are going well?" This process did not include standardized cognitive assessment as all students referred to the clinic had already undergone a full neuropsychological evaluation or consultation consisting of a clinical interview by the neuropsychologist. To avoid overtesting the students, the neuropsychological report was used as a reference for cognitive performance to pair with the motivational interviewing and goal development. This process resulted in the development of two types of therapy goals: (1) cognitive and somatic targets, and (2) academic goals as displayed in Table 2.

Cognitive targets in the area of attention/working memory were identified for five students. Corresponding academic goals for students with attention challenges included increased retention of lecture material and verbal instructions ($N = 4$), and increased reading comprehension ($N = 1$). Cognitive targets in the domain of executive function (self-regulation) were identified for 10 students. Corresponding academic goals for these students included (a) increased assignment completion ($N = 5$), (b) improved grades ($N = 4$), (c) increased school attendance ($N = 2$), and (d) reduced recreational screen time compared with weekly assignment completion ($N = 1$).

Therapeutic approach

Therapeutic approaches were selected collaboratively with the students and, in some cases, parents by having the SLP describe different options for addressing the identified goals and asking the students to share what they thought would be most feasible and impactful. Therapy approaches are shown in Table 2 and categorized by the type of symptom they were designed to address.

Table 2. Speech–language pathology treatment summary

Student	Sessions Attended/ Scheduled	Therapy Goal(s)		Therapy Approach		
		Cognitive and Somatic Target(s)	Academic Goal(s)	Cognitive	Somatic	Psychological
1	4/4	Sustained attention	Increase retention of lecture material and verbal instructions	MSI (internal self-talk)		PE (expectation for improvement; importance of reactivation)
2	6/7	Sustained attention Working memory	Increase reading comprehension	MSI (reading comprehension strategies; reauditorization strategy) ATC (Focus Booster app)		PE (relationship between anxiety and cognitive symptoms)
3	13/17	Sustained attention Working memory Headache management	Increase retention of lecture material and verbal instructions	MSI (note-taking strategies; reading comprehension strategies) ATC (Livescribe pen)	PE (symptom tracking)	PE (expectation for improvement; relationship between anxiety and cognitive symptoms; importance of reactivation)
4	19/28	Self-regulation	Increase assignment completion Reduce recreational screen time	ATC (use of paper planner; Apple iOS screen time setting)		PE (relationship between anxiety and cognitive symptoms)
5	7/11	Self-regulation Sleep	Increase assignment completion	MSI (prediction; task planning sequence; internal self-talk)	MSI (sleep hygiene protocol)	PE (relationship between anxiety and cognitive symptoms)

(*continues*)

Table 2. Speech–language pathology treatment summary (*Continued*)

Student	Sessions Attended/ Scheduled	Therapy Goal(s)		Therapy Approach		
		Cognitive and Somatic Target(s)	Academic Goal(s)	Cognitive	Somatic	Psychological
6	8/9	Sustained attention Working memory	Increase retention of lecture material and verbal instructions	DAT (drill-based attention exercises) MSI (internal self-talk; visualization)		
7	6/8	Self-regulation Headache management	Increase school attendance		PE (symptom tracking)	PE (expectation for improvement; relationship between anxiety and cognitive symptoms; importance of reactivation)
8	16/19	Self-regulation	Increase school attendance	MSI (internal self-talk)		PE (expectation for improvement; relationship between sleep and cognitive symptoms; importance of reactivation)
9	10/14	Self-regulation	Improve grades Increase assignment completion	MSI (internal self-talk)		PE (expectation for improvement; relationship between anxiety and cognitive symptoms; importance of reactivation)
10	11/14	Self-regulation	Improve grades	ATC (use of phone calendar with reminders)		PE (expectation for improvement; relationship between anxiety and cognitive symptoms; importance of reactivation)

(*continues*)

Table 2. Speech–language pathology treatment summary (*Continued*)

