Cognitive function is an important determinant of employment amongst young ischaemic stroke survivors with good physical recovery

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Abstract

Background and purpose: This cross-sectional cohort study aims at investigating young ischaemic stroke survivors with good physical recovery 7 years post-stroke in order to analyze the relation between late cognitive ability and employment.

Methods: Consecutive ischaemic stroke survivors participating in the Sahlgrenska Academy Study on Ischemic Stroke, <55 years of age at stroke onset, and with no or minimal persisting neurological deficits corresponding to a score ≤2 on the National Institutes of Health Stroke Scale at long-term follow-up 7 years post-stroke were included. At this follow-up, the participants were assessed with respect to general cognitive function, processing speed, executive functions, cardiovascular risk factors, self-reported employment, cognitive difficulties, fatigue, depressive symptoms, anxiety and physical function.

Results: Seven years post-stroke 112/142 (79%) had part-time or full-time work and 30/142 (21%) had full-time disability pension or sick leave. Compared to those with full-time disability pension or sick leave, participants with current employment demonstrated significantly better performance with respect to general cognitive function and processing speed, and significantly lower self-ratings for cognitive difficulties, physical limitations, fatigue and depressed mood. Multivariable logistic regression selected self-rated memory (odds ratio [OR] 2.61, 95% confidence interval [CI] 1.61–4.21), processing speed (OR 3.50, 95% CI 1.67–7.33) and self-rated communication skills (OR 3.46, 95% CI 1.75–6.85) as most important correlates (area under the curve 0.83–0.87) of having current employment.

Conclusion: This study indicates that cognitive dysfunction is an important contributor to long-term work disability amongst young stroke survivors with good physical recovery.

Keywords: cognition, employment, long-term outcome, young ischaemic stroke
INTRODUCTION

Globally, ischaemic stroke is the principal cause of adult disability [1] and a major cause of cognitive impairment. Lately, early-onset ischaemic stroke (occurring before the age of 50–55 years) has received greater attention with studies reporting an increase in incidence and prevalence in both high-income and low- to middle-income countries [2]. The long-term prognosis after early-onset ischaemic stroke is of particular interest, as young and middle-aged stroke sufferers usually have a long-life expectancy and thus will live long with the consequences of the acquired brain injury. Despite this, there are few long-term studies of the outcomes in this patient group [3]. So far, their outcomes are usually considered fairly good because of a low mortality rate and relatively good motor recovery [3-5]. However, both short-term [6] and long-term [7] studies indicate that cognitive dysfunctions are common and may impact on long-term functional outcome [8,9]. Furthermore, there are data indicating that the group with unfavorable cognitive outcomes also includes those with a favorable physical recovery [10].

Most work tasks will place demands on cognitive functions and increased complexity in the working life has most probably increased this challenge. The return to work is an important long-term outcome for stroke survivors [11] connected with financial independence and well-being. For survivors of working age, several factors have been identified as important correlates to return to work where the most robust predictors are initial stroke severity and subsequent functional dependence [12-14]. However, the vast majority of young ischaemic stroke survivors are functionally independent and yet may fail to return to work [4,15,16]. In a recent comprehensive review of inability to return to work at stroke age [13], cognitive dysfunction was the second most common factor behind not returning and it was suggested that persisting cognitive impairments may represent a negative factor in patients with otherwise favorable physical recovery. Further studies of long-lasting cognitive dysfunction in relation to employment after stroke are therefore of importance.

