1. Introduction

There are an estimated 270,000 individuals with acquired brain injury (ABI) in Japan, and there are 70,000 in the labor force population between the ages of 18 and 65 [1]. According to a 2005 study, only 13.2% of all hospitals in Japan provided work support for individuals with ABI, which increased to 20% in 2015, though this was limited to certain types of hospitals, such as recovery phase rehabilitation hospitals [2]. Recently, more individuals with ABI have been expected to work since the new legal employment provision of 2018 was enacted to include those with psychiatric disabilities in the legal quota system. This provision requires private companies employing more than 45.5 employees to meet an employment rate of over 2.2% for individuals with disabilities. Further, it requires these companies to include individuals with psychiatric disabilities who have been diagnosed as part of the disability certification system— in addition to those with physical disabilities and intellectual disabilities—in this quota rate [3].

In Japan, part of the role of occupational therapists (OTs) is to act as work supporters who provide transition services from hospital to work using neuropsychological assessment tools, which provide necessary information about individual cognitive functions. The present authors conducted a meta-analysis of the effectiveness
of neuropsychological assessment tools in providing “work support” transition services from hospital to work for individuals with ABI [4]. Results showed that the Wechsler’s Adult Intelligence Scale (WAIS) “verbal test” scores of the employment group were significantly higher than those of the unemployment group. Although some studies showed a significant difference in intellectual functions between employment groups and unemployment groups [5–12], other studies demonstrated no such difference [13, 14]. Many previous studies used three test scores (“verbal test,” “performance test,” and “full scale test”), but these WAIS scores are often measured by therapists in a quiet room and not in a real workplace. Therefore, they are not practically usable with specific work environments in the vocational rehabilitation process. Furthermore, even though some previous studies used more detailed subtest items [15–18], no consensus has been reached among them as to which WAIS subtest items can predict the employability of individuals with ABI.

Therefore, the purpose of this meta-analysis and systematic review is to identify useful WAIS subtest items that can predict employability of individuals with ABI. In our study, such “useful” items were defined as the items that contributed to the significant difference in the WAIS subtest item scores between the employment and unemployment groups.

2. Materials and methods

2.1 Material selection and eligibility criteria

The eligibility criteria for the targeted studies were as follows: (1) studies that examine people with brain injuries, (2) studies that examine an employment and unemployment group using the results from WAIS-R or WAIS-III subtest items, (3) studies that list the average, standard deviation, and number of samples for the employment and unemployment group WAIS subtest items, (4) studies that have been published in academic journals, and (5) studies featured in original papers written in English and Japanese. The papers used in this study comply with the ethical standards of the Declaration of Helsinki.

3. Methods

3.1 Data collection

Using MEDLINE (1971), CINAHL (1981), ERIC (1966), ICHUSHI of the Japan Medical Abstracts Society (1977), and CiNii Articles (2005), we selected research articles that examined useful WAIS subtest items that could predict the employability of individuals with ABI. In addition to the database search, hand searches were conducted to exhaustively collect articles. Search terms for causal diseases of ABI were: “stroke,” “brain damaged,” “head injury,” “cerebrovascular accident,” “cerebrovascular disease,” “brain injury,” “subarachnoid hemorrhage,” “cerebral infarction,” “cerebral hemorrhage,” “encephalitis,” “cerebral hypoxia,” “brain tumor,” “CVA,” and “CVD.” Search terms related to work were: “return to work,” “getting a job,” “employment,” “workplace resettlement,” “social reintegration,” and “vocational rehabilitation.” These searches were performed on October 19, 2019.

3.2 Measures

The Risk of Bias Assessment Tool for Nonrandomized Studies (RoBANS) was used for qualitative evaluation of the collected research articles. The validity and reliability of the RoBANS has been verified [19]. Based on the criterion judgment of the RoBANS, the risk of bias was assessed for the following six domains: (a) selection of participants, (b) confounding variables, (c) measurement of intervention (exposure), (d) blinding of outcome assessment, (e) incomplete outcome data, and (f) selective outcome reporting. Research articles were evaluated using “High+,” “Low−,” and “Unclear?.” More “Lows③” indicated better article quality.

