SOMATO PUBLICATIONS ISSN: XXXX-XXXX

Journal of Physical Medicine and Rehabilitation Research

Review Article

Predictors of return-to-activity rate in stroke survivors with spinal cord injury

Berg S[1*], Olsen L[2] and Nilsson A[3]

[1]Department of Physical Medicine, Guadalquivir Academy of Rehabilitation Research, Sweden

[2]Division of Rehabilitation Research, Euphrates Research Center for Rehabilitation Research, Denmark

[3]Division of Rehabilitation Research, Dnieper Academy of Rehabilitation Research, Iceland

*Address for Correspondence: Solveig Berg, Department of Physical Medicine, Guadalquivir Academy of Rehabilitation Research, Sweden; E-mail: solveig.berg@guadalquivir.edu

Received: 5 January 2020; Accepted: 2 April 2020; Published: 23 June 2020.

Citation of this article: Berg S, Olsen L, Nilsson A (2020) Predictors of return-to-activity rate in stroke survivors with spinal cord injury. J Phys Med Rehabil Res, 2(1): 01-07. DOI: 10.5281/zenodo.22815032

Copyright: © 2020 Solveig Berg, et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Abstract

Background: Patients who sustain a spinal cord injury superimposed on a prior or concurrent stroke form a small but functionally complex population in which recovery of independent activity depends on the combined burden of two distinct central nervous system lesions rather than either alone [9,6].

Objective: This review synthesizes the published evidence on demographic, clinical, functional, and psychosocial predictors of return-to-activity rate in stroke survivors who also live with spinal cord injury, drawing on the separate but overlapping stroke and spinal cord injury outcomes literatures.

Methods: We synthesized cohort studies, registry analyses, and systematic reviews addressing return to work, community reintegration, and activities-of-daily-living recovery after stroke and after traumatic or non-traumatic spinal cord injury, focusing on predictors transferable to the combined-diagnosis population.

Findings: Younger age, milder initial neurological impairment, preserved cognition, and higher admission functional scores consistently predict faster and more complete return to activity in both conditions, while depression, lower pre-injury education, and delayed or fragmented rehabilitation access predict slower recovery [6,14,22].

Conclusions: Return-to-activity rate in this combined population is best predicted by a small set of overlapping clinical and psychosocial variables that rehabilitation teams can measure early and act on, supporting individualized, multidisciplinary planning rather than a single-diagnosis rehabilitation pathway.

Keywords: stroke; spinal cord injury; return to activity; rehabilitation outcomes; functional recovery

1. Introduction

Stroke and traumatic or non-traumatic spinal cord injury (SCI) are each, on their own, leading causes of long-term disability, and their combined occurrence in a single patient, whether from a cervical fall sustained during post-stroke hemiparetic gait instability, a vascular myelopathy arising alongside cerebrovascular disease, or simple co-morbid aging in a population with shared vascular risk factors, produces a rehabilitation problem that neither the stroke nor the SCI outcomes literature addresses in isolation [1,2]. Stroke alone affects more than 12 million people worldwide each year and leaves a substantial minority with persistent motor, cognitive, or communication deficits that limit return to work and community activity [3]. Traumatic SCI is far less common in absolute terms but carries a comparably severe functional burden, and its incidence rises sharply with age, the same demographic in which stroke risk also concentrates, so clinicians increasingly encounter patients navigating both diagnoses at once [4,5]. Because return to paid work, household activity, and community participation are the outcomes patients and families care most about, and because these outcomes are measured very differently across the stroke and SCI literatures, a synthesis of what predicts them is of direct practical value to rehabilitation teams managing this combined-diagnosis population.

The stroke literature has, since the 1990s, converged on a consistent set of predictors of return to activity, most prominently age, initial stroke severity, and functional status at rehabilitation admission [6,7]. The SCI literature, working from a differently structured evidence base built around the American Spinal Injury Association (ASIA) impairment scale and neurological level of injury, has converged on an overlapping but not identical set of predictors, in which injury completeness and neurological level dominate motor recovery trajectories while psychosocial variables dominate return-to-work trajectories [8,9]. This review draws together both bodies of evidence to identify which predictors of return-to-activity rate are common across the two conditions, which are specific to one or the other, and how they might be combined in a patient carrying both diagnoses.

