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INCOG 2.0 Guidelines for Cognitive Rehabilitation Following Traumatic Brain Injury, Part III: Executive Functions

Eliyas Jeffay, PhD, CPsych; Jennie Ponsford, AO, PhD, MA(Clinical Neuropsychology); Amber Harnett, RN, MSc; Shannon Janzen, MSc; Eleni Patsakos, MSc; Jacinta Douglas, PhD, MSc(Psych); Mary Kennedy, PhD, CCC-SLP; Ailene Kua, MSc, PMP; Robert Teasell, MD, FRCPC; Penny Welch-West, MClSc, SLP Reg CASLPO; Mark Bayley, MD, FRCPC; Robin Green, PhD, CPsych

Introduction: Moderate-to-severe traumatic brain injury (MS-TBI) causes debilitating and enduring impairments of executive functioning and self-awareness, which clinicians often find challenging to address. Here, we provide an update to the INCOG 2014 guidelines for the clinical management of these impairments. **Methods:** An expert panel of clinicians/researchers (known as INCOG) reviewed evidence published from 2014 and developed updated recommendations for the management of executive functioning and self-awareness post-MS-TBI, as well as a decision-making algorithm, and an audit tool for review of clinical practice. **Results:** A total of 8 recommendations are provided regarding executive functioning and self-awareness. Since INCOG 2014, 4 new recommendations were made and 4 were modified and updated from previous recommendations. Six recommendations are based on level A evidence, and 2 are based on level C. Recommendations retained from the previous guidelines and updated, where new evidence was available, focus on enhancement of self-awareness (eg, feedback to increase self-monitoring; training with video-feedback), meta-cognitive strategy instruction (eg, goal management training), enhancement of reasoning skills, and group-based treatments. New recommendations addressing music therapy, virtual therapy, telerehabilitation-delivered metacognitive strategies, and caution regarding other group-based telerehabilitation (due to a lack of evidence) have been made. **Conclusions:** Effective management of impairments in executive functioning

Author Affiliations: *KITE Research Institute, Toronto Rehabilitation Institute–University Health Network, Toronto, Ontario, Canada (Drs Jeffay, Bayley, and Green and Mss Patsakos and Kua); Turner Institute for Brain and Mental Health, School of Psychological Sciences, Monash University, Melbourne, Australia and Monash-Epworth Rehabilitation Research Centre, Epworth Healthcare, Melbourne, Australia (Dr Ponsford); Lawson Health Research Institute, Parkwood Institute, London, Ontario, Canada (Mss Harnett and Janzen); Living With Disability Research Centre, La Trobe University, Melbourne, Australia, and Summer Foundation, Melbourne, Australia (Dr Douglas); Communication Sciences and Disorders, Chapman University, Irvine, California (Dr Kennedy); Schulich School of Medicine, University of Western Ontario, St Joseph's Health Care, London, Ontario, Canada (Dr Teasell); Parkwood Institute, St Joseph's Health Care, London, Ontario, Canada, and School of Communication Sciences and Disorders, University of Western Ontario, London, Ontario, Canada (Ms Welch-West); and Temerty Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada (Drs Bayley and Green).*

On behalf of the INCOG Expert Panel.

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Corresponding Author: *Robin Green, PhD, CPsych, 11th Floor, Ste 11E-165, 550 University Ave, Toronto, ON M5G 2A2, Canada (robin.green@uhn.ca).*

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can increase the success and well-being of individuals with MS-TBI in their day-to-day lives. These guidelines provide management recommendations based on the latest evidence, with support for their implementation, and encourage researchers to explore and validate additional factors such as predictors of treatment response. **Key words:** *clinical management*, *dysexecutive syndrome*, *executive function*, *group therapy*, *meta-cognitive*, *music therapy*, *rehabilitation*, *self-awareness*, *traumatic brain injury*, *virtual reality*

MODERATE-TO-SEVERE TRAUMATIC BRAIN INJURY (MS-TBI) results in persisting cognitive impairments, difficulties regulating emotions, and functional disability; these alterations compromise return to school and work, leisure activities, and interpersonal relationships and professional relationships[1]; they are also associated with elevated suicide risk and violent crimes.[2] Executive functioning impairments are the most prevalent of these deficits: Tsai et al[2] found that 48% of their sample experienced executive functioning impairments subacutely, tapering to 38% in the chronic phase. Deficits in executive functions are common because the frontal brain regions are particularly vulnerable to cortical contusions from striking the bony ridges of the skull's interior. Moreover, the extensive frontal lobe white matter connections are vulnerable to traumatic axonal injury secondary to acceleration/deceleration forces.[3,4]

The term "executive functioning" is typically used to describe higher-order cognitive capacities associated with goal-directed behavior.[5] They include, but are not limited to: self-awareness; abstract thinking; planning and executing; mental flexibility; working memory and complex attention; reasoning and problem-solving; judgment; behavioral control; and regulation of emotions.[6] Thus, impairments in executive functioning can deleteriously impact one's social, academic, professional, and economic well-being. Deficits in executive functions have been shown to predict functional, interpersonal, and psychosocial outcomes[7,8] and show greater predictive value for clinical outcomes than attention, speed of processing, and memory.[9]

Moreover, in a recent survey, clinicians reported that executive functions are the most difficult to treat.[10] This may be related in part to the importance of executive functions for the achievement of critical social goals of patients and their families, which in many cases may define successful rehabilitation or lack thereof (eg, family harmony; social cohesion).