Student	Sessions Attended/ Scheduled	Therapy Goal(s)		Therapy Approach		
		Cognitive and Somatic Target(s)	Academic Goal(s)	Cognitive	Somatic	Psychological
11	9/13	Self-regulation	Increase assignment completion	ATC (use of paper planner)		
12	8/9	Self-regulation	Increase assignment completion	ATC (use of task initiation chart) MSI (emotional regulation strategy)		PE (expectation for improvement; relationship between anxiety and cognitive symptoms; importance of reactivation)
13	5/6	Self-regulation	Improve grades	ATC (use of phone calendar with reminders) MSI (reading comprehension strategies)		
14	5/5	Sustained attention Working memory	Increase retention of lecture material and verbal instructions	MSI (prediction; task planning sequence; note-taking strategies; reading comprehension strategies)		
15	6/6	Self-regulation Headache management[a]	Improve grades	ATC (use of phone calendar with reminders) MSI (study skill strategies)	PE (symptom tracking)	

Note. ATC = training assistive technology for cognition; DAT = direct attention training; MSI = metacognitive strategy instruction; PE = psychoeducation.
[a]Headache management included resources from headachereliefguide.com.

Cognitive symptom management

The two most common therapeutic approaches to treating cognitive symptoms identified in the 15 student files were metacognitive strategy instruction (MSI; $N = 11$) and the training of ATC ($N = 8$). In addition to MSI, one student received DAT using drill exercises to target sustained attention.

Specific metacognitive strategies identified in the case series encompassed both task-specific and generalized strategies including (a) internal self-talk ($N = 5$), (b) reading comprehension strategies ($N = 4$), (c) prediction ($N = 2$), (d) task planning sequence ($N = 2$), (e) reauditorization ($N = 1$), (f) study skill strategies ($N = 1$), (g) visualization ($N = 1$), and (h) emotional regulation ($N = 1$). Individual strategy selection was based on information gathered from the clinical interview and review of testing with consideration of academic concerns, student cognitive profile, and student preference (Sohlberg & Turkstra, 2011).

The most frequent form of ATC utilized with the 15 students in the case series was the use of either a paper planner or smartphone calendar app to track weekly homework assignment due dates ($N = 5$). Assistive technology for cognition for one student involved the utilization of a task initiation chart, another student utilized a specific smartphone app designed to promote sustained attention, and one student used a smart pen to assist with retaining school lectures. Finally, one student utilized the Apple iOS screen time feature to track her daily phone time with the overall goal of decreasing her weekly recreational screen time to coincide with an increase in weekly assignment completion.

Direct attention training was implemented with one student to improve sustained attention. It was determined an appropriate therapeutic approach for this student based on the identification of specific deficits in sustained attention through standardized testing that paralleled the concerns shared in the clinical interview. The computer-based approach also appealed to the student and the family.

Somatic symptom management

Four of the 15 students developed goals related to somatic symptom management. The clinician provided three students with PE on headache management. Students were further instructed to track weekly symptoms with the intention of identifying trends and triggers that either exacerbated or lessened their symptoms. The fourth student worked with her clinician to learn and implement metacognitive strategies to improve her sleep hygiene with the goal of improving overall sleep quality.

Psychological symptom management

Psychoeducation was provided to 10 of the 15 students included in the case series and was not associated with specific goals or targets. Four of the five students who did not receive PE did not report a history of depression or anxiety, and all four of these students were not experiencing significant psychological symptoms following their present concussion. The remaining 10 students reported psychological symptoms following their present concussion. Four categories of PE were provided to students based on relevance to the students' psychological overlay in relation to their concussion recovery. The PE categories included (a) facilitating an expectation for improvement ($N = 7$), (b) increasing understanding about the relationship between anxiety and cognitive symptoms ($N = 6$), (c) increasing understanding about the relationship between sleep and cognitive symptoms ($N = 2$), and (d) emphasizing the importance of reactivation to increase activity level ($N = 6$). Specific outcome measures on the impact of PE were not obtained beyond the measurement of functional goals.

Multidisciplinary communication with the SLP

The multidisciplinary concussion treatment group comprised seven different types of practitioners spread in six locations including a colocated physician and pediatric neuropsychologist, a clinical psychologist in a

group practice, a pediatric neurologist in a group practice, a group of physical therapists in a private practice, two educational consultants who worked either for the school district or the state and provided TBI education and oversight of academic support implementation, and four SLP supervisors and their graduate students in a university outpatient clinic. The student sample in this case series represented seven high schools and two middle schools across three school districts within one county.