3.3 Data Integration

Using Review Manager (RevMan) version 5.3.5 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014), we tested the means and standard deviations of the predictive WAIS subtest items, as well as some of the data obtained from the research articles, at a significance level of 5%. Given that continuous variables were collected for the present article, mean values were used as a scale for effect size calculations. Meta-analysis was conducted with the DerSimonian and Laird method, a statistical method for integrating the collected data, to enable the results of the present study to be utilized for the prediction of employability of other groups.

The results of the sensitivity and significance tests of all integrated data for the fixed effect model and random effect model were produced using Comprehensive Meta-Analysis Version 3 (Biostat Incorporated). When the results were consistent, we supposed the presence of sensitivity and those results were included in the present study. When the results were inconsistent, we supposed the absence of sensitivity and those results were excluded from the study. Statistical specificity was also tested using Review Manager (version 5.3.5), and the I² statistic was calculated. According to the Higgins et al. study [20], specificity should be high when the I² statistic is above 50%, which was the case in the present
study.

3.4 Testing Publication Bias

A symmetric Funnel plot was produced from all the integrated data, using a 10% level of significance, as suggested by Egger’s test [21].

4. Results

4.1 Collecting and selecting the studies

From the literature database, 3,776 articles were extracted. There were 1,677 MEDLINE, 808 CINAHL, 86 ERIC, 718 CiNii, and 487 ICHUSHI articles. However, 3,162 studies did not meet the inclusion criteria, and 610 were duplicates. No studies were obtained through a hand search and only four studies met the inclusion criteria set by the present study (Fig. 1).

4.2 Characteristics of the selected studies

Selected studies included three case-controlled studies (75%) and one prospective cohort study (25%). Table 1 shows that most of the cases included brain injury or stroke. All of the selected studies showed that the criterion judgment of the RoBANS was evaluated as “Low” in (a) selection of participants, (b) confounding variables, and (c) measurement of intervention (exposure), “Unclear” in (d) blinding of outcome assessment, and (e) incomplete outcome data (with the exception of one study, which was evaluated as “Low”), and Low in (f) selective outcome reporting. The time elapsed since the occurrence of brain injury was 12.5 to 51.7 months, and the employment rate of individuals with brain injury was 34.5 to 52.6% (Table 1).

4.3 Efficiency of the WAIS subtest items

4.3.1 Verbal test

As a result of data integration from the four studies, there was a significant difference between the employment and unemployment groups’ test scores in “vocabulary” (mean difference of 0.97; 95% CI [0.16, 1.78], \( p = 0.02 \)); no statistical heterogeneity was found (\( p = 0.64, I^2 = 0\% \); Fig. 2). Further, integration of the data resulted in a significant difference in “similarities” (mean difference of 1.42; 95% CI [0.56, 2.28], \( p = 0.001 \)). Again, no statistical heterogeneity was found (\( p = 0.56, I^2 = 0\% \); Fig. 2). There was also a significant difference in “arithmetic” (mean difference of 1.16; 95% CI [0.42, 1.91], \( p = 0.002 \)); no statistical heterogeneity was found (\( p = 0.78, I^2 = 0\% \); Fig. 2). Additionally, significant
Table 1  Research papers that corresponded to the analysis