Given their profound impact on people's lives, and the prolonged[11] and potentially progressive nature of executive impairments,[12] optimization of intervention for executive dysfunction is critical.[13,14] In 2014, we provided guidelines for the management of executive dysfunction following MS-TBI in adults by the International Cognitive (INCOG) group.[15] Given the expanding literature base for TBI cognitive rehabilitation, the purpose of this article is to present updated INCOG guidelines for executive functioning with practice recommendations as well as an updated clinical algorithm and audit tool based on new evidence.

METHODS

We refer the reader to the methods paper of this series for a complete review of the strategies used for the updated literature review (from 2014) and development of the recommendations and other tools for the entire set of guidelines (INCOG 2.0: Methods, Overview, and Principles[16]). In brief, the updated INCOG 2022 guideline followed a thorough search, review, and critical evaluation of clinical practice guidelines (from 2014) for each domain including principles of assessment, posttraumatic amnesia, attention, memory, executive functions, and cognitive-communication. The literature on which these guidelines are based included individuals who sustained their brain injuries as adults. Therefore, the guidelines are intended for this population. An international expert panel comprised of TBI cognitive rehabilitation researchers and clinicians, most involved in the first version of INCOG, formed the authors. In preparation, a detailed Internet and Medline search was conducted to identify any newly published TBI and cognitive rehabilitation evidence-based guidelines (from 2014 until 2021). A systematic search (2014 to July 2021) of multiple databases (Medline, Embase, Cochrane, CINAHL, and PsycINFO) was conducted to identify relevant articles and reviews. Research articles meeting inclusion but published after July 2021 were added based on the discretion of the expert panel. Two authors independently aligned the research articles within the existing INCOG guidelines and flagged areas where new guidelines may be warranted based on the research evidence.

This synopsis of evidence for this topic area was distributed to the Executive Functions Working Group. During the series of videoconference meetings, the working group examined the recommendations matrix, updated some recommendations based on new evidence, articulated novel recommendations based on the evidence available, and considered the clinical applicability of recommendations to enhance outcomes for individuals with TBI. For each recommendation, the cumulative evidence (studies used in the original guidelines and new articles) was evaluated by the panel in terms of study design and study quality, to determine the level of evidence (see Table 1).

TABLE 1 *INCOG level of evidence grading system*

A: Recommendation supported by at least one meta-analysis, systematic review, or randomized controlled trial of appropriate size with relevant control group.
B: Recommendation supported by cohort studies that at minimum have a comparison group (includes small randomized controlled trials) and well-designed single-case experimental designs.
C: Recommendation supported primarily by expert opinion based on their experience, though uncontrolled case studies or series may also be included here.

All relevant references were consolidated into a reference library that was made available to the author team, as they drafted the manuscript and finalized the recommendations accordingly. Consensus of the working group was reached when members unanimously agreed to the wording and evidence grading assignment of all the recommendations. By the end of the process, 11 new references related to executive function (from 2014 forward) were included in the recommendations of this article. The clinical algorithm and audit tool were also updated accordingly.

LIMITATIONS OF USE AND DISCLAIMER

These recommendations are informed by evidence for TBI cognitive rehabilitation interventions that was current at the time of publication. Relevant evidence published after the INCOG guideline could influence the recommendations contained herein. Clinicians must also consider their own clinical judgment, patient preferences, and contextual factors such as resource availability in their decision-making processes when implementing these recommendations.

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RESULTS

Recommendations and literature review

In total, there are 8 recommendations (see Table 2). Of these, 4 are entirely new (ie, music therapy; virtual reality; telerehabilitation-delivered metacognitive strategy training; and caution for other telerehabilitation-delivered group-based treatment). Four recommendations were retained and updated where new evidence was available. The recommendations are based on the literature, where the majority reported on nonmilitary (ie, civilian) populations, mostly male sex, and mostly middle-aged adults. Caution should be used when interpreting these recommendations for patients who fall outside these patient characteristics especially younger adults due to developmental factors.

EXEC #1: Self-monitoring and feedback to enhance self-awareness

1a. Strategies that encourage self-monitoring of performance and involve feedback should be used with individuals with TBI who have impaired self-awareness.

1b. Consider self-awareness training such as video feedback to improve the ability to recognize and correct errors during task performance.

(Updated from INCOG 2014, EXEC 3, p. 343)

Level A evidence.

