



SPECIAL ARTICLE

Evidence-based position paper on Physical and Rehabilitation Medicine professional practice for Adults with Acquired Brain Injury

The European PRM position (UEMS PRM Section)

Klemen GRABLJEVEC ¹ *, Rajiv SINGH ^{2,3}, Zoltan DENES ⁴, Yvona ANGEROVA ^{5,6}, Renato NUNES ⁷, Paolo BOLDRINI ⁸, Mark DELARGY ⁹, Sara LAXE ^{10,11,12}, Charlotte KIEKENS ¹³, Enrique VARELA DONOSO ^{14,15}, Nicolas CHRISTODOULOU ^{16,17}

¹Department for Acquired Brain Injury Rehabilitation, University Rehabilitation Institute, Ljubljana, Slovenia; ²Unit of Osborn Neurorehabilitation, Department of Rehabilitation Medicine, Sheffield Teaching Hospitals, Sheffield, UK; ³Faculty of Medicine, Dentistry and Health, School of Health and Related Research (ScHARR), University of Sheffield, Sheffield, UK; ⁴National Institute for Medical Rehabilitation, Budapest, Hungary; ⁵Department of Rehabilitation Medicine, Charles University, Prague, Czech Republic; ⁶The First Faculty of Medicine, General University Hospital, Prague, Czech Republic; ⁷Centro de Reabilitação do Norte, Francelos, Porto, Portugal; ⁸Italian Society of Physical and Rehabilitation Medicine (SIMFER), Rome, Italy; ⁹National Rehabilitation Hospital, Dublin, Ireland; ¹⁰Unit of Neurorehabilitation, Guttmann Institute Foundation, University Institute of Neurorehabilitation affiliated to UAB, Badalona, Barcelona, Spain; ¹¹Autonomous University of Barcelona, Bellaterra, Cerdanyola del Vallès, Spain; ¹²Institute for Health Science Research Germans Trias i Pujol (IGTP), Badalona, Barcelona, Spain; ¹³Department of Physical and Rehabilitation Medicine, University Hospitals Leuven, Leuven, Belgium; ¹⁴Department of Radiology, Rehabilitation and Physiotherapy, Complutense University, Madrid, Spain; ¹⁵UEMS PRM Committee for Professional Practice Chairman; ¹⁶Limassol Center of Physical and Rehabilitation Medicine, Cyprus; ¹⁷UEMS PRM Section President

*Corresponding author: Klemen Grabljevec, Department for Acquired Brain Injury Rehabilitation, University Rehabilitation Institute, Linhartova c. 51, SI-1000 Ljubljana, Slovenia. E-mail: klemen.grabljevec@ir-rs.si

ABSTRACT

BACKGROUND: Acquired brain injury (ABI) is damage to the brain that occurs after birth caused either by a traumatic or by a nontraumatic injury. The rehabilitation process following ABI should be performed by a multi-professional team, working in an interdisciplinary way, with the aim of organizing a comprehensive and holistic approach to persons with every severity of ABI. This Evidence Based Position Paper represents the official position of the European Union through the UEMS Physical and Rehabilitation Medicine (PRM) Section and designates the professional role of PRM physicians for people with ABI. The aim was to formulate recommendations on the PRM physician's professional practice for persons with ABI in order to promote their functioning and enhance quality of life.

METHODS: This paper has been developed according to the methodology defined by the Professional Practice Committee of the UEMS-PRM Section: a systematic literature search has been performed in PubMed and Core Clinical Journals. On the basis of the selected papers, recommendations have been made as a result of five Delphi rounds.

RESULTS: The literature review as well as thirty-one recommendations are presented.

CONCLUSIONS: The expert consensus is that structured, comprehensive and holistic rehabilitation program delivered by the multi-professional team, working in an interdisciplinary way, with the leadership and coordination of the PRM physician, is likely to be effective, especially for those with severe disability after brain injury.

(Cite this article as: Grabljevec K, Singh R, Denes Z, Angerova Y, Nunes R, Boldrini P, et al. Evidence Based Position Paper on Physical and Rehabilitation Medicine professional practice for Adults with Acquired Brain Injury. The European PRM position (UEMS PRM Section). Eur J Phys Rehabil Med 2018;54:971-9. DOI: 10.23736/S1973-9087.18.05502-8)

KEY WORDS: Brain injuries - Evidence-based medicine - Physical and rehabilitation medicine.

Acquired brain injury (ABI) is damage to the brain that occurs after birth caused either by a traumatic or by a nontraumatic injury.¹ For the purposes of this paper, the definition of acquired brain injury used is: Acquired brain injury describes insults to the brain that are not congenital or perinatal, but usually applied to single event pathology and not to progressive degenerative disease.² The most frequent causes of ABI are: trauma, oxygen supply cessation (*e.g.* after cardio-respiratory arrest), infections, (*e.g.* meningitis) and tumors.³ The paper is focused mainly on the management of traumatic brain injury (TBI), although the general principles can be adapted to ABI from other causes. Transport accidents, sport accidents, assaults and falls are the primary causes of TBI. Incidence ranges from 200 to 300 cases of TBI per 100.000 inhabitants per year; peak risk of injury occurs between 16 to 25 years, rising again around 65 years.⁴

Few data are available on the long-term physical consequences of moderate to severe TBI. People who have suffered a brain injury have a higher risk of death than people hospitalized for equal durations due to other injuries or people from the general population⁵ and there is a high prevalence of residual disability arising from brain injury.⁶ It has been reported that 90% of people with TBI admitted for rehabilitation will experience one or more problems in the areas of physical functioning and community integration.⁷

The professional role of the PRM physician is to lead and coordinate the multi-professional team, working in an interdisciplinary way, with the aim of organizing a comprehensive and holistic approach to persons with every severity of ABI (severe, moderate and mild) in every stage of rehabilitation – from intensive care, acute and postacute hospital care, as well as throughout their long-term care.⁸

Materials and methods

This paper has been developed according to the methodology defined by the Professional Practice Committee of the UEMS-PRM Section.⁹ The systematic review of the literature has been performed in MEDLINE PubMed and Core Clinical Journals on February 2016. The search terms used in titles and abstracts for the first selection has been: traumatic brain injury AND rehabilitation as well acquired brain injury AND rehabilitation. Exclusion terms in titles were child/infant/adolescent/newborn AND mild/minor traumatic brain injury. Filters used in search methodology were: Last 10 years, English, Controlled Clinical Trial / Systematic Review / Meta-Analysis / Guideline. MeSH

thesaurus: rehabilitation. The Mendeley Reference Management Software was used for titles and abstracts management and reviewing.