Indeed, several studies have identified cognitive deficit as an independent predictor of returning to work post-stroke [11,13,15,17-23], and significant associations between cognitive functions and employment have been identified also beyond the first year [11,17,19,21,23]. However, few studies are restricted to young ischaemic stroke (<55 years) with good physical recovery, and cognition is mainly investigated at the early stage as a potential predictor. Waje-Andreassen et al. [23] conducted a study 11.9 years after an ischaemic stroke at young age (n = 144, ≤49 years at index stroke) that reported an independent connection between self-rated long-lasting memory problems and return to work. No objective tests of cognition were included and participants with persistent severe neurological deficits were not excluded. Amongst the prediction studies, a registry-based follow-up study of a cohort of young subjects, restricted to survivors with a mild to moderate ischaemic stroke [17], identified early signs of aphasia as an independent predictor of returning to work at 1–5 years after stroke (n = 769), but no other cognitive variables were tested in this study. Thus, further investigations of associations between employment and comprehensive measures of cognition in the chronic phase after young ischaemic stroke are warranted, and especially for those with favorable physical recovery.

Here employment for young ischaemic stroke survivors 7 years after stroke onset was investigated. Participants without or with only minimal persisting neurological deficits were included in order to study the relation to cognitive function in stroke survivors with good physical recovery. The main objective was to investigate to what extent level of cognition is associated with employment whilst controlling for sociodemographic, clinical and mental background factors.

METHODS

The study sample comprised a subsample from the Sahlgrenska Academy Study on Ischemic Stroke (SAHLSIS), which is described in detail elsewhere [24]. In brief, patients who presented with first-ever or recurrent acute ischaemic stroke between the ages of 18 and 69 years were consecutively recruited at stroke units in western Sweden. Seven years after inclusion to the study, all surviving participants at the Sahlgrenska University Hospital were invited to participate in a comprehensive follow-up consisting of questionnaires and visits to a research nurse and a physician trained in stroke medicine. The questionnaires were sent to the study participants before the visit and uncertainty that arose from the questions in the questionnaire were checked by the research nurse at the subsequent visit. The patients were recruited between 1998 and 2009 and the follow-up visits were conducted from 2005 to 2017.

For the present study all participants in SAHLSIS who (1) were recruited at the Sahlgrenska University Hospital, (2) were <55 years at index stroke, (3) attended the follow-up visit 7 years later and (4) had a National Institutes of Health Stroke Scale (NIHSS) score between 0 and 2 at this follow-up were selected. Written informed consent was obtained from all participants prior to enrollment. This study was approved by the Regional Ethical Review Board in Gothenburg, Sweden (Dnr: 413-04, 823-13).

Assessments

All assessments were conducted at the 7-year follow-up unless otherwise stated. Information on demographics including occupation was collected using questionnaires. The level of education was categorized as low, medium or high corresponding to compulsory school (9 years or less), secondary school and post-secondary education, respectively. Social situation was classified as living alone or living with someone (significant other). Type of work at index stroke was classified into four ordinal skill levels according to the Swedish Standard Classification of Occupations (SSYK 2012) based on the International Standard Classification of Occupation 2008 (ISCO-08).
The skill levels were (1) elementary occupations, (2) workers, (3) professionals (requiring higher education qualifications or equivalent) and (4) managers and professionals (requiring advanced level of higher education).

Neurological deficits according to the NIHSS and cardiovascular risk factors were assessed at baseline and at the 7-year follow-up visit. Our definitions of hypertension, diabetes mellitus and smoking have been described in detail elsewhere [24]. These cardiovascular risk factors were scored as present or not present. Body mass index was calculated as kilograms per square meter. Level of leisure-time physical activity was classified into four ordinal levels according to the modernized version of the Saltin–Grimby Physical Activity Level Scale [25,26] as (1) physically inactive, (2) some light physical activity, (3) regular physical activity and training, and (4) regular hard physical training for competitive sports. The overall level of physical ability and activities of daily living were described by the composite physical domain score from the Stroke Impact Scale (SIS) [27] consisting of self-rated ability in strength, daily activities, mobility and hand function which was converted to a single score ranging between 1 and 100 with higher scores representing fewer perceived difficulties.