Monthly case review meetings to discuss the progress of students currently being tracked by team care providers and coordinate care were optional for all practitioners but mandatory for the neuropsychologist as she served as the team lead. In addition, or alternatively, practitioners could communicate via e-mail between meeting dates to provide updates on students or participate via phone. Supplemental Digital Content Table 3 (available at: http://links.lww.com/TLD/A69) displays the frequency and modality of communication between the SLP and other care providers. The most frequent providers with whom the SLPs communicated were the neuropsychologist ($N = 15$), clinical psychologist ($N = 10$), and educational liaison ($N = 11$). All modalities of communication with these practitioners occurred via the monthly meeting or e-mail exchanges. None of the three practitioners the SLP most often communicated with were colocated to the meeting site, and they had to travel to the meeting that occurred monthly at the university clinic. The SLP was identified to communicate less frequently on students from the case series with the physical therapist ($N = 5$) and the pediatric neurologist ($N = 3$). Communication with the physical therapist occurred via the monthly meetings, and communication with the pediatric neurologist occurred via the monthly meetings and e-mail exchanges.

Frequency of communication was further characterized by the duration of time the students were tracked and discussed by the multidisciplinary team. Communication about students occurred more frequently for students who attended services for a longer duration of time. Students who presented with a more complex recovery pattern were additionally identified to produce more frequent communication between multidisciplinary care providers and also required treatment from a greater number of care providers to achieve symptom resolution. Complex recovery patterns were defined as students who required the services of multiple practitioners or achieved progress at a rate less than expected once beginning treatment in relevant therapy domains.

Clinical outcomes following SLP intervention

Clinical outcome data following SLP intervention were collected from the student's individual file from our university clinic and included the following: primary session measurement, academic outcome measure, therapy outcome, and discharge status. The results of CDM on the clinical outcomes following SLP intervention are presented in Table 3.

Primary session measurement

Each session included collecting performance data on the student's use of skills or concepts taught to manage symptoms and increase function. Session goals in which the therapeutic approach to treatment included MSI or ATC involved targeting the students' fluency and accuracy of the steps to implement a specific metacognitive strategy or utilize a specific external aid. For example, a consistent session goal across the students using ATC to manage homework completion ($N = 5$) targeted the students' abilities to accurately input assignment due dates into their paper or electronic calendars. Session goals for the student receiving DAT included performance on the drills and the student's ability to fluently and accurately implement the steps of metacognitive strategies integrated with drill-based attention exercises. Finally, for students targeting the management of somatic symptoms, session goals included targeting the ability to reflect on trends, triggers, and effective

Table 3. Clinical outcomes following speech–language pathologist intervention

Student	Primary Session Measurement	Academic Outcome Measure	Therapy Outcome	Discharge Status
1	Fluency and accuracy demonstrating steps for how to implement internal self-talk strategy	GAS with hierarchy measuring perceived percentage of recall 2 days after lecture	Level 0 (expected level—able to remember geometry content from 1 day to the next 2 days in a week)	Discharged following goal completion
2	Fluency and accuracy demonstrating steps for how to implement (1) reading comprehension strategies; (2) Focus Booster attention app; (3) reauditorization strategy	Performance on reading comprehension/retention test GAS with hierarchy measuring reported duration of reading time without break or distraction	Improved score 45 points on reading comprehension/ retention posttest Level 0 (expected level—able to read for 30 min without break or distraction)	Discharged following goal completion
3	Fluency and accuracy identifying appropriate settings or activities to implement (1) note-taking strategy; (2) reading comprehension strategies; (3) Livescribe pen Reflection of trends, triggers, and effective management of symptoms via symptom log	Self-report rating scales on the use of (1) note-taking strategy; (2) reading comprehension strategies; (3) Livescribe pen	Moved from 0 (novel) to 5 (independent use) for use of strategies and Livescribe pen	Achieved functional goal, however, did not report overall increase in academic performance at the end of treatment
4	Fluency and accuracy demonstrating steps for weekly assignment entry into paper calendar Reflection on iOS recreational screen time tracker results	GAS with hierarchy measuring number of assignments completed within a 7-day week Apple iOS recreational screen time tracker	Level 0 (expected level—able to complete 6/10 assignments per week) Decreased weekly phone screen time from 5 hr per day to 2 hr, 51 min per day	Discharged following goal completion

(*continues*)

Table 3. Clinical outcomes following speech–language pathologist intervention (*Continued*)