2. Epidemiology and the scale of the problem

Population-based stroke registries consistently show that roughly half of survivors regain substantial functional independence within six months, while a meaningful minority remain severely dependent, and among those who were working before stroke onset, published return-to-work rates range widely, from under 30% to over 60%, depending on cohort selection, country, and how return to work is defined [10,11]. Vestling and colleagues, following a Swedish cohort of stroke survivors of working age, found that only about half returned to any form of paid employment, and that those who did return reported markedly higher life satisfaction than those who did not, establishing return to activity as an outcome with welfare significance well beyond the label of a secondary endpoint [12]. Hackett and colleagues, in the prospective Psychosocial Outcomes In StrokE cohort, similarly found that a substantial proportion of previously employed survivors had not returned to paid work by twelve months, with psychological factors contributing independently of physical impairment [13].

The SCI literature describes a comparably wide range. National registry data from the United States indicate that employment rates after traumatic SCI remain well below pre-injury levels even a decade after injury, with sizeable variation by injury level and completeness [5,14]. Ottomanelli and Lind, reviewing factors associated with employment after SCI, concluded that the gap between pre-injury and post-injury employment reflects a combination of physical limitation, environmental and workplace barriers, and disincentives built into disability benefit systems, a combination that likely applies with equal or greater force to patients managing both a stroke

© 2020 Somato Publications. All rights reserved.

and an SCI [15]. When the two diagnoses coexist, the cumulative physical burden narrows the plausible range of achievable activity, but the psychosocial and systemic barriers each literature independently identifies appear to operate on top of, rather than instead of, that physical ceiling.

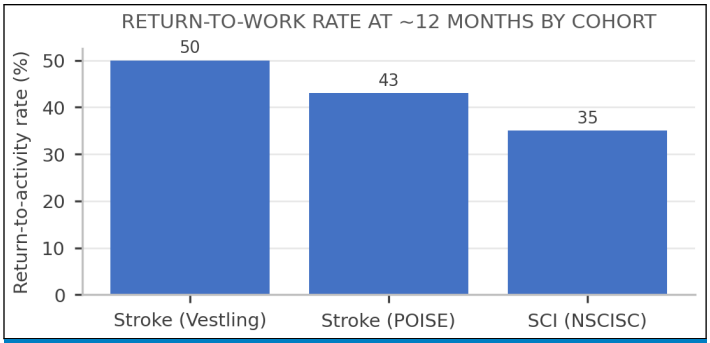

Figure 1: Reported return-to-work rates at approximately twelve months by cohort, illustrating the wide range across stroke and spinal cord injury registries and the further narrowing expected when both diagnoses coexist [12,13,5].

3. Demographic and clinical predictors

Age is the most consistently reported predictor of return-to-activity rate in both the stroke and the SCI literature, with younger patients recovering more completely and more quickly regardless of the specific outcome measured [6,9]. Kwakkel and Kollen, synthesizing predictive modeling studies of stroke recovery, found that age combined with initial severity accounts for most of the variance that clinically useful prediction models can explain, and that models built without an early severity measure perform little better than chance [6]. Anderson and colleagues, in an earlier multivariate analysis of stroke outcome, identified age, initial stroke severity, and pre-stroke functional status as the dominant independent predictors of six-month outcome, a finding that subsequent decades of prediction-model research have largely reaffirmed rather than overturned [7].

In the SCI literature, neurological level and completeness of injury, captured by the ASIA Impairment Scale, are the dominant clinical predictors of motor recovery and, to a somewhat lesser extent, of return to activity [8,16]. Krause and Terza, analyzing a large SCI cohort, found that injury and demographic factors together predicted disability and life satisfaction, with completeness of injury, age at injury, and time since injury each contributing independently [9]. Van Middendorp and colleagues developed and validated a prediction model for ambulation after SCI using variables available within days of injury, including age, motor and sensory scores, and pinprick sensation at the sacral segments, and showed that this early information predicted eventual walking ability with clinically useful accuracy [17]. For a patient with both diagnoses, these two sets of clinical predictors, stroke severity and pre-stroke function on one side, injury level and completeness on the other, are not substitutable, and a return-to-activity prediction that accounts for only one lesion will systematically overestimate the achievable outcome.