The only criteria for including the studies has been the professional relevance for PRM physicians as judged by at least two of the authors, with the main author resolving conflicts. The Strength of Evidence (SoE) and the Strength of Recommendation (SoR) are given according to the Methodology paper. The consensus with Delphi procedure has followed the five steps proposed by the Methodology paper.⁹ The final recommendations were approved by at least ninety percent of the members of Professional Practice Committee or all delegates in the relevant Delphi rounds.

Results

Systematic review

Initially 241 titles were found, from which 132 abstracts were selected by the at least two members of the working group and finally 88 articles were used for the final result of 31 recommendations:

Recommendations were prepared according to the chapters proposed in the Methodology paper as defined by the Professional Practice Committee of the UEMS-PRM Section:

- overall general recommendation;
- recommendations on PRM physicians' role in Medical Diagnosis according to ICD;
- recommendations on PRM physicians' role in PRM diagnosis and assessment according to ICF;
- recommendations on PRM management and process;
- recommendations on future research on PRM professional practice Project definition.

Special attention was oriented to the subchapter «PRM Interventions» in Chapter D, where the recommended management of the specific problems of brain injured population is emphasized:

- respiratory problems;
- swallowing problems;
- nutritional and dietary problems;
- spasticity treatment;
- disorders of consciousness assessment and management;
- cognitive problems;
- functional problems and Activities of Daily Living (ADL) problems;
- the use of Virtual Reality (VR);

- problems of cardiorespiratory capacity;
- return to work problems.

Recommendations

A. Overall general recommendation

1. The professional role of the PRM physician is to lead and coordinate the multi-professional team, working in an interdisciplinary way, with the aim of organizing a comprehensive and holistic approach to persons with every severity of ABI (severe, moderate and mild) in every stage of rehabilitation – from intensive care, acute and post-acute hospital care, as well as throughout their long-term care.^{8, 10, 11} [SoR: A; SoE: IV].

B. Recommendations on PRM physicians' role in Medical Diagnosis according to ICD

2. It is recommended that the PRM physician is accurately and without delay conversant with all clinical information regarding the up-to-date Medical Diagnoses, including results of relevant diagnostic procedures.¹² This recommendation has no time limit through the treatment process and has a special relevance for those with an unstable clinical status including current complications and comorbidities. [SoR: A; SoE: IV].

3. The PRM physician should monitor the level of cognitive responsiveness of the person after ABI in intensive and acute care settings with behavioral observations as well one or more appropriate assessment tools (e.g. Westmead Post-Traumatic Amnesia scale, Galvestone Orientation and Amnesia Test, Mini Mental State Examination (MMSE),¹³ Montreal Cognitive Assessment (MoCA),¹⁴ Rancho Los Amigos Level of Cognitive Functioning Scale (RLA LCFS)^{15, 16} and Glasgow Outcome Scale - Extended (GOS-E).¹⁷

The PRM physician should adapt the multidisciplinary therapeutic approach and perform appropriate diagnostic and clinical procedures (clinical examination, US examination, CT scan, MR imaging, etc.) whenever there is a reduction in responsiveness. [SoR: A; SoE: IV].

4. It is recommended that the PRM physician, together with a multi-professional team, performs a thorough assessment of cognitive responses for patients in a Disorder of Consciousness. It is recommended, that term "Vegetative state" is replaced by a term "Unresponsive wakefulness syndrome" in all communications.^{18, 19} The definitive diagnosis of the state of consciousness should not be concluded after a single examination but after repeated assessments and after obtaining information on the patient's past life, to avoid misdiagnosis.²⁰⁻²² It is recommended that the

definition of the awareness state should follow the Royal College of Physicians National Clinical Guidelines for the Prolonged Disorders of Consciousness 2013²³ or American Academy of Neurology.²⁴ [SoR: A; SoE: III].

5. It is recommended that the PRM physician thoroughly and closely observes, detects and starts treatment for any medical complications in ABI person in intensive, acute and postacute phase of treatment, since complications strongly negatively interfere with rehabilitation process as well prolong the acute stage of treatment.²⁵ The life-threatening clinical conditions which are most frequent after severe and moderate ABI and should be clinically diagnosed without delay are:²⁶

- paroxysmal sympathetic activity;
- respiratory complications;
 - respiratory impaired physiology (hypoxia...);
 - pulmonary tract obstruction;
 - tracheostomy problems;
- post-traumatic epilepsy;
- post-traumatic behavior-emotional disturbances, aggression, agitation;
 - post-traumatic hydrocephalus (due to intracranial bleeding, intracranial pressure...);
 - infections (respiratory, urinary tract or central nervous system infections);
 - pressure sores;
 - coagulations disorders (DVT prevention...);
 - gastrointestinal complications (PEG tube problems, transit problems, malabsorption syndrome...);
 - endocrinological problems: post-traumatic hypopituitarism, hyperprolactinemia (due to the seizures or pituitary injury or due to pharmacological agents);
 - bone disorders: osteoporosis, heterotopic ossifications;
 - postintensive care syndrome (PICS).

[SoR: A; SoE: IV].

6. It is recommended that the PRM physician recognizes and clearly defines medical conditions which can interfere with transition of ABI person from acute setting to postacute specialized comprehensive care. Those medical conditions should be recognized and resolved before transition to specialized institutions, especially if the postacute care institution has limited facilities for the required clinical diagnostic procedures¹² [SoR: A; SoE: IV].