The updated recommendations are supported by 2 new randomized control trials (RCTs).[17,18] The original findings comprised 2 systematic reviews, 6 randomized RCTs, and 16 studies using nonrandomized designs.

Increasing awareness of deficits requires increasing self-reflection and self-monitoring for errors, and these capacities do not cut across domains. For example, one can be self-aware of a memory impairment, but not self-aware of a difficulty with reasoning. Hence, self-awareness intervention must be considered for activities in each cognitive/emotional domain. Treatment approaches with the best evidence include: (i) delivery of metacognitive strategy training, which encourages self-monitoring of performance (further discussed in EXEC 2), and (ii) the delivery of feedback, including specific self-awareness training to promote the recognition (and hence correction) of one's errors.

In their 2019 review of self-awareness interventions, Cicerone et al[19] recommended metacognitive strategy training to foster self-monitoring. However, research in this area has had mixed results. For example, Cantor et al[18] employed meta-cognitive strategies to aid self-awareness among other executive functions in 98 individuals with MS-TBI using the novel Short-Term Executive Plus (STEP) program that incorporates training in emotional regulation, attention, and problem-solving. Using a waitlist control RCT with minimization, they found some pre- versus posttreatment executive function improvements, but no improvements in self-awareness. Mixed results may speak in part to the limitations of self-awareness discrepancy rating tools,[20] for which ratings depend on self-report versus an informant, and are subject to demonstrated biases in the informant (eg, mood), and reliant on adequate memory and verbal function in the participant.

Self-awareness studies have included verbal (explicit), video (also known as audiovisual), and experiential feedback.[20] Some studies have directly compared these types of feedback. In an RCT, Schmidt et al[21]

TABLE 2 *Evidence table*[a]

	Guideline recommendation	Grade	Reviews	RCTs	Other
	Section title				
EXEC #1a	*Monitoring and feedback*	A		Cantor et al[18]	
EXEC #1b	Strategies that encourage self-monitoring of performance and involve feedback should be used with individuals with TBI who have impaired self-awareness.			Fleming et al[17]	
	Self-awareness training				
	Consider self-awareness training such as video feedback to improve the ability to recognize and correct errors during task performance.				
EXEC #2	*Metacognitive strategies*	A		Cantor et al[18]	Cizman Staba et al[24]
	Metacognitive strategy instructions (eg, goal management training, plan-do-check-review, and prediction performance) should be used with individuals with TBI for difficulties with a range of executive functioning impairments that may include problem-solving, planning and organization, and other elements of executive function. Common elements of all metacognitive strategies are self-monitoring, incorporating feedback into future performance, and emotional self-regulation training. These strategies should be focused on everyday problems and functional outcomes of personal relevance to the person.			Elbogen et al[25] Tornås et al[26]	
	Note: Metacognitive strategy instruction is optimized when the person with traumatic brain injury has awareness of the need to use a strategy and can identify contexts in which the strategy should be used. Further metacognitive strategy instruction should be conducted at least 6 mo post-TBI and in the community in context.				
EXEC #3	*Strategies to improve reasoning skills*	A			
	Strategies to improve the capacity to analyze and synthesize information should be used with individuals with traumatic brain injury who have impaired reasoning skills.				
EXEC #4	*Group-based interventions*	A		Cantor et al[18]	
	Group-based interventions should be considered for remediation of executive and problem-solving deficits after traumatic brain injury.				

(*continues*)

TABLE 2 *Evidence table*[a] (Continued)

	Guideline recommendation	Grade	Reviews	RCTs	Other
EXEC #5	*Rhythmical/music therapy* In individuals with executive function impairments (with or without previous musical experience), consider a structured music therapy program that includes (1) rhythmical training, (2) structured cognitive-motor training, and (3) assisted music playing that is individualized to the person's interests and progression through the program. *Definitions from Siponkoski et al*[28]*:* *Rhythmical training:* playing sequences of musical rhythms and coordinated bimanual movements on a djembe drum and own body. *Structured cognitive-motor training*: playing musical exercises on a drum set with varying levels of movement elements and composition of drum pads, accompanied by the therapist with piano. *Assisted music playing:* learning to play the participant's own favorite songs on the piano with the help of the therapist and using figure notes[43]	A	Mishra et al[32]	Martínez-Molina et al[30] Siponkoski et al[29]	
EXEC #6	*Virtual reality* Where available, we recommend clinicians consider the use of virtual reality programs, in addition to in-person visits to provide timely and equitable access to care for individuals with a TBI with executive dysfunction.	A	Alashram et al[35] Manivannan et al[34]		De Luca et al[37]
EXEC #7	*Telerehabilitation-delivered metacognitive strategy training* One-to-one remotely delivered interventions (eg, for goal management training), set up according to established telerehabilitation guidelines, are recommended if remote delivery is the most convenient or the only mode of reaching the person.	C			
EXEC #8	*Telerehabilitation-delivered group-based treatment* Telerehabilitation-delivered group-based treatments of executive function may not achieve the same outcomes as in person and require further evaluation. Therefore, they are not recommended at this time.	C			