Student	Primary Session Measurement	Academic Outcome Measure	Therapy Outcome	Discharge Status
5	Fluency and accuracy demonstrating steps for how to implement (1) prediction; (2) task-planning sequence; and (3) internal self-talk strategies	Self-report of the number of incomplete assignments at the end of the school year	Decreased number of incomplete assignments from 15 to 0 by the end of the school year	Discharged following goal completion
	Fluency and accuracy demonstrating steps for how to implement steps of sleep hygiene protocol	GAS with hierarchy measuring number of quality nights of sleep per week across consecutive weeks	Level 0 (expected level—able to have a "good night sleep" 3 nights per week, 4 consecutive weeks)	
6	Fluency and accuracy demonstrating steps for how to implement (1) internal self-talk; (2) visualization strategies	Self-report rating scales on the use of (1) internal self-talk; (2) visualization strategies	Moved from 0 (novel) to 5 (independent use) for use of strategies No data for drill-based attention exercises as posttest was not completed	Discharged following goal completion
7	Reflection of trends, triggers, and effective management of symptoms via symptom log	Self-report on the number of daily hours completing online school modules	Increased duration of time completing online modules from 0 hr per day to 3 hr per day	Client discontinued therapy (appointment burden; parent perception treatment not helpful)
8	Fluency and accuracy demonstrating steps for how to implement internal self-talk strategies	GAS with hierarchy measuring duration of time spent in school per week	Level 0 (expected level—able to attend school for 3 hr per day, 5 days per week)	Discharged following goal completion
9	Fluency and accuracy demonstrating steps for how to implement internal self-talk strategies	Self-report of academic grades at the end of treatment GAS with hierarchy measuring percentage of weekly assignments completed	Increased GPA from 1.25 to 2.25 Level 0 (expected level—able to complete 60% of weekly assignments	Discharged following goal completion

(*continues*)

Table 3. Clinical outcomes following speech–language pathologist intervention (*Continued*)

Student	Primary Session Measurement	Academic Outcome Measure	Therapy Outcome	Discharge Status
10	Fluency and accuracy demonstrating steps for weekly assignment entry into Google calendar	Self-report of academic grades at the end of treatment GAS with hierarchy measuring number of days per week where all assignments were input into Google calendar app	Increased GPA from 1.83 to 2.17 Level 0 (expected level—able to input all assignments into Google calendar app 3 days per week)	Achieved functional goal, however, did not achieve desired GPA of 3.00 by the end of treatment
11	Fluency and accuracy demonstrating steps for weekly assignment entry into paper calendar	GAS hierarchy measuring number of days planner is used across consecutive weeks	Level +1 (better than expected level—able to use planner 5 days per week for 4 consecutive weeks)	Discharged following goal completion
12	Self-reflection on adherence to planning and tracking sheet documenting homework initiation	GAS hierarchy measuring the level of homework initiation	Level +2 (best possible outcome—able to initiate school work 100% of the time at home)	Discharged following goal completion
	Fluency and accuracy demonstrating steps for how to implement emotional regulation strategy	Self-report rating scale on use of emotional regulation strategy	Moved from 0 (novel) to 3 (used 7 times in a week) for use of emotional regulation strategy	
13	Fluency and accuracy demonstrating steps for (1) weekly reminder entry into phone calendar; (2) how to implement reading comprehension strategies	Self-report tracking sheet on the weekly use of alarms to complete school-related activities Self-report of academic grades at the end of treatment	Increased use of alarms from 0 per week to 17 per week Increased GPA from 1.83 to 2.83	Discharged following goal completion

(*continues*)

Table 3. Clinical outcomes following speech–language pathologist intervention (*Continued*)

Student	Primary Session Measurement	Academic Outcome Measure	Therapy Outcome	Discharge Status
14	Fluency and accuracy demonstrating steps for how to implement (1) prediction; (2) task-planning sequence; (3) reading comprehension strategies; and (4) note-taking strategies	Self-report rating scales on the use of (1) prediction; (2) task planning; (3) reading comprehension strategies; and (4) note-taking strategies	Moved from 0 (novel) to 5 (independent use) for use of strategies	Discontinued due to perceived mastery of strategies
15	Self-reflection on adherence to calendar schedule Fluency and accuracy demonstrating steps for how to implement study skill strategies Self-reflection on headache triggers and management	Self-report of academic grades at the end of treatment Headache Impact Test (HIT)	Increased GPA from 1.80 to 2.33 HIT score decreased from 60 (very severe impact) to 50 (some impact)	Discharged following goal completion

Note. GAS = goal attainment scaling; GPA = grade point average.

techniques for managing symptoms through the use of symptom logs.