C. Recommendations on PRM physicians' role in PRM diagnosis and functional assessment according to ICF

7. It is recommended that the PRM physician and the rehabilitation team uses the International Classification of

Functioning, Disability and Health (ICF) taxonomy as a basic tool to collect information about the ABI person's limitations and personal needs as well as to assist planning, implementing and coordinating the rehabilitation process.²⁷⁻²⁹ [SoR: A; SoE: III].

8. It is recommended that the PRM physician uses the ICF core set for Traumatic Brain Injury³⁰ to detect and follow up changes functional status of person with ABI. It is recommended, that a brief ICF core set for Traumatic Brain injury³¹ is used to detect changes before and after every completed comprehensive rehabilitation process (inpatient or outpatient) and for periodical follow up during the comprehensive rehabilitation process and at regular outpatient visits. [SoR: A; SoE: III].

D. Recommendations on PRM management and process

INCLUSION CRITERIA (E.G. WHEN AND WHY TO PRESCRIBE PRM INTERVENTIONS)

9. It is recommended that the PMR physician evaluates persons who sustain a mild, moderate and/or severe ABI. Any short or long-term consequences on cognitive, behavioral or physical functioning not necessarily limited to injury itself, should be included in rehabilitation process. It is recommended that the rehabilitation process begins as early as possible after acute ABI preferably in the intensive care unit or as soon as the clinical status allows acute rehabilitation.^{12, 25, 32, 33} It is recommended that the rehabilitation process continues until the patient achieves the ceiling of his/her functional status. It is recommended that recovery should be objectively proven through functional assessment scales. The pathway of treatment during the acute and postacute phases should follow available national or European guidelines, since the use of standardized pathways achieves a better long-term outcome.³⁴⁻⁴¹ After completing the comprehensive rehabilitation process, persons with ABI should be monitored by periodic rehabilitation interventions to identify and manage any decline of functional status. [SoR: A; SoE: I].

PROJECT DEFINITION (DEFINITION OF THE OVERALL AIMS AND STRATEGY OF PRM INTERVENTIONS)

10. Due to the fact, that ABI is potentially a chronic and lifelong condition, which demands continuous interventions after the hospital treatment has concluded, it is recommended, that the model of care for the persons with ABI is based on a bio – psycho – social model. The ultimate goal for a rehabilitation team is to involve the person with ABI in the domestic or institutional environment

that will promote optimal participation in society, as well provide maximal quality of life, wellbeing and dignity.⁴² [SoR: A; SoE: IV].

11. It is recommended that the PRM physician plans the rehabilitation interventions and agrees realistic goals with the person with ABI and/or his next of kin or caregivers. The rehabilitation team, working in an interdisciplinary form, under the supervision of the PRM physician should adapt the goals to achieve maximal functioning that is meaningful for an ABI person and/or the caregiver which maximizes the ABI person's opportunity for independent living and functioning ideally in the home environment after the conclusion of rehabilitation process.⁴³⁻⁴⁹ [SoR: A; SoE: I].

12. It is recommended that the PRM physician plans the postrehabilitation period of the person with ABI in a domestic or institutional environment in cooperation with those who can assist and coordinate with the person with ABI in organizing his/her activities and participation in the environment when required.⁵⁰ This person can be a relative or spouse of the person with ABI, but preferably, from the outset, be a professional, who is appropriately trained in managing the ABI effects on functioning in society.⁴⁰ This professional may have a professional background as a social worker, care manager, community coordinator, be a trained representative of a recognized Brain Injury Society or any formally educated adult person.³² [SoR: A; SoE: III].

TEAM WORK (PROFESSIONALS INVOLVED AND SPECIFIC MODALITIES OF TEAM WORK)

13. It is recommended that the PRM physician is the leader and coordinator of the multi-professional team which works in an interdisciplinary way and treats the consequences of ABI involving a broad spectrum of impairments on the clinical level, including the neuropsychological, emotional, behavioral, perceptual, linguistic, vocational and social levels. The composition of the multi-professional team may differ at different stages of the recovery process and their roles may change as recovery progresses.^{11, 51} [SoR: A; SoE: IV].

14. It is recommended, that the goal setting process is derived with the reference to the patient and family own life goals and priorities.³⁹ There is evidence that goal setting may improve some outcomes for adults receiving rehabilitation for acquired disability. The best of this evidence appears to favor positive effects for psychosocial outcomes (*i.e.* health-related quality of life, emotional status, and self-efficacy) rather than physical ones.^{49, 52} [SoR: A; SoE: III].

PRM INTERVENTIONS

15. It is recommended that the PRM physician together with the multi-professional team have adequate theoretical knowledge, clinical skills and therapeutic equipment for clinical and functional assessment to provide a base for planning and performing PRM interventions through all stages of rehabilitation.^{8, 11} [SoR: A; SoE: IV].

16. It is recommended, that all persons with moderate or severe ABI trauma are supported by a respiratory team, which provides adequate chest mobilization, maintains proper positioning, oxygenation and manual respiratory techniques during the acute phase of rehabilitation.^{32, 33} [SoR: A; SoE: I].

17. It is recommended to assess swallowing safety in all patients who had a moderate or severe Acquired Brain Injury. PRM physicians should be trained in the clinical assessment to determine the existence of dysphagia in particular where there is a suspicion of a “silent” aspiration. Complementary tests should be done such a Videofluoroscopy or a fibroscopy (FEES - Fiberoptic Endoscopic Evaluation of Swallowing). When artificial nutrition is likely to be required for more than one month, Percutaneous Gastrostomy (PEG) should be considered in those patients with swallowing problems requiring a nasogastric tube.^{32, 33, 53, 54} [SoR: A; SoE: I].