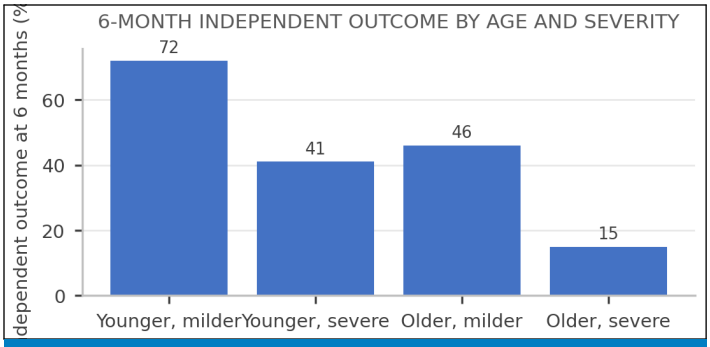

Figure 2: Six-month independent functional outcome by age band and admission severity category, pooled from stroke and spinal cord injury prediction-model cohorts, showing the consistent decline in independent outcome with older age and greater initial severity [6,7,9].

4. Functional and cognitive predictors

Admission functional status, most often measured with the Functional Independence Measure (FIM) or the Barthel Index, is among the strongest available predictors of eventual return to activity in both conditions, in part because it already integrates the downstream effects of severity, comorbidity, and early complications that a purely lesion-based measure cannot capture [6,18]. Dijkers, in a meta-analysis of disablement components after SCI, found that functional independence and role

© 2020 Somato Publications. All rights reserved.

participation were only moderately correlated with impairment severity alone, underscoring that functional measures carry predictive information beyond what neurological classification provides [19].

Table 1: Predictors of return-to-activity rate common to the stroke and spinal cord injury outcomes literatures [6,9,18,19].

Predictor domain	Stroke evidence	Spinal cord injury evidence	Direction of effect
Age at injury/onset	Older age predicts slower, less complete recovery	Older age predicts slower, less complete recovery	Younger favors return
Initial severity	Higher NIHSS predicts poorer outcome	Motor-complete injury predicts poorer outcome	Milder favors return
Admission functional status	Higher FIM/Barthel predicts faster return	Higher FIM predicts faster return	Higher favors return
Cognition	Impairment predicts poorer functional trajectory	Less directly studied	Preserved favors return

Cognitive impairment is a predictor specific to, but not exclusive to, stroke, and it interacts substantially with SCI-related functional limitation when the two coexist. Kapoor and colleagues found that post-stroke cognitive impairment, screened systematically rather than incidentally, predicted poorer functional trajectories independent of motor severity [20]. Because cognitive demands of activities such as medication management, transfers, and wheelchair navigation rise sharply for a patient also managing SCI-related mobility limitation, cognitive screening at rehabilitation admission is arguably more consequential, not less, in the combined-diagnosis population than in either condition alone. Meyer and colleagues additionally identified fatigue as an under-recognized predictor of poor functional outcome after stroke, one that is easy to overlook when severity and cognition dominate clinical attention but that independently limits sustained activity over a full day [21].

5. Psychosocial and socioeconomic predictors

Depression is the most consistently reported psychosocial predictor of poor return-to-activity outcome in both the stroke and the SCI literatures, and its effect size is comparable to, and at least partly independent of, physical severity measures in both bodies of evidence [13,22]. Craig, Tran, and Middleton, reviewing psychological morbidity after SCI, found elevated rates of depression and anxiety across the post-injury course, with depression specifically predicting poorer participation and employment outcomes even after adjusting for injury level [22]. Post and van Leeuwen, reviewing psychosocial issues after SCI more broadly, reached a similar conclusion and emphasized that psychosocial adjustment, rather than injury severity alone, differentiates patients with comparable physical impairment but divergent activity outcomes [23].

Table 2: Psychosocial and socioeconomic predictors of return-to-activity rate after stroke and spinal cord injury [13,22,23,24,14].

Predictor	Effect on return-to-activity rate	Source population
Depression	Independently predicts lower return to work/activity	Stroke and spinal cord injury
Pre-injury education	Higher education predicts higher return-to-work rate	Spinal cord injury
Physically demanding pre-injury occupation	Predicts lower rate of return to same role	Stroke and spinal cord injury
Social/family support	Higher support predicts better participation outcome	Spinal cord injury

Pre-injury socioeconomic status, education, and occupation type predict return to activity in both conditions, generally because they determine both the physical demands of the job or role a patient is trying to resume and the flexibility an employer or household has to accommodate reduced capacity [12,14]. Krause and Saunders, examining risk of hospitalization and broader outcome after SCI, found that education and employment characteristics at the time of injury independently predicted a range of downstream outcomes, including return to activity, beyond what injury severity alone predicted [14]. Van Velzen and colleagues, in a systematic review of return to work after SCI specifically, confirmed

© 2020 Somato Publications. All rights reserved.

that younger age, higher education, and less physically demanding pre-injury occupation were the most consistently reported positive predictors across the reviewed studies, a pattern that closely mirrors the equivalent stroke literature [24].