| Author            | Year | Country | Research design     | Disease and quantity of data                                      | Average age (SD) | Male/Female | Elapsed period after brain injury (SD) | Neuropsychological examination used | Employed/Unemployed | Employment rates (%) |
|-------------------|------|---------|---------------------|------------------------------------------------------------------|------------------|-------------|----------------------------------------|-------------------------------------|---------------------|---------------------|
| Tomita et al.     | 1999 | Japan   | Case-control study  | Traumatic head injury, 60                                        | 28.1 (10.7)      | 56/4        | employment group: 12.5 (27.3) months  | WAIS-R                              | 26/34               | 43.3                |
| Youine et al.     | 2008 | Japan   | Case-control study  | Traumatic head injury, 26, Cerebral vascular disease, 26, Hypoxia encephalopathy, 3, Brain tumor, 3 | 36.0 (11.3)      | 29/9        | employment group: 5.17 (83.2) months  | WAIS-R, WMS-R, RBMT, TMT, Kanahiroi test, CAT, BADS | 20/18               | 52.6                |
| Sawada et al.     | 2010 | Japan   | Case-control study  | Traumatic head injury, 70, Stroke, 37, Hypoxia encephalopathy, 3, Encephalitis & Meningitis, 3 | 40.9 (14.3)      | 91/22       | 50.6 (72.4) months                     | WAIS-R, RBMT, TMT                  | 40/73               | 35.4                |
| Akamine et al.    | 2015 | Japan   | Prospective cohort study | Traumatic head injury, 18, Cerebral vascular disease, 9, Brain tumor, 1, Hypoxia encephalopathy, 1 | 32.1 (10.7)      | 20/9        | 41.7 (57.1) months                     | WMS-R, WAIS-III, WCST, BADS       | 10/19               | 34.5                |

SD: standard deviation
WAIS-R (III): Wechsler Adult Intelligence Scale-Revised (III), WMS-R: Wechsler Memory Scale-Revised, RBMT: The Rivermead Behavioral Memory Test, TMT: Trail Making Test, CAT: Clinical Assessment of Attention, BADS: Behavioral Assessment of the Dysexecutive Syndrome, WCST: Wisconsin Card Sorting Test
difference was found in “digit span” (mean difference of 0.95; 95% CI [0.25, 1.65], p = 0.008), and no statistical heterogeneity was found (p = 0.12, I² = 49%; Fig. 2). Finally, there was no significant difference in “comprehension” (mean difference of 0.51; 95% CI [−0.61, 1.63], p = 0.37), and no statistical heterogeneity was found (p = 0.17, I² = 41%; Fig. 2).
4.3.2 Performance Test

Data integration from the four studies resulted in a significant difference between the employment and unemployment groups’ test scores in “picture completion” (mean difference of 1.05; 95% CI [−0.26, 2.36], \( p = 0.12 \)), and statistical heterogeneity was found (\( I^2 = 59\% \); Fig. 3). There was also a significant difference in “coding” (mean difference of 1.37; 95% CI [0.63, 2.11], \( p = 0.0003 \)), but no statistical heterogeneity was found (\( p = 0.71, I^2 = 0\% \); Fig. 3). A significant difference was found in “block design” (mean difference of 1.91; 95% CI [0.99, 2.83], \( p < 0.0001 \)); no statistical heterogeneity was found (\( p = 0.64, I^2 = 0\% \); Fig. 3). In addition, there was no significant difference in “picture arrangement” (mean difference of 1.11; 95% CI [−0.76, 2.98], \( p = 0.25 \)); statistical heterogeneity was found (\( p = 0.002, I^2 = 80\% \); Fig. 3). There was no significant difference in “object assembly” (mean difference of 0.61; 95% CI [−0.31, 1.53], \( p = 0.20 \)), and no statistical heterogeneity was found (\( p = 0.43, I^2 = 0\% \); Fig. 3). Finally, no significant publication bias was found across all tests.

5. Discussion

The useful WAIS subtest items that could predict employability of individuals with ABI included four tasks under the verbal test (“vocabulary,” “digit span,” “arithmetic,” and “similarities”) and two tasks under the performance test (“block design” and “coding”).

The “vocabulary” and “digit span” tests require one to have abilities such as working memory or continuous attention [22]; however, jobs that require employees to have considerable working memory assets can pose difficulties for ABI people in the workplace [23]. Recent studies clarified that the working memory of individuals with ABI could predict job retention two years after disability occurrence [24]. Other studies showed that 50% of ABI functional limitations are related to attention deficit, and that even typing becomes a vocational limitation in the workplace [23]. Furthermore, attention deficit has repeatedly been shown as one of the negative factors affecting employment of individuals with ABI [12, 17].