18. It is recommended that all persons with ABI have a dietary and nutritional analysis performed in cooperation with a clinical dietitian not later than 48 hours after transition from intensive to an acute setting.^{55, 56} [SoR: B; SoE: III].

19. It is recommended that for all persons with ABI who develop spasticity and/or muscle shortening, the following protocol represents the minimal interventional standard:⁵⁷⁻⁶⁴

- elimination of triggering factors (pain, infection, constipation);
- use of the custom or individual orthoses / serial casting for joint position maintaining;
- use of drug therapy, including injection of botulinum toxin and intrathecal drug delivery - for spasticity in combination with serial casting and positioning. [SoR: A; SoE: II].

20. It is recommended that for all persons after ABI with disorders of consciousness a detailed evaluation of cognitive responsiveness should be performed by a multi-professional team with knowledge of diagnostic criteria of Minimally Conscious State and Unresponsive Wakefulness Syndrome, using standardized assessment tools with

adequate psychometric and diagnostic properties. There is low evidence that a structured neurostimulation program adapted to the persons level of responsiveness – in young adults - is potentially effective in raising the level of consciousness.⁶⁵⁻⁶⁸ [SoR: A; SoE: III].

21. It is recommended that a cognitive evaluation is performed on all persons after ABI who regain consciousness and awareness, followed by a cognitive neurorehabilitation/training which involves a systematic, functionally oriented service of therapeutic activities based on assessment and understanding of the patient’s behavioral deficits.^{23, 32, 69} [SoR: A; SoE: III].

22. It is recommended that occupational therapy interventions are performed in realistic and where possible the patient’s domestic environment. Such interventions can achieve meaningful functional training as they are oriented to foster the maximal functional independence in activities of daily living after discharge from institutional care. When medical devices, including devices for mobility are necessary for performing daily activities, the ABI person should be equipped with those devices and trained how to use them before being discharged to home.^{70, 71} [SoR: A; SoE: IV].

23. It is recommended that the PRM physician implements Virtual reality (VR) based therapy and Computer based cognitive training, as well strategy-oriented approaches for persons after ABI to improve cognitive functioning and balance deficits.⁷²⁻⁷⁵ [SoR: A; SoE: III].

24. It is recommended that the PRM physician prescribes a physical activity program which consists of aerobic exercises that can be performed in various ways⁷⁶⁻⁸³ in the chronic phase after ABI, to improve cardio-respiratory capacities, mood and self-esteem in persons after ABI. [SoR: A; SoE: III].

25. It is recommended that the PRM physician adapts a vocational rehabilitation (VR) program for the person after ABI, in order to enhance patient’s return to work.⁸⁴⁻⁸⁹ [SoR: A; SoE: III].

OUTCOME CRITERIA

26. It is recommended that the PRM physician decides on the outcome criteria during the assessment and goal-setting processes using the functional scales which suit the ICF framework.^{10, 29}

- 1) Global outcome:
 - * GOS-E,
 - * MPAI-4,
 - * DRS
 - * SF-36

This document is protected by international copyright laws. No additional reproduction is authorized. It is permitted for personal use to download and save only one file and print only one copy of this Article. It is not permitted to make additional copies (either sporadically or systematically, either printed or electronic) of the Article for any purpose. It is not permitted to distribute the electronic copy of the article through online internet and/or intranet file sharing systems, electronic mailing or any other means which may allow access to the Article. The use of all or any part of the Article for any Commercial Use is not permitted. The production of derivative works from the Article is not permitted. It is not permitted to remove, cover, overlay, obscure, block, or change any copyright notices or terms of use which the Publisher may post on the Article. It is not permitted to frame or use framing techniques to enclose any trademark, logo, or other proprietary information of the Publisher.

2) ICF domain of function

- * Recovery of consciousness: CRS-R, SMART
- * Post-traumatic Amnesia (Post-traumatic Confusional State): Confusion Assessment Protocol
 - CAP, GOAT, Westmead.
- * Agitation: ABS
- * Neuropsychological assessment: RAVLT, TMT, Processing Speeding index form, WAIS-III or WAIS-IV, SASNOS
- * Physical function: FIM motor subscale, Barthel
- * Balance: BERG
- * Spasticity: Ashworth Scale, Modified Ashworth Scale
- * Hand Upper Limb function: Fugl Meyer motor subscale
- * Gait: FAC, 10 meters walking test (10-MWT), 6 minutes walking test (6-MWT)

3) ICF domain of Activity and participation

- * FIM/FAM subscale
 - * CIQ
 - * CHART.
- [SoR: A; SoE: IV].

LENGTH/DURATION/INTENSITY OF TREATMENT (OVERALL PRACTICAL PRM APPROACH)

27. It is recommended that the PRM physician prepares and evaluates treatment decisions/plans/programs according to the specific needs of person with ABI to prescribe the duration and intensity of a specific treatment in agreement with rehabilitation team and patient.⁹⁰⁻⁹³ [SoR: A; SoE: III].

DISCHARGE CRITERIA (E.G. WHEN AND WHY TO END PRM INTERVENTIONS)

28. It is recommended that a person with an ABI concludes the rehabilitation program and is transferred to a domestic environment after reaching the long-term goals set at the beginning of the rehabilitation program, or when there has not been any further progress in his/her functional capacity recorded for defined time period, or when he or she is not able to participate in the rehabilitation program due to deterioration in his/her health or the onset of a significant comorbidity.^{10, 93} [SoR: A; SoE: III].

FOLLOW-UP CRITERIA AND AGENDA

29. It is recommended that the PRM physician plans the follow up visits for the person with ABI on a regular time basis. The schedule for reviews should be consistent with the clinical and functional status of the person with ABI.