Abbreviations: RCT, randomized controlled trial; TBI, traumatic brain injury.
[a]Refer to Tate et al[15] for evidence contributing to the recommendations prior to 2014.

examined 3 types of feedback: video+verbal, verbal-only, and experiential feedback only. Video+verbal feedback was superior to either of the other 2 for both online (in the moment) and intellectual awareness (self-knowledge of deficits) and maintained its effectiveness 8 to 10 weeks thereafter.[22] Importantly, direct comparison between verbal and experiential feedback showed no advantage of verbal feedback.[17,20] These null findings of verbal feedback align with the cross-sectional study by Richardson and colleagues[20] of 69 subjects with mild-to-severe TBI in which the frequency of feedback from close others showed no relationship with degree of self-awareness. Thus, video plus verbal feedback is encouraged.

Some contextual recommendations the clinician may consider are: (1) applying "pause, prompt, praise." "Pause" and "prompt" phases support self-identification of problems and solutions, and self-generation may improve recall.[6] "Praise" has been associated with less defensiveness and greater treatment compliance.[23] (2) For patients with memory impairment, deliver feedback *during* practice rather than *after* when errors may be forgotten. (3) Consider providing feedback within multiple treatment contexts/settings to enhance generalizability. (4) Therapies can be started without full awareness of deficit—especially as participation in therapy itself may heighten awareness. Therapists should continuously evaluate self-awareness throughout rehabilitation. If no therapeutic progress is made in other therapies, an exclusive focus on self-awareness may be appropriate until awareness improves.

EXEC #2: Metacognitive strategy instructions (eg, goal management training, plan-do-check-review, and prediction performance) should be used with individuals with TBI for difficulties with a range of executive functioning impairments that may include problem-solving, planning and organization, and other elements of executive function. Common elements of all metacognitive strategies are self-monitoring, incorporating feedback into future performance, and emotional self-regulation training. These strategies should be focused on everyday problems and functional outcomes of personal relevance to the person (updated from INCOG 2014, EXEC 1, p. 343).

Level A evidence.

The evidence base for treating individuals with metacognitive strategies in our prior guidelines included 21 studies, 8 of which were RCTs. Since then, 4 new studies have been included.[18,24–26] Overall, the weight of the evidence continues to support the use of metacognitive strategies to enhance executive functioning.

Metacognitive strategy instruction is optimized when the person with TBI has awareness of the need to use a strategy and can identify contexts in which the strategy should be used. As well, metacognitive strategy instruction should be employed at least 6 months post-TBI and in a community context. However, as noted, the training itself can be utilized to enhance awareness of deficits and may be beneficial in the absence of full awareness, provided there is compliance in setting meaningful goals and adequate therapy participation.

The evidence from recent studies of meta-cognitive strategies has been mixed, with some nonsuccessful trials. Elbogen et al[25] carried out a high-quality RCT in which 112 dyads (individuals with MS-TBI plus posttraumatic stress disorder each with a family/friend partner) were randomized to the Cognitive Applications for Life Management (CALM) goal management training program (which incorporated mobile devices for cueing and training attentional control) or to a brain health training control arm that used mobile technology to train memory. The study found improvements in emotion regulation, but not cognitive outcomes of executive function, though the authors noted high baselines on cognitive executive measures may have contributed. Moreover, this study examined a military sample and it remains unclear whether the findings generalize to MS-TBI in civilian samples.

On the other hand, an RCT with strong evidence by Tornås et al[26] in a group of 70 individuals in the chronic stages of acquired brain injury (ABI) showed significant improvements on self-report and performance-based measures of executive functioning from a program that compared goal management training and external cueing to a psychoeducation program on brain health. These improvements extended 6 months after the end of training but not 5 years post suggesting booster sessions may be necessary to maintain improvements.[27] As well, a small, single-arm pilot study assessed feasibility in 7 individuals with ABI of the goal-oriented attentional self-regulation (GOALS) program following ABI. They found significant pre- to postimprovements on neuropsychological measures of executive control and self-report of goal attainment.[24] Lastly and as described earlier, Cantor et al[18] found significant treatment effects, predominantly for self-reported executive function deficits.

Despite some studies failing to show efficacy in any or all executive measures, there is overall a strong evidence base for the use of meta-cognitive strategies for the amelioration of executive functioning impairments after MS-TBI.

EXEC #3: Strategies to improve the capacity to analyze and synthesize information should be used with individuals with TBI who have impaired reasoning skills (updated from INCOG 2014, EXEC 2, p. 343).

Level A evidence.

This recommendation remains nearly unchanged from INCOG 2014. Only the RCT by Cantor et al,[18] which employed the STEP program, provided new supportive evidence; specifically, they found enhanced self-reported problem-solving impairments.