Cognitive assessments

Cognitive function was assessed by two tests and two self-rating scales. The general cognitive level was measured by the Barrow Neurological Institute Screen (BNIS) for higher cerebral functions [28,29]. The total score, ranging from 0 to 50, summed the subscores from a pre-screen and seven cognitive domains (language, orientation, attention, visuospatial functions, memory, emotions and awareness). Good validity and sensitivity for cognitive function and dysfunction after brain lesions have been demonstrated for this screening battery [30,31]. In addition, processing speed was measured by a timed version of the Star Cancellation test with a time limit of 30 s and with a maximum score of 54. Star Cancellation is an A4 sized paper-and-pencil subtest of the normalized and standardized Behavioral Inattention Test (BIT) [32]. A mirrored copy of the test was used and participants were instructed to cancel as many as possible of the targets (small stars) spread amongst several distractors (letters, short words and large stars). Two self-rating scales of cognition from SIS [27] were also included. Memory and thinking (SIS domain 2) consists of four items about memory and four items of thinking summing to a score between 8 and 40. Communication and reading (SIS domain 4) includes seven items about perceived ability to communicate and understand a conversation summing to 7–35. The total scores from each of these subscales were converted to a score ranging between 1 and 100, with higher scores representing fewer perceived difficulties.

Extended assessment of cognition

From 2005 to 2010, all participants below 50 years of age at index stroke were invited to a more comprehensive cognitive testing at the 7-year follow-up including 11 additional cognitive tests. As from 2011, these tests were extended to all participants up to 54 years of age at index stroke. All these participants were tested by the same neuropsychologist (JV) or by our research nurse (IE) who had been trained in administering the tests by JV. Conventional standardized and validated tests of cognition [33–35] were used. The number of tests was two for simple reaction time, four for processing speed and five for executive functions. The tests are described in Tables 1 and S1.

Anxiety, depressive symptoms and fatigue

The anxiety and depression subscales (HADS-A and HADS-D) of the self-rating Hospital Anxiety and Depression Scale (HADS) [36] were used to measure mood state. The score range is 0–21 for each of the subscales, with higher scores representing greater severity. The level of fatigue was described by the Vitaly (energy/fatigue) subscale from the self-rating Short Form 36 (SF-36) scale [37]. This subscale consists of four items each ranging from 1 to 6 with a total range of 4–23 which was converted to a score ranging between 1 and 100, with higher scores representing greater energy and lower fatigue.

Employment

The outcome variables were (1) no work versus full- or part-time work and (2) no work versus full-time work. Participants who were self-employed, unemployed but actively looking for work or full-time students were considered as full-time working.

Statistics

Data obtained at the 7-year follow-up were analyzed cross-sectionally. Two-group analyses were made with the Mann–Whitney U test (continuous data) and chi-squared test (categorical data). In these analyses, the univariable association with working either full- or part-time (full/part) or full-time was investigated in comparison to no work. In order to identify the most important correlates of full- or part-time work and full-time only, all variables with a p value <0.15 in the two-group comparison were included in a subsequent multivariable logistic regression with forward stepwise variable selection. At all calculations of multivariable odds ratio (OR) the continuous variables (except SSYK and leisure-time physical activity) were standardized and ORs for one standard deviation (SD) increase in the variables are given in order to facilitate comparisons.

RESULTS

A total of 290 patients had an age <55 years at index stroke and 221 were eligible at the 7-year follow-up (Figure 1). At this follow-up,
27 did not appear at the face to face visit and the reasons for not participating are given in Figure 1. Of those appearing at the visit, 33 were excluded due to a score on NIHSS $>2$. Of the remaining 161 participants, three had incomplete data on the occupational situation, 12 were excluded due to full-time pension already at baseline and four were excluded as the pension or sick leave at follow-up was due to other reasons than stroke. Hence, the final available study group comprised 142 subjects.

Baseline characteristics

At the time of the index stroke, the vast majority of participants were working full-time (73%) or part-time (9%), whilst sick leave, part-time pension and parental leave were observed for one participant for each such classification (Table 2). Nine patients were unemployed jobseekers at the time of the index stroke. Workers and Managers and professionals were the most common type of work in our study group (43% and 31%, respectively). Eleven participants (two with no work at follow-up and nine with work) experienced a recurrent stroke during the period between the index stroke and the follow-up. In 58 participants the index stroke was localized to the left hemisphere, in 55 to the right hemisphere and in 22 to the cerebellum and/or brainstem; seven had lesions at more than one of these locations.