The “similarities” subtest requires abstract thinking through identification of commonalities among multiple sources of information [24]. The “block design” subtest in the perceptual reasoning index also requires abstract thinking. Sawada et al. [17] suggest that a certain decrease in abstract thinking abilities would make it difficult for an individual to cope with unknown tasks. One study shows that 73.1% of workers with ABI reported their difficulties in the workplace through the following statement: “when I face some new problems, I tend to get confused and have no idea how to cope with them” [23]. We can learn from this study that abstract thinking abilities in the workplace may significantly impact job retention. Moreover, “vocabulary” ability has been repeatedly identified as an important workplace asset where tasks such as paperwork and communication with coworkers using appropriate expressions are required to perform the job properly [14].

The “coding” subtest in the perceptual reasoning index requires one to cope with sequential tasks correctly and in a timely manner [24]. One study shows that 53.4% of workers with ABI reported that they might receive attention due to their impairments and supervisors might indicate that “their work is rather slow” [23]. This implies that sequential and systematic coping abilities are some of the key assets for retaining one’s job. “Block design,” as mentioned earlier in terms of abstract thinking, requires one to have a capacity for trial-and-error when new problem-solving skills are needed to perform challenging tasks [24]. It has also been shown that 53.4% of workers with ABI reported that “it was hard to change the working behavior accordingly when such a sudden change in my thinking and my flexible behavior is expected” [23]. For workers with ABI, limitations in their capacity for trial-and-error thinking and behavior change might negatively affect their ability to keep their jobs.

Given these cognitive requirements, test items such as “vocabulary,” “digit span,” “arithmetic,” “similarities,” “block design,” and “coding” may be related to key cognitive functions necessary for the employability of individuals with ABI. It is suggested that occupational therapists use these findings to more effectively and efficiently assess and train their patients with ABI.

The employment rate of individuals with brain injuries was 40.7% one year after injury occurrence, and 40.8% two years after injury occurrence; as such, the time elapsed after brain injury was found to have no effect on employment rate [25]. On the other hand, it has been reported that the unemployment rate increases when the support period extends long after brain injury occurrence [26]. The employment rates in the four studies examined in this paper were similar to those of previous studies, and the employment rates didn’t tend to change in the period after brain injury.

Given that the present study analyzes only Japanese papers, its generalizability is limited. Further research is needed to accumulate the results of WAIS subtest items from various countries, and to analyze these with respect to differences in social policy, welfare systems, work support programs, racial heterogeneity, test-taking culture, and other confounding factors between coun-
tries. Such differences may affect the employability of ABI patients, their performance on neuropsychological tests, and the strategies and resources they utilize to procure and retain employment. We have endeavored to begin this process with a Japanese sample, and hope that others will follow in due course. One possible reason for why we could not find English articles on the WAIS subtest items is that some Western academics have been critical about using neuropsychological test results to predict employability [27]. Rather than excluding neuropsychological test results from these considerations, it is necessary to study these in tandem with the perspectives of family members, employers, and employees.

The present study is also limited because it included the results of only four studies in its analysis. However, identifying the useful WAIS subtest items related to specific cognitive functions that predict employability of individuals with ABI has practical implications for medical and vocational rehabilitation processes. Further studies are encouraged to use these neuropsychological subtests for daily assessment and intervention when planning and developing evidence-based vocational rehabilitation programs.
rehabilitation programs for individuals with ABI.

6. Summary and Conclusions

A systematic review and meta-analysis were conducted to identify specific cognitive functions, as measured by the WAIS subtest items, that would predict work ability of individuals with ABI. As a result, we found that the cognitive functions of “working memory,” “continuous attention,” “abstract thinking,” “vocabulary and expression,” and “time series processing” were relevant for predicting employability.

In previous studies, there was no consensus on the relationship between WAIS scores and employment. Based on the results of this study, we think that the “vocabulary,” “digit span,” “arithmetic,” “similarities,” “block design,” and “coding” subtests, which test the cognitive functions specified above, are useful WAIS subtests for predicting employability. These findings can be used effectively in vocational rehabilitation to design efficient and effective work support services for individuals with ABI. Further studies are encouraged to explore the relationship between these neuropsychological subtests and employability for other populations, and to examine its potential applications in rehabilitation settings.

Conflicts of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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