EXEC #4: Group-based interventions should be considered for remediation of executive and problem-solving deficits after

traumatic brain injury (adapted from INCOG 2014, EXEC 1, p. 343).

Level A evidence.

The totality of evidence from our prior guidelines for group-based treatment of executive functions was weakly supportive, resulting in level B evidence.[15] Since then, stronger evidence has emerged supporting level A evidence for group-based treatment.[18] As mentioned earlier, the STEP program by Cantor and colleagues[18] found significant pre- to postefficacy for some executive functions, predominantly using self-report outcomes. It should be noted that this group-based RCT also incorporated one-to-one sessions.

EXEC #5: In individuals with executive function impairments (with or without previous musical experience), consider a structured music therapy program that includes (1) rhythmical training, (2) structured cognitive-motor training, and (3) assisted music playing that is individualized to the person's interests and progression through the program (adapted from ONF-INESS 2015).*

Level A evidence.

This is a new recommendation based on level A evidence from 3 studies (2 RCTs; 1 meta-analysis) that focused on music therapy and executive functioning after MS-TBI. Siponkoski and colleagues[28,29] conducted a repeated-measures crossover (AB/BA) RCT consisting of 2, 60-minute, sessions of rhythmical training, structured cognitive-motor training, and assisted music playing, twice a week for 10 weeks versus a usual care control condition. The AB group ($n = 20$) significantly improved on measures of executive function within the first 3 months, with evidence of maintenance at 6-month follow-up.[28] Adding a follow-up at 18 months that included informant data,[29] the significant early improvements in self-reported behavioral regulation were maintained at the 6-month follow-up in the AB group, though were reflected in the participant, but not informant ratings. No statistically significant differences were found on any other measures (ie, global executive composite score, emotional regulation index, or metacognition index) across any time points.

Recently, Martínez-Molina et al[30] extended the work of Siponkoski and colleagues by exploring structural and functional brain-related changes to music therapy after an MS-TBI. In a similar crossover RCT design, 23 subjects completed the same 20 sessions as reported by Siponkoski and colleagues.[28] Music training was associated with greater connectivity within the frontoparietal, default mode, and the sensorimotor networks. Moreover, these findings were related to improved general executive function (higher Frontal Assessment Battery scores),[31] set shifting (less errors on the number-letter task), and reduction of deficits in self-monitoring. Thus, music therapy improved cognitive functioning with evidence of commensurate connectivity changes.

Finally, Mishra and colleagues[32] conducted a meta-analysis examining the effects of music therapy on executive functioning after a TBI. Music therapy was found to stimulate sensorimotor coordination of different neural networks through rhythmic cueing and was significantly associated with improvements in executive functioning on cognitive tests.

Overall, there is emerging level A evidence that music therapy improves executive functioning, and with associated neural changes, with one study finding improvements in mental flexibility after just 1 session.[33] In their meta-analysis,[32] patients ranged widely in time post-injury, suggesting a wide therapeutic window.

EXEC #6: Where available, we recommend clinicians consider the use of virtual reality programs, in addition to in-person visits to provide timely and equitable access to care for individuals with a TBI with executive dysfunction (INCOG 2022).

Level A evidence.

This is a new recommendation and our search exploring virtual reality after an MS-TBI revealed level A evidence from 3 studies (1 cohort; 2 reviews). Virtual reality is a platform rather than a specific type of intervention. Accordingly, there is a large degree of heterogeneity in the methodology and immersion level used. As per Manivannan and colleagues' description,[34] most methodologies can be categories into game-based, task-oriented, or simulation of instrumental activities of daily living. Immersion levels can be categorized into fully immersive (eg, head-mounted display), semi-immersive (eg, use of peripheral such as a joystick), or nonimmersive (eg, keyboard and screen only).

Despite the heterogeneity of the specific virtual reality intervention used across studies, virtual reality as a general program was concluded to be useful as a rehabilitative tool as per a systematic review of the effects of virtual reality interventions on neurocognitive functions following a TBI. All 3 studies that specifically focused on executive functions as the primary outcome reported positive effects. The strongest evidence of virtual reality comes from Alashram et al,[35] who performed a systematic review of cognitive rehabilitation post-TBI. Nine studies were included in their review, with 1 study[34] overlapping with Manivannan and colleagues.[36] The

**Note*: Definitions from Siponkoski et al.[28] Rhythmical training: playing sequences of musical rhythms and coordinated bimanual movements on a djembe drum and own body. Structured cognitive-motor training: playing musical exercises on a drum set with varying levels of movement elements and composition of drum pads, accompanied by the therapist with piano. Assisted music playing: learning to play the participant's own favorite songs on the piano with the help of the therapist and using figure notes (https://www.figurenotes.org/what-is-figurenotes/). (INESSS-ONF 2020; level A)

main finding was that virtual reality may be useful for executive function (and memory), with weak evidence for attention. Of the 5 studies that evaluated executive functions, 3 were of excellent quality, 1 was poor quality due to an absence of a control group, and 1 was an uncontrolled case study.