Employment at the 7-year follow-up

At follow-up, 112 (79%) were in full- or part-time work and 30 (21%) had full disability pension or sick leave. Of those in work, 60 (54%) were working full-time and 52 (46%) part-time. One of those categorized as full-time work was an unemployed job seeker and two were students. Of those with full pension or sick leave at the follow-up, the employment status at index stroke was full-time for 18 (60%), part-time for three (10%), unemployed or sick leave part-time for five (17%), other for one (3%), and for three (10%) data were missing. Detailed information on employment status at follow-up for the different categories of employment at baseline is displayed in Table S2.

The results from the group comparisons between no work and full/part-time work are given in Table 3. Significantly greater performance and self-ratings were demonstrated for those with full/part-time work for all cognitive variables ($p$ values between 0.004 and $<0.001$), for overall physical ability ($p < 0.001$), for ratings of depressed mood ($p < 0.001$) and for ratings of fatigue ($p = 0.006$). Also, lower age ($p = 0.012$) was associated with full/part-time work. The same observations were true for the relationships with full-time compared to no work ($p$ values between 0.018 and $<0.001$; see Table 3) with the addition of a higher frequency of men with full-time work ($p = 0.013$).

### TABLE 1

Tests for extended assessment of cognition

| Test name | Main domains tested | Scores |
|-----------|---------------------|--------|
| Simple reaction time | | |
| Alertness, with no warning, from the Test of Attentional Performance (TAP)$^a$ | Tonic alertness | Median reaction time |
| Alertness, with warning, from the TAP$^a$ | Phasic alertness | Median reaction time |
| Processing speed | | |
| Trail making test A (TMT-A)$^b$ | Speed of visuospatial scanning and visual–motor sequencing | Completion time |
| Visual field/neglect from TAP$^a$ | Speed of visuospatial attention, right and left side | Median reaction time on left and right side |
| Color naming from the color word interference test (CWI) in Delis–Kaplan Executive Function System (D-KEFS)$^c$ | Speed of naming | Completion time |
| Word reading (from CWI in D-KEFS)$^c$ | Speed of reading words | Completion time |
| Executive functions | | |
| Trail making test B (TMT-B)$^b$ | Divided attention, set-shifting and visual–motor sequencing | Completion time |
| Inhibition (from CWI in D-KEFS)$^c$ | Inhibition of a dominant and automatic response | Completion time |
| Inhibition/switching (from CWI in D-KEFS)$^c$ | Cognitive flexibility, inhibitory control, working memory | Completion time |
| Verbal fluency, words (from D-KEFS)$^c$ | Letter/phonological fluency | Number of correct words |
| Verbal fluency, animals (from D-KEFS)$^c$ | Semantic retrieval and category fluency | Number of correct animals |

$^a$TAP, Zimmermann and Fimm, 2007.
$^b$TMT-A, Reitan, 1955; Spreen and Strauss, 1998.
$^c$D-KEFS [34].
The multivariable regression analysis (Table 4) selected low levels of self-rated problems with memory and thinking (OR 2.61, 95% CI 1.61–4.21) and faster processing speed (OR 1.52, 95% CI 0.94–2.45) as the model for detection of study participants in full/part-time work (area under the curve 0.83). For detection of study participants in full-time work only (Table 4) the associations were somewhat stronger; the multivariable analysis selected low ratings of problems with communication (OR 3.46, 95% CI 1.75–6.85) and faster processing speed (OR 3.50, 95% CI 1.67–7.33) with an area under the curve of 0.87.