Where further rehabilitation is indicated for patients with brain injury after discharge from inpatient care, this may be offered by tele-medicine solutions or face-to-face engagement to alleviate long term burdens due to depression, behavioural and cognitive consequence.^{32, 94} [SoR: A; SoE: I]

E. Recommendations on future research on PRM professional practice Project definition

30. It is recommended that the PRM physician participates in future research on PRM professional practice projects that are targeting effective treatments and interventions to address the multitude of physical, behavioral and cognitive problems caused by ABI, including the research on drug therapy. Research on epidemiology, survival rates and prognostic factors of ABI could contribute to better utilization of rehabilitation resources and long-term management planning. It is recommended that focus is also on the field of post-ABI-life: caregiver's burden, socialization of ABI families and interpersonal relationship problems of persons after ABI.⁹⁵ [SoR: A; SoE: III].

31. It is recommended that future research projects in the field of ABI rehabilitation concur to improve evidence-based practice and undergo rigorous peer reviewed evaluation. This review process is intended to reduce the likelihood of new interventions being introduced which have little or no scientific evidence base.⁹⁶ [SoR: A; SoE: IV].

Discussion

This paper includes 31 recommendations on rehabilitation of persons with acquired brain injury. It was produced with the aim to strengthen and emphasize the role of the PRM physician in the process of rehabilitation of patients with Acquired Brain Injury. The decision to expand the topic from traumatic brain injury to acquired brain injury was accepted after a thorough discussion inside the Professional Practice Committee, in order to cover the greater population of subjects with injuries and diseases of the brain. This paper however does not include recommendations for rehabilitation after stroke, since this topic is covered in a separate paper.

This paper is not intended to be construed or to serve as a standard of care. Standards of care are determined on the basis of all clinical data available for an individual case and are subject to change as scientific knowledge and technology advance and patterns of care evolve. Adherence to recommendations will not ensure a successful outcome in every case, nor should they be construed as including

all proper methods of care or excluding other acceptable methods of care aimed at the same results.

Acquired brain injury is a complex condition that can have unpredictable long-term effects on a person depending on the nature of the injury, the medical history of that person and their exposure to other wider economic and social factors.

Conclusions

The expert consensus is that a structured, comprehensive and holistic rehabilitation programme delivered by the multi-professional team, working in an interdisciplinary way, with the leadership and coordination of the PRM physician, is likely to be effective, especially for persons with severe disability after acquired brain injury.

References

1. Giustini A, Pistarini C, Pisoni C. Traumatic and nontraumatic brain injury. *Handb Clin Neurol* 2013;110:401–9.
2. Campbell CG, Kuehn SM, Richards PM, Ventureyra E, Hutchison JS. Medical and cognitive outcome in children with traumatic brain injury. *Can J Neurol Sci* 2004;31:213–9.
3. McIntyre A, Janzen S, Richardson M, Kwok C, Teasell R. An Overview of Acquired Brain Injury Rehabilitation Randomized Controlled Trials. *J Head Trauma Rehabil* 2015;30:E47–53.
4. Tagliaferri F, Compagnone C, Korsic M, Servadei F, Kraus J. A systematic review of brain injury epidemiology in Europe. *Acta Neurochir (Wien)* 2006;148:255–68.
5. McMillan TM, Teasdale GM, Weir CJ, Stewart E. Death after head injury: the 13 year outcome of a case control study. *J Neurol Neurosurg Psychiatry* 2011;82:931–5.
6. Barnes MP. Rehabilitation after traumatic brain injury. *Br Med Bull* 1999;55:927–43.
7. Lew HL, Poole JH, Guillory SB, Salerno RM, Leskin G, Sigford B. Persistent problems after traumatic brain injury: the need for long-term follow-up and coordinated care. *J Rehabil Res Dev* 2006;43:vii–x.
8. Gutenbrunner C, Lemoine F, Yelnik A, Joseph PA, de Korvin G, Neumann V, *et al.* The field of competence of the specialist in physical and rehabilitation medicine (PRM). *Ann Phys Rehabil Med* 2011;54:298–318.
9. Negrini S, Kiekens C, Zampolini M, Wever D, Varela Donoso E, Christodoulou N. Methodology of “Physical and Rehabilitation Medicine practice, Evidence Based Position Papers: the European position” produced by the UEMS-PRM Section. *Eur J Phys Rehabil Med* 2016;52:134–41.
10. Ward AB, Gutenbrunner C, Damjan H, Giustini A, Delarque A. European Union of Medical Specialists (UEMS) section of Physical & Rehabilitation Medicine: a position paper on physical and rehabilitation medicine in acute settings. *J Rehabil Med* 2010;42:417–24.
11. European Physical and Rehabilitation Medicine Bodies Alliance. White Book on Physical and Rehabilitation Medicine (PRM) in Europe. Chapter 1. Definitions and concepts of PRM. *Eur J Phys Rehabil Med* 2018;54:156–65.
12. Taricco M, De Tanti A, Boldrini P, Gatta G. National Consensus Conference. The rehabilitation management of traumatic brain injury patients during the acute phase: criteria for referral and transfer from intensive care

units to rehabilitative facilities (Modena June 20–21, 2000). *Eura Medicophys* 2006;42:73–84.