Alashram and colleagues[35] concluded that a treatment protocol that included 2 to 4 sessions per week with each session ranging from 20 to 40 minutes for a total of 10 to 12 sessions may provide maximal benefits. However, this recommendation needs to be validated. Virtual reality as a rehabilitation tool is in its early stages, with 1 group reporting evidence that a telerehabilitation virtual reality program is feasible and safe for cognitive therapy in individuals with TBI.[37] Other aspects of the technology need to be explored and refined such as the type of virtual reality platform, equipment, and immersion level (ie, immersive vs nonimmersive virtual reality). While it is premature to recommend a specific rehabilitative protocol to improve executive functions after TBI, there is sufficient level A evidence that it can be useful as a rehabilitation intervention to improve executive functions after MS-TBI.

EXEC #7: One-to-one remotely delivered interventions (eg, for goal management training), set up according to established telerehabilitation guidelines, are recommended if remote delivery is the most convenient or the only mode of reaching the person (INCOG 2022).

Level C evidence.

Based on our search criteria, we failed to identify any studies that provided level A or B evidence for the use of telerehabilitation as a medium for individualized goal management. However, the panel of experts agreed that continued therapy over yet-to-be proven media is likely more therapeutic than discontinuation of therapy due to in-person access limitations (eg, pandemic-related restrictions, proximity, and mobility). Thus, this is a new recommendation with level C (expert opinion) evidence only. Researchers and clinicians are encouraged to conduct studies that compare the differences in executive function progress with respect to in-person therapy versus telerehabilitation.

EXEC #8: Telerehabilitation-delivered group-based treatments of executive function may not achieve the same outcomes as in person and require further evaluation. Therefore, they are not recommended at this time (INCOG 2022).

Level C evidence.

To date, there is insufficient evidence and insufficient expert support from the panel for combining telerehabilitation and group-based treatment of executive functions for MS-TBI. No studies that met the inclusion criteria for the current guidelines examined group versus individualized telerehabilitation for the treatment of executive functioning. It is unfortunately unclear whether the low cost and high clinical efficiency of group-based therapy would extend to a telerehabilitation setting. Given the greater complexity and potentially deleterious clinical consequences of group-based executive function treatment when delivered remotely and with the lesser supervision and controls of remote delivery, there was consensus (Level C–expert opinion) that this should not be implemented until further evidence accrues.

Algorithm

The algorithm (see Figure 1; Supplemental Digital Content available at: http://links.lww.com/JHTR/A635) highlights that practical goals should be developed in tandem with the individual and clinician to improve learning and transfer of functional skills. Thus, identified goals need to be assessed in relation to their executive and other cognitive impairments. Assessment of executive function should not be confined to the cognitive domain but should include assessment of behavioral or emotional regulation, environmental or personal situational factors, motor-sensory functions, and psychological status. Moreover, these assessments may include, but not be limited to, clinical examinations, chart review, interview (including family members), and self-reports examining discrepancy between their self-report and others. A large discrepancy would be clinically useful to understand the level of self-awareness. Enhancing self-awareness, if it is significantly impaired, is a critical next step supported by the strength of the updated evidence (EXEC 1a, 1b, and 3). Reassessment is recommended after improvement in the client's self-awareness and/or motivation.

For those individuals who have awareness of their deficits and are motivated to recover, metacognitive strategy instruction (EXEC 2) and group-based interventions (EXEC 4) continue to be valuable evidenced-based strategies that improve executive impairments. Structured music therapy and virtual reality programs should be considered based on the most recent evidence (EXEC 5 and 6). There should be reassessment after all interventions to determine the outcomes of the treatment.

Audit tool

The purpose of the audit tool (see Table 3) is to evaluate adherence to clinical practice guidelines in the real world (see INCOG 2.0: Methods, Overview, and Principles[16]). Based on the established and updated evidence base on the rehabilitation benefits of metacognitive strategy training on executive functions and self-awareness after TBI, the INCOG panel voted to keep it as the most important intervention in the audit tool. Clinicians and organizational leaders are encouraged to use these tools in review or audit of