Academic outcome measure

The most common outcome measure utilized to track student's progress on academic goals was the use of goal attainment scaling (GAS; Grant & Ponsford, 2014; Malec, 2001). The primary advantage of GAS is being able to scale and measure progress on individualized goals that are important and meaningful to the client by delineating possible levels of progress toward selected goals. Typically, goal hierarchies are generated with five equidistant, discrete levels (−2, −1, 0, +1 and +2) where −1 represents baseline performance and 0 represents expected improvement, with +1 and +2 corresponding to better than expected improvement and best possible improvement, and −1 corresponding to less than expected improvement because they would remain at baseline, and −2 corresponding to much less than expected improvements. When following specific GAS procedures, goal hierarchies can be generated that allow valid, reliable measurement of progress on specific functional goals that are meaningful to students and allow progress for different goals to be aggregated (Krasny-Pacini et al., 2017). Goal attainment scaling was used as an outcome measurement for nine students and encompassed hierarchies to measure progress on (a) homework completion ($N = 5$), (b) attention and retention of school material ($N = 2$), and (c) school attendance ($N = 1$).

The second most common outcome measures utilized to track student's progress on academic goals were rating scales that students used to document their use and perceived effectiveness of the targeted strategies and tools ($N = 4$) and their academic grades at the conclusion of treatment ($N = 4$). Examples of self-report rating scales included rating on a scale of 1–5 indicating how often the students used their strategies or rating on a scale of 1–5 indicating how helpful their strategy was in a specific time frame or situation.

Several other academic outcome measures ($N = 5$) were utilized including (a) comparison of pre- and posttest performance on a reading comprehension test; (b) data from Apple iOS screen time feature to track weekly, recreational phone screen time compared with weekly assignment completion, or (c) frequency or duration counts for target behaviors such as weekly assignments completed, number of alarms input into phone, or number of minutes devoted to completing online school modules.

Therapy outcome

Seven of the nine students utilizing GAS as an outcome measurement obtained level 0, the expected level of change, for their desired goal. One student obtained level +1, better than expected level, and another student obtained level +2, best possible outcome. Supplemental Digital Content Appendix A (available at: http://links.lww.com/TLD/A70) shows examples of Goal Attainment Scales for four students who achieved expected level of change (level 0) on their goal.

All four students utilizing self-monitoring of strategies reported independent strategy use with a positive impact to address their desired functional goal, which for three of the students corresponded to retention of lecture material and verbal instructions and for one student corresponded to increased assignment completion.

All four students measuring outcome by comparing pre- and posttreatment academic grades increased their grade point average (GPA). Students 9 and 13 increased their GPAs one full point, 1.25–2.25 and 1.83–2.83, respectively. Student 15 increased his GPA 0.53 points from 1.80 to 2.33. Student 10 increased his GPA 0.34 points from 1.83 to 2.17; however, he did not consider this increase in GPA to be enough of an improvement as his goal was to achieve a GPA of 3.00 or higher by the end of the academic school year, coinciding with the conclusion of treatment.

The five students who did not measure progress on academic goals using GAS or rating scales utilized a variety of measurements including the following. One student's therapy outcome was measured pre-/postcomparison on the CampusReader

reading comprehension test (Griffiths, Sohlberg, Kirk, Fickas, & Biancarosa, 2016), which showed a 45-point increase on the raw score of the assessment. Another student's therapy outcome was measured by tracking weekly, recreational screen time, which displayed a reduction of 2 hr per week of recreational screen time from the beginning of treatment to conclusion of treatment. This reduction in screen time coincided with the student achieving Level 0 on her GAS goal, which was to complete 6 of 10 assignments per week. One student's therapy outcome was measured by weekly self-report corroborated by parent of incomplete assignments, which she decreased from 15 to 0 at the conclusion of treatment. Another student's therapy outcome was measured by tracking the number of alarms he independently placed weekly in his phone as reminders to complete school assignments. The number of weekly alarms input into his phone increased from 0 to 17 at the conclusion of treatment. One student's therapy outcome was measured by weekly self-report corroborated by parent on the number of hours per day he spent completing online school modules, which increased from 0 to 3 hr per day at the time he discontinued treatment.