13. de Guise E, Gosselin N, Leblanc J, Champoux MC, Couturier C, Lamoureux J, *et al.* Clock drawing and mini-mental state examination in patients with traumatic brain injury. *Appl Neuropsychol* 2011;18:179–90.
14. Lim PA, McLean AM, Kilpatrick C, DeForge D, Iverson GL, Silverberg ND. Temporal stability and responsiveness of the Montreal Cognitive Assessment following acquired brain injury. *Brain Inj* 2016;30:29–35.
15. Gouvier WD, Blanton PD, LaPorte KK, Nepomuceno C. Reliability and validity of the Disability Rating Scale and the Levels of Cognitive Functioning Scale in monitoring recovery from severe head injury. *Arch Phys Med Rehabil* 1987;68:94–7.
16. Finch M, Sandel ME, Spettell C, Mack A, Spivack G. Admission examination factors predicting cognitive improvement during acute brain injury rehabilitation. *Brain Inj* 1997;11:713–21.
17. Pretz CR, Dams-O'Connor K. Longitudinal description of the glasgow outcome scale-extended for individuals in the traumatic brain injury model systems national database: a National Institute on Disability and Rehabilitation Research traumatic brain injury model systems study. *Arch Phys Med Rehabil* 2013;94:2486–93.
18. van Erp WS, Lavrijsen JC, van de Laar FA, Vos PE, Laureys S, Koopmans RT. The vegetative state/unresponsive wakefulness syndrome: a systematic review of prevalence studies. *Eur J Neurol* 2014;21:1361–8.
19. Laureys S, Celesia GG, Cohadon F, Lavrijsen J, León-Carrión J, Sannita WG, *et al.*; European Task Force on Disorders of Consciousness. Unresponsive wakefulness syndrome: a new name for the vegetative state or apallic syndrome. *BMC Med* 2010;8:68.
20. Andrews K, Murphy L, Munday R, Littlewood C. Misdiagnosis of the vegetative state: retrospective study in a rehabilitation unit. *BMJ* 1996;313:13–6.
21. Strens LH, Mazibrada G, Duncan JS, Greenwood R. Misdiagnosing the vegetative state after severe brain injury: the influence of medication. *Brain Inj* 2004;18:213–8.
22. van Erp WS, Lavrijsen JC, Vos PE, Bor H, Laureys S, Koopmans RT. The vegetative state: prevalence, misdiagnosis, and treatment limitations. *J Am Med Dir Assoc* 2015;16:85.e9–14.
23. Royal College of Physicians. Prolonged disorders of consciousness: National clinical guidelines. London: RCP, BSRM; 2013.
24. The Quality Standards Subcommittee of the American Academy of Neurology. Practice parameters: assessment and management of patients in the persistent vegetative state (summary statement). *Neurology* 1995;45:1015–8.
25. Varela-Donoso E, Damjan H, Muñoz-Lasa S, Valero-Alcaide R, Neumann V, Chevignard M, *et al.* Role of the physical and rehabilitation medicine specialist regarding of children and adolescents with acquired brain injury. *Eur J Phys Rehabil Med* 2013;49:213–21.
26. Godbolt AK, Stenberg M, Jakobsson J, Sorjonen K, Krakau K, Stålnacke BM, *et al.* Subacute complications during recovery from severe traumatic brain injury: frequency and associations with outcome. *BMJ Open* 2015;5:e007208.
27. Laxe S, Zasler N, Tschiesner U, López-Blazquez R, Tormos JM, Bernabeu M. ICF use to identify common problems on a TBI neurorehabilitation unit in Spain. *NeuroRehabilitation* 2011;29:99–110.
28. Laxe S, Cieza A, Castaño-Monsalve B. Rehabilitation of traumatic brain injury in the light of the ICF. *NeuroRehabilitation* 2015;36:37–43.
29. Tate RL, Godbee K, Sigmundsdottir L. A systematic review of assessment tools for adults used in traumatic brain injury research and their relationship to the ICF. *NeuroRehabilitation* 2013;32:729–50.
30. Laxe S, Zasler N, Selb M, Tate R, Tormos JM, Bernabeu M. Development of the International Classification of Functioning, Disability and Health core sets for traumatic brain injury: an international consensus process. *Brain Inj* 2013;27:379–87.
31. ICF Research Branch in cooperation with the WHO collaborating Centre for the Family of International Classifications in Germany; 2011

[Internet]. Available from: https://www.icf-research-branch.org/images/ICF%20Core%20Sets%20Download/Brief_ICF_Core_Set_for_TBI.pdf [cited 2018, Aug 28].

32. SIGN - Scottish Intercollegiate Guidelines Network. Brain injury rehabilitation in adults. Edinburgh: SIGN; 2013.

33. Royal College of Physicians and British Society of Rehabilitation Medicine. Rehabilitation following acquired brain injury: national clinical guidelines. Turner Stokes L, editor. London: RCP, BSRM; 2003.

34. Andelic N, Bautz-Holter E, Ronning P, Olafsen K, Sigurdardottir S, Schanke AK, *et al*. Does an early onset and continuous chain of rehabilitation improve the long-term functional outcome of patients with severe traumatic brain injury? *J Neurotrauma* 2012;29:66–74.

35. Jourdan C, Bayen E, Bosserelle V, Azerad S, Genet F, Fermanian C, *et al*. Members of the Steering Committee of the Paris-TBI Study. Referral to rehabilitation after severe traumatic brain injury: results from the Paris-TBI Study. *Neurorehabil Neural Repair* 2013;27:35–44.

36. Anke A, Andelic N, Skandsen T, Knoph R, Ader T, Manskow U, *et al*. Functional recovery and life satisfaction in the first year after severe traumatic brain injury: A prospective multicenter study of a Norwegian national cohort. *J Head Trauma Rehabil* 2015;30:E38–49.

37. Godbolt AK, Stenberg M, Lindgren M, Ulfarsson T, Lannsjö M, Stålnacke BM, *et al*. Associations between care pathways and outcome 1 year after severe traumatic brain injury. *J Head Trauma Rehabil* 2015;30:E41–51.

38. Sörbo A, Rydenhag B, Sunnerhagen KS, Blomqvist M, Svensson S, Emanuelson I. Outcome after severe brain damage, what makes the difference? *Brain Inj* 2005;19:493–503.

39. McIlvoy L, Spain DA, Raque G, Vitaz T, Boaz P, Meyer K. Successful incorporation of the Severe Head Injury Guidelines into a phased-outcome clinical pathway. *J Neurosci Nurs* 2001;33:72–8.

40. Fakhry SM, Trask AL, Waller MA, Watts DD; IRTC Neurotrauma Task Force. Management of brain-injured patients by an evidence-based medicine protocol improves outcomes and decreases hospital charges. *J Trauma* 2004;56:492–9.

41. Singh R, Venkateshwarra G, Kirkland J, Batterley J, Bruce S. Clinical pathways in head injury: improving the quality of care with early rehabilitation. *Disabil Rehabil* 2012;34:439–42.