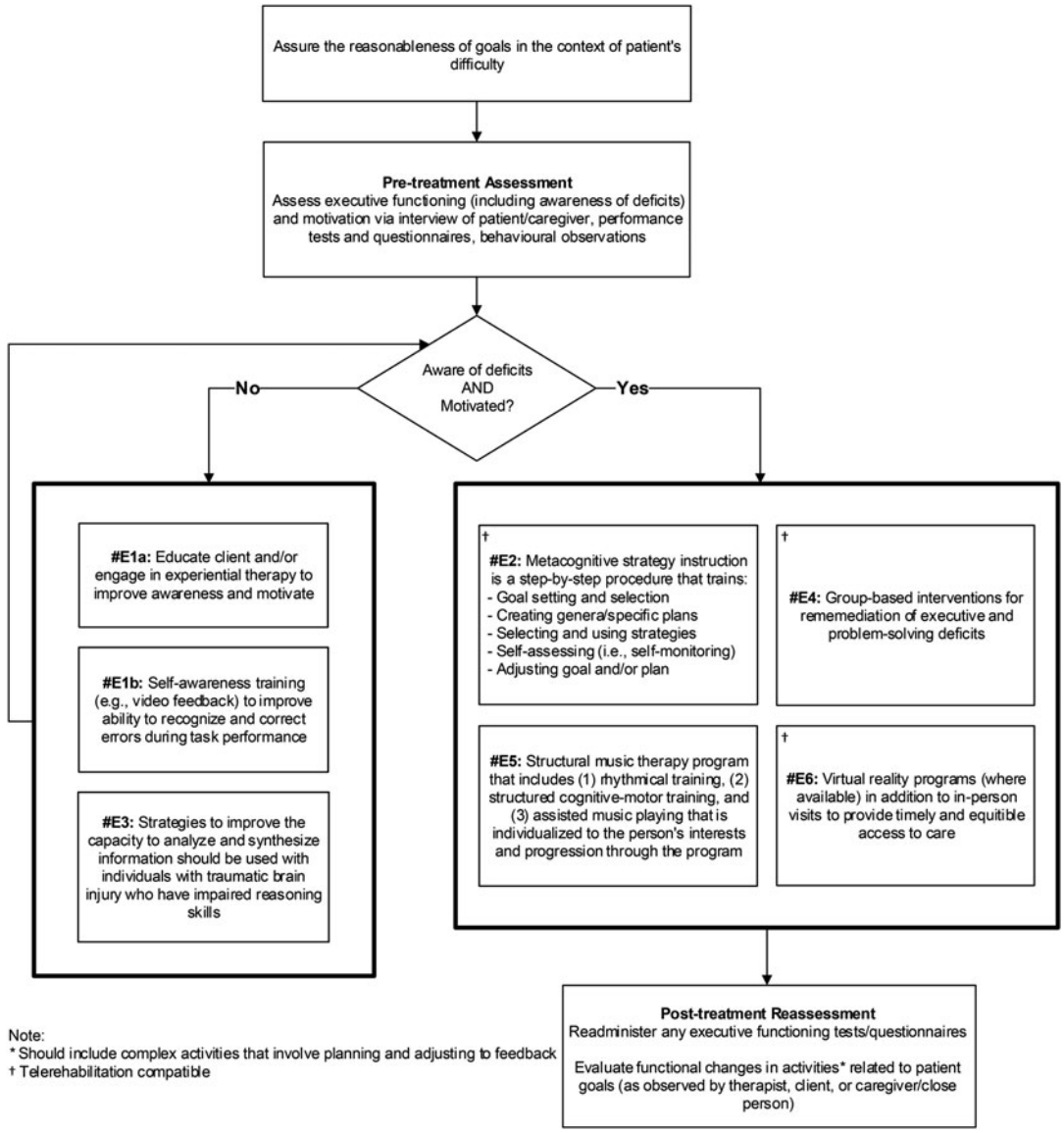

Figure 1. Algorithm.

individual patient charts to determine degree of adherence to the recommendations. This is most successful in changing practice when these audit results are fed back to the team for discussion of opportunities for improvement.

DISCUSSION

These updated guidelines utilize evidence from the original guidelines (50 unique primary studies and 7 sets of systematic reviews) plus an additional 11 articles that were identified since then. The 2014 guidelines[15] comprised 4 practice recommendations that focused on self-awareness, metacognitive strategies, interventions for impairments in reasoning, and group-based therapies for problem-solving. These were all carried forward, with minor adaptations. In the current guidelines, 2 new recommendations were added based on emerging evidence, namely music therapy and virtual reality. Music therapy had accruing evidence, but a systematic review from Mishra and colleagues[32] provided level A evidence of significant improvement in executive function. Similarly, there is level A evidence to support the benefits of virtual reality therapy after an MS-TBI. Level C evidence supported the final 2 interventions regarding telerehabilitation. One-to-one telerehabilitation was recommended for executive functioning in MS-TBI, despite a dearth of available evidence to support it; the recommendation was made in light of the ongoing COVID-19 pandemic at the time of writing, to ensure new or ongoing access to treatment in the context of infection risk or other major barriers.