Ninety-two participants were assessed with the extended battery of cognitive tests. The main reasons for not participating (n = 15) were “short of time” or increasing fatigue and/or cognitive strain. Due to the limited sample size, only descriptive results of associations across the different tests in relation to the presence of full/part-time work at follow-up are provided. The pattern is illustrated by a forest plot of the OR and 95% CI for the results from the different cognitive tests (Figure 2). In univariable analyses, the strongest associations to full/part-time work were observed for processing speed (completion time for trail making test A [OR 0.40, 95% CI 0.22–0.71] and reaction time toward the right side in visuospatial attention [OR 0.35, 95% CI 0.19–0.65]) and for executive functions (completion time for color–word interference inhibition/switching [OR 0.33, 95% CI 0.18–0.63]). Detailed results for the extended battery of cognitive tests can be found in Table S3.

**DISCUSSION**

In this cohort of young ischaemic stroke participants with no or only marginal neurological deficits, one out of five had full disability pension or sick leave at follow-up 7 years post-stroke. Employment showed an independent association with cognitive function in terms of both processing speed and self-rated cognition. The increase of the odds for full/part-time work was 161% for 1 SD unit increase in the self-rating of memory and thinking ability. The increase in odds for full-time work was 250% for 1 SD unit increase in processing speed and 246% for 1 SD unit increase in the self-rating of memory and thinking ability. The increase in odds for full-time work was 250% for 1 SD unit increase in processing speed and 246% for 1 SD unit increase in the self-rating of communication ability. Results from the extended cognitive testing of a subsample indicated that complex executive attention (combined attentional inhibition and switching) was also an important correlate to employment, although the sample size did not allow for formal statistical testing of the independent importance of this factor.

Our study points to the importance of self-perceived problems of memory and of communication in the long term in young stroke with favorable physical outcome. In accordance with our findings, self-reported impairment in memory was reported as the most important independent correlate to employment in an average of 12 years after an ischaemic stroke at young age (n = 144) [23] [Correction added on 09 August 2021 after first online publication: n value in the preceding sentence has been corrected]. However, no other measures of cognition were included and the study was not restricted to those
with mild neurological deficits [23]. Studies that include formal tests of memory [19, 38] have also reported independent associations with return to work but they were not restricted to young stroke and no follow-up was conducted beyond the first year. Tanaka et al. [38] (n = 335) found that memory, attention and intelligence were independent significant predictors of early return to work after stroke onset for those with mild physical disability (modified Rankin Scale ≤ 2; n = 255, stroke of different cause, age 15–64 years). Kotila et al. [19] identified memory as a significant early predictor of return to work at 12 months post-stroke (n = 58, stroke of different cause, age <65 years), but this study was not restricted to mild stroke.

It is indeed likely that perceived difficulties with communication several years after stroke can interfere significantly with the hold of full-time employment. An association with the classification of language impairments/aphasia has been observed in earlier studies of return to work [17, 21, 39, 40] but only one of these studies [17] was conducted as a long-term investigation of young ischaemic stroke with favorable physical outcome. No previous long-term studies of this group of stroke survivors have investigated the importance of self-rated communication skills in relation to employment. An interesting question for coming investigations is the relation between self-perceived cognitive ability and the outcome in objective tests of the same ability. In the present study, self-rated cognition had a relatively weak correlation with the results of the assessment of overall cognition (0.28 and 0.26, post hoc analyses) whilst stronger associations were observed with depression (0.50 and 0.61). Forthcoming studies could therefore investigate the possible connection between self-rated cognitive capacity and aspects of emotional well-being in relation to employment in the long term after stroke.

A strong independent relation between processing speed and full-time work was also identified. In line with our findings, Kauranen et al. [15] reported the strongest univariable association between impaired processing speed and full-time employment at 6 months post-stroke, using a comprehensive battery of cognitive tests. Furthermore, the number of impaired cognitive tests, including processing speed, was the only significant independent early predictor of the inability to return to work (n = 140, ischaemic stroke, age 18–65 years, NIHSS median 1 at discharge). However, no long-term follow-up was conducted in this study. To our knowledge there are no previous long-term studies (>1 year post-stroke) that have investigated the possible association between employment and processing speed.