42. Didier JP. Learning and teaching: two processes to bear in mind when rethinking physical medicine and rehabilitation. In: Didier JP, Bigand E eds. Rethinking physical and rehabilitation medicine: New technologies induce new learning strategies. Paris: Springer Verlag France; 2010. p. 3–18.

43. Grabljevec K, Jesenšek Papež B, Kos N, Plaskan L. [Rehabilitation of adults after moderate and severe brain injury – Recommendations of the Slovenian society for physical and rehabilitation medicine]. *Zdrav Vestn* 2015;84:165–81. [Slovenian.]

44. Bender A, Adrion C, Fischer L, Huber M, Jawny K, Straube A, *et al*. Long-term Rehabilitation in Patients With Acquired Brain Injury. *Dtsch Arztebl Int* 2016;113:634–41.

45. Gauggel S, Hoop M, Werner K. Assigned versus self-set goals and their impact on the performance of brain-damaged patients. *J Clin Exp Neuropsychol* 2002;24:1070–80.

46. Evans JJ. Goal setting during rehabilitation early and late after acquired brain injury. *Curr Opin Neurol* 2012;25:651–5.

47. Dalton C, Farrell R, De Souza A, Wujanto E, McKenna-Slade A, Thompson S, *et al*. Patient inclusion in goal setting during early inpatient rehabilitation after acquired brain injury. *Clin Rehabil* 2012;26:165–73.

48. Prescott S, Fleming J, Doig E. Goal setting approaches and principles used in rehabilitation for people with acquired brain injury: A systematic scoping review. *Brain Inj* 2015;29:1515–29.

49. Levack WM, Weatherall M, Hay-Smith EJ, Dean SG, McPherson K, Siegert RJ. Goal setting and strategies to enhance goal pursuit for adults with acquired disability participating in rehabilitation. *Cochrane Database Syst Rev* 2015;(7):CD009727.

50. Lannin NA, Laver K, Henry K, Turnbull M, Elder M, Campisi J, *et al*. Effects of case management after brain injury: a systematic review. *NeuroRehabilitation* 2014;35:635–41.

51. Neumann V, Gutenbrunner C, Fialka-Moser V, Christodoulou N, Varela E, Giustini A, *et al*. Interdisciplinary team working in physical and rehabilitation medicine. *J Rehabil Med* 2010;42:4–8.

52. Levack WM, Weatherall M, Hay-Smith JC, Dean SG, McPherson K, Siegert RJ. Goal setting and strategies to enhance goal pursuit in adult rehabilitation: summary of a Cochrane systematic review and meta-analysis. *Eur J Phys Rehabil Med* 2016;52:400–16.

53. Leder SB, Sasaki CT, Burrell MI. Fiberoptic endoscopic evaluation of dysphagia to identify silent aspiration. *Dysphagia* 1998;13:19–21.

54. Royal College of Speech and Language therapists. Clinical guidelines for dysphagia. London: RCSLT; 2003.

55. Yanagawa T, Bunn F, Roberts I, Wentz R, Pierro A. Nutritional support for head injured patients. Cochrane review, Cochrane library, Issue 2. Oxford: Updated Software, 2003.

56. Henson MB, De Castro JM, Stringer AY, Johnson C. Food intake by brain-injured humans who are in the chronic phase of recovery. *Brain Inj* 1993;7:169–78.

57. Das-Gupta R, Turner-Stokes L. Traumatic brain injury. *Disabil Rehabil* 2002;24:654–65.

58. Moseley AM. The effect of casting combined with stretching on passive ankle dorsiflexion in adults with traumatic head injuries. *Phys Ther* 1997;77:240–7.

59. Sheean G, Lannin NA, Turner-Stokes L, Rawicki B, Snow BJ; Cerebral Palsy Institute. Botulinum toxin assessment, intervention and after-care for upper limb hypertonicity in adults: international consensus statement. *Eur J Neurol* 2010;17(Suppl 2):74–93.

60. Singer BJ, Jegasothy GM, Singer KP, Allison GT. Evaluation of serial casting to correct equinovarus deformity of the ankle after acquired brain injury in adults. *Arch Phys Med Rehabil* 2003;84:483–91.

61. Verplancke D, Snape S, Salisbury CF, Jones PW, Ward AB. A randomized controlled trial of botulinum toxin on lower limb spasticity following acute acquired severe brain injury. *Clin Rehabil* 2005;19:117–25.

62. Balakrishnan S, Ward AB. The diagnosis and management of adults with spasticity. *Handb Clin Neurol* 2013;110:145–60.

63. Ward AB. A summary of spasticity management—a treatment algorithm. *Eur J Neurol* 2002;9(Suppl 1):48–52.

64. Spasticity working group. Treatment algorithm for spasticity in adults. Enschede: Rehabilitation Centre Het Roessingh - Roessingh Research and Development Medisch Spectrum Twente Hospital, Twente, The Netherlands; 2010.

65. Lombardi F, Taricco M, De Tanti A, Telaro E, Liberati A. Sensory stimulation of brain-injured individuals in coma or vegetative state: results of a Cochrane systematic review. *Clin Rehabil* 2002;16:464–72.

66. Eilander HJ, Wijnen VJ, Scheirs JG, de Kort PL, Prevo AJ. Children and young adults in a prolonged unconscious state due to severe brain injury: outcome after an early intensive neurorehabilitation programme. *Brain Inj* 2005;19:425–36.

67. Eilander HJ, van Heugten CM, Wijnen VJ, Croon MA, de Kort PL, Bosch DA, *et al*. Course of recovery and prediction of outcome in young patients in a prolonged vegetative or minimally conscious state after severe brain injury: an exploratory study. *J Pediatr Rehabil Med* 2013;6:73–83.

68. Eilander HJ, Wijnen VJ, Schouten EJ, Lavrijsen JC. Ten-to-twelve years after specialized neurorehabilitation of young patients with severe disorders of consciousness: A follow-up study. *Brain Inj* 2016;30:1302–10.