TABLE 3 *Audit guidelines for priority recommendations: Executive function*

Intervention (guideline recommendation)	Specific activities, devices, or tools	Assessment of need and effectiveness	Patient characteristics	Discipline
Environmental supports and training Metacognitive strategy instructions (eg, goal management training, plan-do-check-review, and prediction performance) should be used with individuals with traumatic brain injury for difficulties with a range of executive functioning impairments that may include problem-solving, planning and organization, and other elements of executive function. Common elements of all metacognitive strategies are self-monitoring, and incorporating feedback into future performance. These strategies should be focused on everyday problems and functional outcomes of personal relevance to the person. *Note*: Metacognitive strategy instruction is optimized when the person with traumatic brain injury has awareness of the need to use a strategy and can identify contexts in which the strategy should be used. Further metacognitive strategy instruction should be conducted at least 6 mo post-TBI and in the community in context.	• Psychoeducation • Goal identification • Anticipate, plan, and select strategies to achieve goals • Predict and evaluate performances • Therapist feedback on performances • Train using functional, everyday activities • Environmental manipulation • Use of checklists • Rehearsal • Other	• Assessment for need conducted • Training provided	• Impaired executive function (eg, difficulty with problem-solving, planning, and organization)	• OT • PT • SLP • MD • Neuro • Other

Abbreviation: TBI, traumatic brain injury.

However, group-based telerehabilitation treatment was not recommended for executive function until supported by evidence.

Additional interventions were identified that did not have sufficient evidence to be included in the recommendations, but nonetheless warrant some discussion.

Potential Emerging Treatments

In our review the team identified some emerging treatments that may be important in future but were not ready for formal recommendations.

1. *Dance/yoga therapy.* Dancing is a component of music therapy; however, on its own, there is currently no level C or greater evidence for benefits on executive functioning after MS-TBI. Dancing and yoga both combine physical and mental exercise, but arguably require more motivation to engage. While there is some RCT level of evidence to suggest improvements on verbal working memory and reasoning after dance therapy, the impact on global executive functioning was insignificant.[38] Future studies should help to discern

the additive benefits of dance to physical exercise alone.

2. *Cerebrolysin.* There is some RCT level of evidence to suggest the potential benefits of cerebrolysin therapy after a moderate to severe TBI[39]; however, the mechanisms of action are not completely understood as cerebrolysin contains multiple compounds and it is unclear which is the active ingredient. Relatedly, it is currently not an approved therapy in the United States, Canada, or Australia. More evidence from high-quality studies is needed.
3. *Subacute transcranial direct current stimulation.* As detailed under Attention #8 in the INCOG 2.0, Part II: Attention and Information Processing Speed[40] article, subacute transcranial direct current stimulation should not be used outside the context of clinical research due to insufficient evidence of its efficacy.
4. *Recombinant human growth hormone (rHGH).* Reimunde and colleagues[41] examined the use of rHGH in a cohort study finding that both placebo and rHGH improved functioning on cognitive subtests of digit, and manipulative IQ but only the rHGH group improved significantly on cognitive subtests such as understanding, numbers and incomplete figures ($P < .05$), verbal IQ, and total IQ ($P < .01$). Clinicians should consider the use of rHGH for individuals with pituitary dysfunction, those with no specific contraindications, and where an endocrinologist experienced in rHGH use monitors outcomes and potential side effects. The use of rHGH should not be implemented outside the context of research trials due to a lack of high-quality studies with sufficient sample sizes that have demonstrated an adequate benefit-to-risk ratio.
5. *Neurofeedback.* A recent systematic review concluded that there is insufficient evidence to support the use or utility of neurofeedback to improve executive functioning after MS-TBI.[42] The expert panel is aware that individuals have engaged in these types of therapies with positive testimonies. However, when these therapies are scientifically examined to determine their impact on executive functioning, the results to date do not support their use.[42] The recommendation from the expert panel at this time is that neurofeedback should not be used outside the context of a clinical research trial.

Overall, the quality and types of evidence for these recommendations ranged from reviews and rigorously completed, large RCTs to uncontrolled single-case series. As identified by Tate et al,[15] there was considerable methodological variability across studies with differing interventions and outcomes employed, doses of intervention, and variable and often limited characterization of patients. As well, predictors of response to treatment were not examined to our knowledge. We encourage researchers to conduct and design high-quality studies that explore the relationship between the potential therapies described earlier and executive functioning after an MS-TBI. Following standards such as unified measurements of evidence (PEDro-P and ROBiNt), including common data elements, comprehensive characterization of samples, closely and creatively examining predictors of response to treatment, and including measures of generalizability (ie, medium and far transfer) would improve the state of neurorehabilitation of executive function after MS-TBI. Further research is also needed with adults who sustained their injuries during developmental periods, such as childhood and adolescence, for whom the typical development of executive functions has been disrupted. The COVID-19 pandemic has been an accelerator for the adoption of technology across all of health care. The incorporation of technology earlier in the rehabilitation process may yield better functional executive outcomes (eg, text reminders to attend metacognitive strategy therapy)[14] and should be explored.

CONCLUSION

Effective management of impairments in executive functioning can increase the success and well-being of individuals with MS-TBI in their day-to-day lives. These guidelines provide management recommendations based on the latest evidence, with support for their implementation. Further research is needed to expand the breadth of executive function interventions, examine predictors of treatment response, and explore the efficacy of telerehabilitation-delivered, group-based interventions.

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