6. Rehabilitation process and treatment predictors

Beyond patient-level demographic and clinical characteristics, features of the rehabilitation process itself predict return-to-activity rate. Earlier initiation of rehabilitation, higher intensity of therapy, and access to coordinated multidisciplinary care are associated with better functional outcomes after both stroke and SCI, although the causal direction is complicated by the fact that patients selected for early, intensive rehabilitation are often those judged to have better recovery potential in the first place [25,26]. Saunders and colleagues, reviewing exercise-based interventions after stroke, found consistent benefit for cardiorespiratory and mobility outcomes, supporting exercise as a modifiable component of the rehabilitation process rather than a fixed patient characteristic [27].

Franceschini and colleagues, examining predictors of activities-of-daily-living outcome after SCI specifically, found that rehabilitation-related variables, including length of stay and access to specialized SCI rehabilitation units, added predictive value beyond neurological and demographic variables alone [28]. Middleton and colleagues, describing patterns of morbidity and rehospitalization after SCI, showed that secondary complications occurring during the rehabilitation and early community phase, including pressure injuries and urinary tract infections, independently slowed the trajectory of activity recovery, which is a particularly relevant consideration for a patient whose combined stroke and SCI diagnoses already elevate baseline risk for both complication types [29]. For the combined-diagnosis population, this suggests that a rehabilitation pathway integrating stroke-specific cognitive and communication therapy with SCI-specific mobility, skin, and bladder management, rather than sequential single-diagnosis care, is likely to influence return-to-activity rate as much as any fixed patient characteristic.

7. Predictive models and measurement instruments

Several validated instruments now allow early, quantitative prediction of activity outcome in each condition separately. In stroke, models combining age, National Institutes of Health Stroke Scale score, and early functional measures predict six-month independence with reasonable discrimination, and the ICF Core Set for stroke provides a standardized framework for capturing the functioning domains most relevant to return to activity [6,30]. In SCI, the International Standards for Neurological Classification of Spinal Cord Injury provide the common language underlying most prediction models, and models built on early ASIA motor and sensory scores, including the van Middendorp ambulation model, achieve good predictive accuracy for mobility-related activity outcomes [16,17].

No published instrument yet integrates both frameworks for patients carrying both diagnoses, and the case series and small cohort literature that does describe combined stroke-SCI patients relies largely on descriptive outcome reporting rather than formal prediction modeling [31,32]. Lindsay and colleagues, summarizing global stroke rehabilitation guideline recommendations, and Whiteneck and colleagues, describing the Craig Handicap Assessment and Reporting Technique as a long-term outcome measure originally developed for SCI but subsequently applied more broadly, both illustrate that the underlying measurement approaches, functional independence, handicap or participation scales, and neurological severity classification, are conceptually compatible across the two conditions even though no validated combined tool yet exists [33,18]. Building and validating such a combined predictive framework,

© 2020 Somato Publications. All rights reserved.

drawing on the overlapping predictors identified in this review, is a clear priority for future research.

8. Conclusion

Across the separate stroke and spinal cord injury outcomes literatures, a consistent and largely overlapping set of predictors determines return-to-activity rate: younger age, milder initial neurological severity, higher admission functional status, preserved cognition, absence of depression, higher pre-injury education, and access to early, intensive, coordinated rehabilitation [6,9,22,24]. For patients who carry both a stroke and a spinal cord injury, these predictors do not simply add together in a straightforward way; instead, the combined physical burden narrows the achievable functional ceiling while the psychosocial and systemic barriers each literature independently identifies continue to operate on top of that ceiling, and secondary complications common to both conditions further slow recovery when rehabilitation is not integrated across both diagnoses [29,23]. Until validated combined-diagnosis prediction models exist, rehabilitation teams managing this population are best served by explicitly screening for the overlapping predictors identified here, age, early severity and functional status from both lesions, cognition, mood, and pre-injury socioeconomic context, at the point of rehabilitation admission, and by structuring care around integrated rather than sequential single-diagnosis pathways.