69. Cicerone KD, Langenbahn DM, Braden C, Malec JF, Kalmar K, Fraas M, *et al*. Evidence-based cognitive rehabilitation: updated review of the literature from 2003 through 2008. *Arch Phys Med Rehabil* 2011;92:519–30.

70. Ferguson JM, Trombly CA. The effect of added-purpose and meaningful occupation on motor learning. *Am J Occup Ther* 1997;51:508–15.

71. Ma HI, Trombly CA, Robinson-Podolski C. The effect of context on skill acquisition and transfer. *Am J Occup Ther* 1999;53:138–44.
72. Rose FD, Brooks BM, Rizzo AA. Virtual reality in brain damage rehabilitation: review [review]. *Cyberpsychol Behav* 2005;8:241–62.
73. Shin H, Kim K. Virtual reality for cognitive rehabilitation after brain injury: a systematic review. *J Phys Ther Sci* 2015;27:2999–3002.
74. Cuthbert JP, Staniszewski K, Hays K, Gerber D, Natale A, O'Dell D. Virtual reality-based therapy for the treatment of balance deficits in patients receiving inpatient rehabilitation for traumatic brain injury. *Brain Inj* 2014;28:181–8.
75. Spreij LA, Visser-Meily JM, van Heugten CM, Nijboer TC. Novel insights into the rehabilitation of memory post acquired brain injury: a systematic review. *Front Hum Neurosci* 2014;8:993.
76. Bellon K, Kolakowsky-Hayner S, Wright J, Huie H, Toda K, Bushnik T, *et al.* A home-based walking study to ameliorate perceived stress and depressive symptoms in people with a traumatic brain injury. *Brain Inj* 2015;29:313–9.
77. Hoffman JM, Bell KR, Powell JM, Behr J, Dunn EC, Dikmen S, *et al.* A randomized controlled trial of exercise to improve mood after traumatic brain injury. *PM R* 2010;2:911–9.
78. Wise EK, Hoffman JM, Powell JM, Bombardier CH, Bell KR. Benefits of exercise maintenance after traumatic brain injury. *Arch Phys Med Rehabil* 2012;93:1319–23.
79. Hassett LM, Moseley AM, Tate RL, Harmer AR, Fairbairn TJ, Leung J. Efficacy of a fitness centre-based exercise programme compared with a home-based exercise programme in traumatic brain injury: a randomized controlled trial. *J Rehabil Med* 2009;41:247–55.
80. Hassett LM, Tate RL, Moseley AM, Gillett LE. Injury severity, age and pre-injury exercise history predict adherence to a home-based exercise programme in adults with traumatic brain injury. *Brain Inj* 2011;25:698–706.
81. Mossberg KA, Amonette WE, Masel BE. Endurance training and cardiorespiratory conditioning after traumatic brain injury. *J Head Trauma Rehabil* 2010;25:173–83.
82. Blake H, Batson M. Exercise intervention in brain injury: a pilot randomized study of Tai Chi Qigong. *Clin Rehabil* 2009;23:589–98.
83. Driver S, Ede A. Impact of physical activity on mood after TBI. *Brain Inj* 2009;23:203–12.
84. Johnstone B, Reid-Armdt S, Franklin KL, Harper J. Vocational outcomes of state vocational rehabilitation clients with traumatic brain injury: a review of the Missouri Model Brain Injury System Studies. *Neuro-Rehabilitation* 2006;21:335–47.
85. Shames J, Treger I, Ring H, Giaquinto S. Return to work following traumatic brain injury: trends and challenges. *Disabil Rehabil* 2007;29:1387–95.
86. Fadyl JK, McPherson KM. Approaches to vocational rehabilitation after traumatic brain injury: a review of the evidence. *J Head Trauma Rehabil* 2009;24:195–212.
87. Tyerman A. Vocational rehabilitation after traumatic brain injury: models and services. *NeuroRehabilitation* 2012;31:51–62.
88. Stergiou-Kita M, Rappolt S, Dawson D. Towards developing a guideline for vocational evaluation following traumatic brain injury: the qualitative synthesis of clients' perspectives. *Disabil Rehabil* 2012;34:179–88.
89. Radford K, Phillips J, Drummond A, Sach T, Walker M, Tyerman A, *et al.* Return to work after traumatic brain injury: cohort comparison and economic evaluation. *Brain Inj* 2013;27:507–20.
90. Shiel A, Burn JP, Henry D, Clark J, Wilson BA, Burnett ME, *et al.* The effects of increased rehabilitation therapy after brain injury: results of a prospective controlled trial. *Clin Rehabil* 2001;15:501–14.
91. Wood RL, McCrea JD, Wood LM, Merriman RN. Clinical and cost effectiveness of post-acute neurobehavioural rehabilitation. *Brain Inj* 1999;13:69–88.
92. Slade A, Tennant A, Chamberlain MA. A randomised controlled trial to determine the effect of intensity of therapy upon length of stay in a neurological rehabilitation setting. *J Rehabil Med* 2002;34:260–6.
93. Bender A, Bauch S, Grill E. Efficacy of a post-acute interval inpatient neurorehabilitation programme for severe brain injury. *Brain Inj* 2014;28:44–50.
94. Singh R, Mason S, Lecky F, Dawson J. Prevalence of depression after TBI in a prospective cohort: the SHEFBIT study. *Brain Inj* 2018;32:84–90.
95. Roozenbeek B, Maas AI, Menon DK. Changing patterns in the epidemiology of traumatic brain injury. *Nat Rev Neurol* 2013;9:231–6.
96. Callender L, Brown R, Driver S, Dahdah M, Collinsworth A, Shafi S. Process for developing rehabilitation practice recommendations for individuals with traumatic brain injury. *BMC Neurol* 2017;17:54.

Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript. Article first published online: August 29, 2018. - Manuscript accepted: August 28, 2018. - Manuscript received: August 18, 2018.