Discharge status

Of the 15 students presented in the case series, 11 were discharged following improvement on their academic outcome measure and reported an increase in grades, assignment completion, or school attendance. However, in spite of a positive academic outcome, two of the three students who did improve on their academic outcome reported that the increases were not sufficient to meet their GPA goal; thus, different goals may have been more helpful for them. One student discontinued treatment before achieving his therapy goal or reporting an increase in academic performance due to perceived appointment burden and parent perception that the therapy was not helpful. Two students achieved their therapy goals but did not report an improvement in their desired academic performance. One student self-discharged as she felt that she had mastered the strategies to increase retention of lecture material and verbal instructions and did not need more intervention.

DISCUSSION

This retrospective case series utilized CDM for the purposes of describing (a) the profiles of individuals with prolonged cognitive symptoms postconcussion referred for SLP intervention, (b) the specific treatment ingredients utilized by SLPs to support adolescent students with prolonged cognitive symptoms postconcussion, (c) the frequency and modality of communication between multidisciplinary concussion management care providers, and (d) the clinical outcomes following SLP intervention. The second intention of the case series was to analyze the results of CDM to develop hypotheses about potential active treatment components that could be empirically tested and implemented in a variety of settings.

The small sample size using descriptive data prohibits drawing any conclusions about treatment efficacy or responsivity. However, the application of CDM to the students referred for SLP services allowed us to ecologically explore the characteristics of a sample of students with PCS and analyze the corresponding direct treatments and associated goals implemented by SLPs within the context of multidisciplinary community practitioners. Currently, the literature does not offer direction to SLPs on the delivery of treatment to students with PCS outside of theoretical position statements on the involvement of SLPs in concussion management (Brown et al., 2019; Hardin & Kelly, 2019; Salvatore & Fjordbak, 2011). It is desired that this retrospective case review will encourage development and evaluation of interventions to facilitate students' return to learn for students with PCS.

Who is at risk for developing PCS?

The population characteristics of this sample aligned with the literature describing predictors of PCS. The majority of the students

presented in the case series had sustained multiple concussions, reported a history of anxiety/depression, and reported the presence of symptoms from multiple symptom clusters (Broshek et al., 2015; Emery et al., 2016; Oldenburg, Lundin, Edman, Nygren-de Boussard, & Bartfai, 2016; Ponsford et al., 2012; Silverberg & Iverson, 2011). Repeat concussion has been identified to significantly impact recovery in animal models, specifically when the second injury occurs within the window of recovery of the first injury. This implies that it may be important to identify students' timeline of multiple concussions to better characterize the potential physiological impact on the presence and severity of their symptoms (Belanger, Spiegel, & Vanderploeg, 2010; Prins, Alexander, Giza, & Hovda, 2013; Prins, Hales, Reger, Giza, & Hovda, 2011). Preexisting psychological symptoms and total number of symptoms reported following the concussion have been identified as predictors of PCS (Broshek et al., 2015; Foy, 2009; Silverberg & Iverson, 2011; Tator et al., 2016) underscoring the importance of collecting this information at the time of neuropsychology evaluation or clinical psychology evaluation to better identify students at risk for developing PCS.

Family's disposition toward their child's recovery from concussion has also been identified as a potential risk factor for the development of PCS. An individual's and family expectations about symptom trajectory influence the individual's selective attention to and anxiety about the presence of symptoms, which, in turn, can exacerbate the individual's perceived symptom severity and overall level of anxiety (Mittenberg, DiGiulio, Perrin, & Bass, 1992). Parents have additionally been identified to report symptoms or challenges for their child inconsistent with what the child self-reports (Barlow, Crawford, Brooks, Turley, & Mikrogianakis, 2015). The current case series did not include a measurement of family disposition that limits an analysis of this factor. However, given the potential effect of parent disposition on the development of PCS, an attempt was made to informally examine parent disposition in this sample. The treating SLP and neuropsychologist retrospectively reviewed the cases and, based on their clinical interactions, they jointly assigned categories of parental attitude toward the respective child's symptoms and recovery. Parents identified as *Overemphasis* were judged to show misattribution, expectation for continued symptoms, or appeared overly focused on symptoms. Parents categorized as *Adaptive* demonstrated a disposition that was perceived as appropriate and aligned with student symptom presentation. A categorization of *Underemphasis* was used to designate a disposition suggesting that the parent did not endorse the concussion event as responsible for prolonged effects, and the lack of validation negatively impacted the student's progress. Although not an objective measure, it is interesting that eight of 15 parents were retrospectively labeled *Overemphasis*, suggesting that parent misattribution or expectation of continued symptoms had a negative impact on the student's recovery.