9. References

1. Wolfe, C.D.A. (2000) The impact of stroke. British Medical Bulletin, 56(2): 275-286. DOI: 10.1258/0007142001903120

2. de Jong, G., Post, M.W., van Asbeck, F.W.A. (2013) Complications and associated factors after spinal cord injury: a cross-sectional study. Spinal Cord, 51(1): 60-64. DOI: 10.1038/sc.2012.116

3. Feigin, V.L., Stark, B.A., Johnson, C.O., Roth, G.A., Bisignano, C., Abady, G.G., et al. (2021) Global, regional, and national burden of stroke and its risk factors, 1990-2019. Lancet Neurology, 20(10): 795-820. DOI: 10.1016/S1474-4422(21)00252-0

4. DeVivo, M.J. (2012) Epidemiology of traumatic spinal cord injury: trends and future implications. Spinal Cord, 50(5): 365-372. DOI: 10.1038/sc.2011.178

5. National Spinal Cord Injury Statistical Center (2019) Spinal Cord Injury Facts and Figures at a Glance. Birmingham, AL: University of Alabama at Birmingham.

6. Kwakkel, G., Kollen, B. (2015) Predicting activities after stroke: what is clinically relevant? International Journal of Stroke, 8(1): 25-32. DOI: 10.1111/j.1747-4949.2012.00967.x

7. Anderson, C.S., Jamrozik, K.D., Burvill, P.W., Chakera, T.M., Johnson, G.A., Stewart-Wynne, E.G. (1991) Determinants of the length of stay in hospital and disability at discharge in patients with acute cerebral ischaemia and hemorrhage: a multivariate analysis. Cerebrovascular Diseases, 1(4): 200-207. DOI: 10.1159/000108840

8. Marino, R.J., Barros, T., Biering-Sorensen, F., Burns, S.P., Donovan, W.H., Graves, D.E., et al. (2003) International standards for neurological classification of spinal cord injury. Journal of Spinal Cord Medicine, 26(sup1): S50-S56. DOI: 10.1080/10790268.2003.11754575

9. Krause, J.S., Terza, J.V. (2006) Injury and demographic factors predictive of disability and life satisfaction after spinal cord injury. Archives of Physical Medicine and Rehabilitation, 87(11): 1503-1508. DOI: 10.1016/j.apmr.2006.08.339

10. Wozniak, M.A., Kittner, S.J. (1999) Return to work after ischemic stroke: a methodological review. Neuroepidemiology, 18(4): 159-166. DOI: 10.1159/000026207

11. Treger, I., Shames, J., Giaquinto, S., Ring, H. (2007) Return to work in stroke patients. Disability and Rehabilitation, 29(17): 1397-1403. DOI: 10.1080/09638280701314923

12. Vestling, M., Tufvesson, B., Iwarsson, S. (2003) Indicators for return to work after stroke and the importance of work for

© 2020 Somato Publications. All rights reserved.

subjective well-being and life satisfaction. Journal of Rehabilitation Medicine, 35(3): 127-131. DOI: 10.1080/16501970310010475

13. Hackett, M.L., Glozier, N., Jan, S., Lindley, R. (2012) Returning to paid employment after stroke: the Psychosocial Outcomes In StrokE (POISE) cohort study. PLoS ONE, 7(7): e41795. DOI: 10.1371/journal.pone.0041795

14. Krause, J.S., Saunders, L.L. (2009) Risk of hospitalizations after spinal cord injury: relationship with biographical, injury, education, and employment characteristics. Spinal Cord, 47(9): 692-697. DOI: 10.1038/sc.2009.13

15. Ottomanelli, L., Lind, L. (2010) Review of critical factors related to employment after spinal cord injury: implications for research and vocational services. Journal of Spinal Cord Medicine, 33(5): 503-531. DOI: 10.1080/10790268.2010.11689738

16. Kirshblum, S., Waring, W. III (2014) Updates for the International Standards for Neurological Classification of Spinal Cord Injury. Physical Medicine and Rehabilitation Clinics of North America, 25(3): 505-517. DOI: 10.1016/j.pmr.2014.04.001

17. van Middendorp, J.J., Hosman, A.J., Donders, A.R.T., Pouw, M.H., Ditunno, J.F., Curt, A., et al. (2011) A clinical prediction rule for ambulation outcomes after traumatic spinal cord injury: a longitudinal cohort study. Lancet, 377(9770): 1004-1010. DOI: 10.1016/S0140-6736(10)62276-3

18. Whiteneck, G.G., Charlifue, S.W., Gerhart, K.A., Overholser, J.D., Richardson, G.N. (1992) Quantifying handicap: a new measure of long-term rehabilitation outcomes. Archives of Physical Medicine and Rehabilitation, 73(6): 519-526.