The association between processing speed and employment after stroke is of particular relevance as impaired processing speed has been identified as a common consequence after stroke [41] that is associated with long-term functional outcome assessed 5 years post-stroke [8]. Processing speed is also highly associated with the cognitive impairments observed in subcortical small vessel disease [42]. However, all cognitive domains were not included in our study and it is therefore not possible to reach a conclusion regarding the potentially most important cognitive domain in relation to employment. It may also be noted that processing speed was not identified as a significant independent predictor of return to work 6 months post-stroke in a retrospective analysis of archival data (n = 244, stroke with NIHSS ≤16) [43], but this study differed from our investigation by including both ischaemic and hemorrhagic stroke, ages between 25 and 87 years, and with a follow-up as early as 6 months. In another study [44], neither processing speed nor memory was identified as a significant independent predictor of employment 12 months post-stroke (n = 217, ischaemic stroke, age 18–70 years, modified Rankin Scale ≤2) but this study was not restricted to young stroke and no follow-up was conducted after the first year. Indeed, for young stroke survivors, further studies are warranted in order to identify the most important long-term correlates of employment amongst the different specific cognitive domains.

This study, based on one single follow-up of employment as long as 7 years after the index ischaemic stroke, does not take into account that employment may have differed at different stages across this period. This is a limitation but it is important to notice that the aim of this study was not to describe the rate of returning to work after stroke. Instead the primary aim was to describe the

### TABLE 2 Baseline characteristics at the index stroke

| Characteristic                                      | Total n |   |
|----------------------------------------------------|---------|---|
| Sex, male                                          | 142     | 81| 57% |
| Age, years (mean and SD)                           | 142     | 43| 9.3 |
| Employment at the stroke event                     | 142     |   |
| Work full-time                                     | 104     | 73% |
| Work part-time                                     | 13      | 9% |
| Sick leave full-time                               | 1       | 1% |
| Sick leave part-time                               | 1       | 1% |
| Disability pension part-time                       | 1       | 1% |
| Unemployed, jobseeker                              | 9       | 6% |
| Parental leave                                     | 1       | 1% |
| Other                                              | 1       | 1% |
| Missing data                                       | 11      | 8% |
| Type of work and skill level according to SSYK     | 142     |   |
| Managers and professionals (skill level 4)         | 44      | 31% |
| Professionals (lower level) (skill level 3)        | 16      | 11% |
| Workers (skill level 2)                            | 61      | 43% |
| Elementary occupations (skill level 1)             | 9       | 6% |
| Students                                           | 5       | 4% |
| Other ranks (privates etc.)                        | 4       | 3% |
| Missing data                                       | 3       | 2% |
| Smoking, current                                   | 141     | 48| 34% |
| Hypertension, yes                                  | 141     | 43| 30% |
| Diabetes, yes                                      | 142     | 10| 7% |

Abbreviation: SSYK, Swedish Standard Classification of Occupations.

*The participants were consecutively recruited between 1998 and 2009 at Sahlgrenska University Hospital.
## TABLE 3  
Comparisons between no work and full/part-time work and between no work and full-time work for cognitive, demographic, occupational, clinical and mental variables 7 years after stroke