What are SLP interventions that should be further evaluated?

Overall, the findings from the CDM suggested that SLP intervention may be effective for students experiencing prolonged cognitive symptoms postconcussion using direct interventions in a one-on-one setting, particularly MSI and ATC. This finding provides direction for future research to test the hypothesis that these methods are efficacious in the PCS student population. Consistent with the literature, MSI was determined to be the appropriate intervention for students with deficits related to attention and executive functioning as the intervention promotes self-reflection and self-management (Kennedy & Coelho, 2005; Kennedy et al., 2008; Sohlberg & Ledbetter, 2016). Metacognitive strategy instruction was identified to be a successful therapeutic approach for the cognitive targets of attention, working memory, and self-regulation and such academic goals as increased retention of verbal instructions and increased school attendance. Furthermore,

ATC was the selected intervention to support students in the skills of planning and time management (Gillespie, Best, & O'Neill, 2012; Sohlberg & Ledbetter, 2016). Assistive technology for cognition was implemented to address cognitive targets of attention, working memory, and self-regulation and academic goals including increased retention of verbal instructions, increased assignment completion, and improved grades.

What are the key components of multidisciplinary coordination?

Although the treatment context was a university clinic, the SLP interventions could conceivably be delivered in a school system; however, current barriers to treating prolonged cognitive effects in schools have been identified. Such barriers include (a) a general lack of training on concussion and its effects on learning during graduate training or through continuing education opportunities, (b) a lack of sensitive assessments to properly evaluate the effects of concussion, and (c) a general lack of inclusion on the concussion management team (Duff, Proctor, & Haley, 2002; Duff & Stuck, 2015).

The CDM findings further suggested that it is feasible to coordinate with a variety of disciplines that are not colocated when there is a meeting structure and when one practitioner takes the lead to coordinate communication. It is interesting to examine some of the possible effects from having access to multidisciplinary coordination. An examination of the SLP session notes revealed examples of how the SLP student/supervisor dyad modified and likely improved treatment on the basis of communication with other professionals. There were examples of changes in client messaging and client/parent education. For example, client messaging on headache management was adjusted on the basis of feedback from the neurologist (e.g., the neurologist suggesting that the SLP reinforce to the student, "It is ok if your headache increases a little bit while studying; it won't harm you"). An example of adjusting client/parent education occurred as a result of communication with the psychologist to support a student and his parent's concerns with his recovery. The psychologist perceived the parent to be inadvertently undermining therapy as there were unconscious parental gains in their child being "sick" and needing to stay home with the parent. Coordination and communication with the psychologist allowed all disciplines involved in the student's care (SLP, psychologist, neuropsychologist) to reinforce one educational message to both the student and the parent on the expectations of recovery and importance of returning to a typical school routine.

In the present case series, the pediatric neuropsychologist took the lead in establishing a meeting and creating a mutual consent to communicate process. In another setting, the lead position could be the SLP or the school psychologist, both of whom could conduct an initial cognitive evaluation. The position that one individual should be identified to form and lead the team of medical and school personnel treating a complicated concussion case is supported in the literature (Gioia, 2016). Whether multidisciplinary concussion management occurs in a university clinic setting with collaboration between SLPs and ATs (Knollman-Porter et al., 2014; Knollman-Porter et al., 2019), in a specialized university clinic for the treatment of mTBI (Hardin & Kelly, 2019), or in the K-12 academic setting with the collaboration of SLPs and ATs (Dachtyl & Morales, 2017), it is important to have a designated lead and an established treatment structure.

Limitations

This retrospective case series contains limitations. First, although the sample showed similar profiles to those with PCS described in the literature, the small sample size of 15 students limits the generalizability of the CDM findings to the greater population of adolescents experiencing PCS. The small sample size is further weakened by the convenience method of sampling in which they enrolled in the case series. Of the 23 total students who received services in the university clinic from the start of enrollment, only 15 provided

informed consent to use their clinical data. This discrepancy in which students provided consent may bias the CDM results, specifically data related to demographics, SLP treatment, and outcomes of intervention. Moreover, an additional 15 students were referred to the university clinic from the neuropsychologist during the period of enrollment in the case series and did not pursue services. Therefore, the sample consisted of students who both elected to pursue services in the university clinic after being referred and willingly provided informed consent to use their clinical data for the purpose of this retrospective case series, potentially biasing the sample.