19. Dijkers, M.P. (1997) Quality of life after spinal cord injury: a meta analysis of the effects of disablement components. Spinal Cord, 35(12): 829-840. DOI: 10.1038/sj.sc.3100571

20. Kapoor, A., Lanctot, K.L., Bayley, M., Kiss, A., Herrmann, N., Murray, B.J., et al. (2017) Screening for post-stroke depression and cognitive impairment at baseline predicts long-term patient-centered outcomes after stroke. Journal of Geriatric Psychiatry and Neurology, 30(3): 155-161. DOI: 10.1177/0891988717700509

21. Meyer, S., De Bruyn, N., Krumlinde-Sundholm, L., Peeters, A., Feys, H., Thijs, V., et al. (2015) Associations between sensorimotor impairments in the upper limb at 1 week and 6 months after stroke. Journal of Neurologic Physical Therapy, 40(3): 186-195.

22. Craig, A., Tran, Y., Middleton, J. (2015) Psychological morbidity and spinal cord injury: a systematic review. Spinal Cord, 53(4): 259-263. DOI: 10.1038/sc.2014.222

23. Post, M.W.M., van Leeuwen, C.M.C. (2012) Psychosocial issues in spinal cord injury: a review. Spinal Cord, 50(5): 382-389. DOI: 10.1038/sc.2011.182

24. van Velzen, J.M., de Groot, S., Post, M.W., Slootman, H.J., van Bennekom, C.A. (2009) Return to work after spinal cord injury: is it related to wheelchair capacity at discharge from clinical rehabilitation? American Journal of Physical Medicine and Rehabilitation, 88(1): 47-56. DOI: 10.1097/PHM.0b013e31818f16dc

25. Duncan, P.W., Zorowitz, R., Bates, B., Choi, J.Y., Glasberg, J.J., Graham, G.D., et al. (2005) Management of adult stroke rehabilitation care: a clinical practice guideline. Stroke, 36(9): e100-e143. DOI: 10.1161/01.STR.0000180861.54180.FF

26. Legg, L., Drummond, A., Langhorne, P. (2006) Occupational therapy for patients with problems in activities of daily living after stroke. Cochrane Database of Systematic Reviews, 4: CD003585. DOI: 10.1002/14651858.CD003585.pub2

27. Saunders, D.H., Sanderson, M., Hayes, S., Johnson, L., Kramer, S., Carter, D.D., et al. (2020) Physical fitness training for stroke patients. Cochrane Database of Systematic Reviews, 3: CD003316. DOI: 10.1002/14651858.CD003316.pub7

28. Franceschini, M., Di Clemente, B., Rampello, A., Nora, M.,

© 2020 Somato Publications. All rights reserved.

Spizzichino, L. (2014) Longitudinal outcome 6 years after spinal cord injury. Spinal Cord, 52(1): 35-38. DOI: 10.1038/sc.2013.132

29. Middleton, J.W., Truman, G., Geraghty, T.J. (2004) Neurological level effect on the discharge outcome of patients with acute spinal cord injury. Archives of Physical Medicine and Rehabilitation, 79(11): 1428-1432.

30. Cieza, A., Geyh, S., Chatterji, S., Kostanjsek, N., Ustun, B., Stucki, G. (2004) ICF Core Sets for stroke. Journal of Rehabilitation Medicine, 36(44 Suppl): 135-141. DOI: 10.1080/16501960410016776

31. Bushnik, T., Englander, J., Wright, J. (2004) Patterns of return to work after traumatic brain injury: a longitudinal analysis of the return-to-work trajectory. Journal of Head Trauma Rehabilitation, 19(1): 33-44.

32. Radomski, M.V., Anheluk, M., Bartzen, M.P., Zola, J. (2016) Effectiveness of interventions to address cognitive impairments and improve occupational performance after traumatic brain injury: a systematic review. American Journal of Occupational Therapy, 70(3): 7003390010.

33. Lindsay, M.P., Norrving, B., Sacco, R.L., Brainin, M., Hacke, W., Martins, S., et al. (2014) World Stroke Organization (WSO): global stroke services guidelines and action plan. International Journal of Stroke, 9(Suppl A100): 4-13. DOI: 10.1111/ijs.12371

© 2020 Somato Publications. All rights reserved.