|                      | Full sick leave/pension | Full/part-time work | Full-time work |
|----------------------|-------------------------|---------------------|---------------|
|                      | Median (IQR) or n (%)   | Median (IQR) or n (%) | Z/χ² | p       |
|                      | Total n                | Total n             |       |         |
| Cognition            |                         |                     |       |         |
| BNIS total sum       | 30 41 (37–43)          | 112 43 (40–47)      | −2.92 | 0.004  |
| STAR test at 30 s    | 29 41 (35–45)          | 112 46 (40–53)      | −3.14 | 0.002  |
| Self-rated memory and thinking (SIS domain 2) | 28 73 (66–88) | 110 94 (84–100) | −4.26 | <0.001 |
| Self-rated communication reading (SIS domain 4) | 28 82 (71–93) | 109 100 (93–100) | −4.26 | <0.001 |
| Demographics and occupational |                     |                     |       |         |
| Age, years           | 30 57 (50–60)          | 112 53 (43–58)      | 2.52  | 0.012  |
| Gender, male         | 30 14 (47%)            | 112 67 (60%)        | 1.67  | 0.196  |
| Social situation, living with someone | 30 21 (70%) | 112 80 (71%) | 0.02  | 0.878  |
| Highest level of education | 30 112 | 3.75 | 0.154 |
| Elementary/not finished/other | 9 (30%) | 17 (15%) | 0.75  | 0.386  |
| Upper secondary, training school, college | 11 (37%) | 56 (50%) | 0.75  | 0.386  |
| University           | 10 (33%)               | 39 (35%)            | 1.27  | 0.20   |
| Type of work: Skill level SSYK (1–4) | 28 2 (2–3) | 106 2 (2–4) | −1.20 | 0.229  |
| Activity at spare time (1–4) | 29 2 (2–2) | 111 2 (2–3) | −0.32 | 0.746  |
| Clinical data and physical ability/ADL |                     |                     |       |         |
| Neurological deficits, NIHSS = 1–2 | 30 9 (30%) | 112 25 (22%) | 0.77  | 0.381  |
| Composite physical/ADL SIS score b | 28 88 (76–97) | 110 90 (90–100) | −3.44 | <0.001 |
| BMI                  | 29 28 (25–31)          | 111 26 (24–29)      | 1.59  | 0.112  |
| Smoker, yes          | 30 8 (27%)             | 112 17 (15%)        | 2.15  | 0.142  |
| Hypertension, yes    | 30 14 (47%)            | 112 42 (37%)        | 0.83  | 0.362  |
| Diabetes, yes        | 30 6 (20%)             | 111 10 (9%)         | 2.84  | 0.092  |
| Mental, emotion and energy |                     |                     |       |         |
| HAD anxiety          | 30 6 (2–9)             | 112 4 (1–8)         | 1.23  | 0.22   |
| HAD depression       | 30 7 (3–9)             | 112 2 (1–5)         | 3.66  | <0.001 |
| Energy/fatigue subscale of SF-36 | 29 40 (30–65) | 109 60 (40–80) | −2.73 | 0.006  |

Note: Variables are presented as median (IQR, range from 25th to 75th percentiles) or n (%).

Abbreviations: ADL, activities of daily living; BMI, body mass index; BNIS, Barrow Neurological Institute Screen; HAD, Hospital Anxiety and Depression Scale; IQR, interquartile range; NIHSS, National Institutes of Health Stroke Scale; SF-36, Short Form 36; SIS, Stroke Impact Scale; SSYK, Swedish Standard Classification of Occupations; Z/χ², Z values from the Mann–Whitney U test or chi-squared value.

bTwo-group analyses were made with the Mann–Whitney U test (continuous data) and the chi-squared test (categorical data).

*The composite physical domain score (strength, hand function, ADLs/instrumental activities of daily living, mobility) from the SIS.
most important associations between long-lasting difficulties or impairments in relation to employment amongst ischaemic stroke survivors with a good physical recovery. Likewise, information on the cognitive status and on the mental state (history of anxiety, depression and fatigue) before the stroke and during the follow-up period would have offered a wider background and understanding to the findings presented. The absence of longitudinal data on cognitive function and employment for a control group is also a limitation. Moreover, the employment status of the participants compared to the general employment situation in Sweden was not analyzed. However, according to the Swedish Pensions Agency in Sweden the mean age for old-age retirement (not including sickness compensation) in Sweden during 1998–2016 ranged between 64.5 and 64.9 years with a somewhat higher age for females than males. As all study participants were <62 years at follow-up, the vast majority can be expected to be part of the