Second, the CDM methodology utilized in this study lacks replicability as it was executed on the basis of the infrastructure of the multidisciplinary concussion management team. The authors had the benefit of partnering with a neuropsychologist who conducts a complete cognitive assessment and acquires a full background history on all students. This partnership allowed for more accessible student data that may weaken the study's ability to be replicated.

Similar to the previous case series conducted by Sohlberg and Ledbetter (2016), the present case series was limited by the presence of inconsistency in dosage of treatment, type of intervention, and outcome measurement across students. The intention was to use CDM in the present case series to describe the specific ingredients employed by SLPs to identify what may contribute to positive functional outcomes for students' desired goals. This case series was descriptive only; thus, no causal claims can be made from the findings of the CDM. The findings of future studies investigating the treatment of prolonged cognitive symptoms postconcussion in adolescents could be strengthened by the isolation of one specific intervention and outcome measure and then experimentation through a single case research design or quasi-experimental design.

Of note was the utility of GAS to objectively measure levels of progress on therapy goals. It would have been conceivable, and more objective, to translate all the different types of outcome measures into GAS goals, which would have allowed more comparison and analysis of goal achievement. For example, rather than counting the total number of weekly assignments completed, a goal hierarchy could be generated with equidistant levels of progress indicating the total weekly assignments. The use of GAS goals would allow measurement of treatment efficacy for individually specified goals (for a review of how to use GAS in research, see Krasny-Pacini et al., 2017).

Although direct intervention provided by SLPs appears to demonstrate the potential to make positive impact on return to learn for students with ongoing symptoms postconcussion, it is important to acknowledge the complexity of these cases. Occasionally, when goals were not achieved, there were other factors that prevented a satisfactory outcome. For example, Student 3 achieved the goal to learn strategies and utilize ATC that increased verbal retention of lecture material. He additionally achieved the functional goal of identifying settings and activities in which the use of strategies or ATC would be helpful. Student 10 achieved the goal of inputting all assignments into his smartphone calendar app. However, both Student 3 and Student 10 continued to struggle academically following discharge from treatment due to ongoing somatic factors (headache) and psychological factors (test anxiety) affecting function (ability to consistently complete assignments on time).

CONCLUSIONS

The results of this retrospective case series support the nascent literature that identifies risk factors for prolonged effects including previous concussions as well as premorbid learning and psychological conditions (Broshek et al., 2015; Emery et al., 2016; Oldenburg et al., 2016; Ponsford et al., 2012; Silverberg & Iverson, 2011). The study also supports the cognitive rehabilitation literature suggesting that the implementation

of MSI, ATC, and PE can be effective in managing functional cognitive impairments postconcussion. Furthermore, consistent with the position statement literature, the case series supports the importance of multidisciplinary coordination.

The CDM results suggest treatment hypotheses that can be empirically tested if the interventions and systems were procedularized. Based on our retrospective case series, we hypothesize that a multicomponent model of intervention that includes personalized cognitive interventions involving MSI or ATC, embedded with psychoeducational supports and a mechanism for communication with other relevant providers, can mitigate the prolonged cognitive symptoms postconcussion and support students to address desired goals related to academic aims. The specific treatment ingredients that this CDM study suggests may be helpful to manualize and experimentally evaluate including the following: (a) collaborative goal setting process that identifies challenges and leads to the identification of measurable academic aims and therapy approaches with associated session goals, (b) toolbox with a range of cognitive strategies and ATC tools that can address the heterogenous challenges in attention or executive functions that may be a direct result of concussion or due to somatic or psychological factors affecting cognitive function, (c) a communication system to share information with other medical and educational providers treating the students, and (d) knowledge of the psychological and somatic factors common in concussion recovery that translates into appropriate PE for concussion management. Developing a treatment framework that is sufficiently broad to be adaptable to different settings that has prescribed, replicable interventions that can be tested would be the first step. The authors have begun this effort to describe a process for selecting goals and intervention approaches and then manualizing the psychoeducational, MSI and ATC approaches. In recognition of the importance of a communication framework and structure that can support a multidisciplinary team that may not be colocated or dedicated to one population, the authors have begun exploring the use of structured electronic communication protocols to increase the efficiency and effectiveness of communication.

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