TABLE 4 Multivariable logistic regression for full/part-time and full-time work at the time of the follow-up

|                                | OR (95% CI) | Chi-squared | p      |
|--------------------------------|-------------|-------------|--------|
| Full/part-time work at follow-up, n = 104 of 131 |             |             |        |
| Self-rated memory              | 2.61 (1.61–4.21) | 15.25       | <0.001 |
| STAR test at 30 s              | 1.52 (0.94–2.45) | 2.87        | 0.09   |
|                                 | AUC 0.83    |             |        |
| Full-time work at follow-up, n = 58 of 85 |             |             |        |
| Self-rated communication        | 3.46 (1.75–6.85) | 12.71       | <0.001 |
| STAR test at 30 s              | 3.50 (1.67–7.33) | 10.99       | 0.001  |
|                                 | AUC 0.87    |             |        |

Notes: Hosmer–Lemeshow Statistic: full/part-time work, chi-squared 9.79, df 9, p = 0.37; full-time work, chi-squared 6.58, df 8, p = 0.58.
For all variables, odds ratios (OR) and 95% confidence interval (CI) for one standard deviation increase in the predictor variables are given.
Abbreviation: AUC, area under the curve.

aStepwise forward with probability for entry 0.05 and for removal 0.10.
bEleven participants excluded due to missing data.
cFive participants excluded due to missing data.

FIGURE 2 Univariable relations between cognitive functions and full/part-time employment at the time of the follow-up. All tests measure reaction time or time for completing the task except for verbal fluency investigating the number of correct words and naming of animals. For all variables the odds ratio (OR) and 95% confidence interval for one standard deviation change in the predictor variables are given. Tests of alertness and selective attention are from the Test of Attentional Performance. Tests of verbal fluency are from Delis–Kaplan Executive Function System (D-KEFS). CWI, color–word interference tests from D-KEFS; AUC, area under the curve.
work force. The average rates for unemployment for the population between 16 and 64 years during 1998–2017 ranged between 5.9% and 9.3% (Statistics Sweden), which is comparable to the proportion of participants who were unemployed at stroke onset in the present study (6%). Another limitation is that some factors previously shown to influence return to work were not included, such as the expectations of the participants in relation to return to work and the presence of different types of support for returning to work. Furthermore, the limited number of participants included in the extended assessment of cognitive tests was a limitation and the small group not working limited the statistical power of these analyses. Lastly, only survivors with good physical recovery were included. Thus, our study does not allow for conclusions regarding employment amongst stroke survivors with persisting major physical impairments.

In conclusion, in this cross-sectional follow-up study of a cohort of young ischaemic stroke survivors with favorable physical outcome it is shown that cognitive dysfunction is independently associated with long-term work disability. The findings from our study highlight that long-term work disability is relatively common also amongst ischaemic stroke survivors with no or minor persisting obviously stroke-related deficits, and that cognitive difficulties may contribute. Further studies in the area of long-term employment after stroke are warranted. Such studies may preferably investigate the influence of the different cognitive domains in relation to employment as well as explore support strategies and adjustments aimed at minimizing the negative effects of cognitive dysfunction for returning and staying in work long term after stroke.

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CONFLICT OF INTEREST

The authors declare no financial or other conflicts of interest.

AUTHOR CONTRIBUTIONS

Hans Samuelsson: Conceptualization (equal); data curation (equal); formal analysis (equal); methodology (equal); project administration (equal); writing—original draft; writing—review and editing (equal).

Jo Viken: Data curation (equal); investigation (equal). Petra Redfors: Conceptualization (equal); data curation (equal); investigation (equal). Lukas Holmegaard: Conceptualization (equal); data curation (equal); investigation (equal); writing—review and editing (equal). Christian Blomstrand: Conceptualization (equal); funding acquisition (equal); methodology (equal); project administration (equal); writing—review and editing (equal). Christina Jern: Conceptualization (equal); formal analysis (equal); funding acquisition (equal); methodology (equal); project administration (equal); writing—review and editing (equal).

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