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Examination of the validity and reliability of the Perceive, Recall, Plan, and Perform-long COVID (PRPP-Long COVID) self-report assessment for Thai adults with long COVID

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ABSTRACT

Background: Long COVID harms multiple aspects of occupational performance, affecting daily routines, academic pursuits, and work efficiency due to compromised physical, mental, and cognitive abilities. Notably, patients with long COVID commonly report persistent cognitive impairments.

Objectives: This study aims to adapt and evaluate the validity and reliability of the self-report assessment; the PRPP-Long COVID in Thai adults with long COVID**.**

Materials and methods: The Perceive, Recall, Plan, and Perform-Long COVID (PRPP-Long COVID) was adapted from the perceive, recall, plan, and perform (PRPP) System of Task Analysis: Thai version. This self-report assessment is used to assess the deficits of information processing capacity in individuals recovering from COVID-19. The psychometric properties of the PRPP-Long COVID were investigated, including content validity, internal consistency, and intra-rater reliability. Thirty individuals aged between 21 and 59 years had previously tested positive for COVID-19 by RT-PCR or Antigen Test Kit (ATK) and had recovered at least three months before participating in this study. All of them had an education level of at least secondary school. The PRPP-Long COVID was sent to three experts to examine for the Index of Item Objective Congruence (IOC). After that, the revised version of the PRPP-Long COVID was distributed to the participants. They were given the Google form link submission in 2 rounds, seven days apart, to test intra-rater reliability. For data analysis, descriptive statistics were utilized to calculate demographic characteristics, while the Cronbach alpha coefficient and the Intra-class Correlation Coefficients (ICCs) were used to estimate the internal consistency and intra-rater reliability of the PRPP-Long COVID, respectively.

Results: The IOC values for each question demonstrated a high level of agreement (IOC=0.67-1.00). The internal consistency of the 34 questions in the PRPP-Long COVID indicated a high level of reliability, with α=0.93. The intra-rater reliability of the PRPP-Long COVID was moderate to good (ICC=0.55-0.88).

Conclusion: The PRPP-Long COVID self-rated assessment has been determined to have acceptable validity and reliability.

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Introduction

Covid-19 is an infectious disease caused by the SARS-CoV-2 coronavirus. Recent data shows many

confirmed COVID-19 cases totaling 770,437,327, including 6,956,900 deaths. Therefore, the spread of SARS-CoV-2 has significantly impacted the world.[1] Although there are many changes in virus strains, vaccination can reduce the severity of COVID-19 symptoms. However, several studies have reported that a large number of people have persistent abnormal symptoms after COVID-19 infection, a condition known as "Long COVID".[2] Long COVID refers to a condition that can affect individuals who have previously been infected with the SARS-Co V-2 virus, have been treated, and have generally recovered for at least three months but still have persistent abnormal symptoms such as fatigue, shortness of breath, and cognitive dysfunction. These symptoms may persist for over two months and significantly interfere with daily life. The prevalence of Long COVID is more common among females than males, and individuals aged 35-49 have a higher likelihood of experiencing Long COVID.[3]

Long COVID-19 has demonstrated a multifaceted impact on various aspects of occupational performance, including activities of daily living, academic, and work efficiency, due to impairments in multiple domains such as physical, mental, and information processing.[4] Patients with Long COVID report prolonged effects on their cognitive abilities. A previous study indicated that individuals who recovered from COVID-19 at 3 and 6 months demonstrated lower attention and information processing speed scores than healthy people.[5] Another study showed that problematic information processing, verbal fluency, and executive functions are usually found during 1-3 months after experiencing COVID-19.[6,7] Moreover, after seven months, many patients show impaired memory, perception, and cognition. They are still unable to function at their prior capacities and persist with an overwhelming number of symptoms. These problems affect work performance [8] and reduce overall quality of life.

An essential role of occupational therapists in health promotion and prevention is providing services to people with long-term COVID-19 and evaluating information processing skills. This evaluation aims to plan rehabilitation programs to improve information processing abilities. In doing so, developing self-assessment tools for information processing deficits is essential for individuals with long COVID who may have problems with information processing.

At present, there are many assessment tools for evaluating cognitive strategies deficits which developed by occupational therapists such as, the assessment of motor and process skills (AMPS),[9] the executive function performance test (EFPT),[10] the cognitive performance test (CPT),[11] and the Perceive, Recall, Plan, and Perform (PRPP) system of task analysis.[12] PRPP system of task analysis is a client-centered assessment tool for individuals with cognitive difficulties. It identifies deficits in information processing strategies during task performance and guides targeted intervention.[13] The process begins with task analysis and focuses on problematic components of performance. Its strengths include adaptability to clients' preferences, systematic task breakdown, and clear identification of functional skills and deficits. Consequently, the PRPP system of task analysis is valuable for detecting performance changes and informing treatment planning.

In Thailand, the PRPP system of task analysis had been translated into a Thai-language known as the "PRPP System of Task Analysis: Thai version"[14] and then it was evaluated in various groups including patients with stroke,[15] schizophrenias,[16] and children with learning disabilities.[17] The PRPP system of task analysis was originally developed as a performance-based assessment and later adapted into questionnaire formats, such as the PRPP@SCHOOL-1 (TQ & PQ), for parent or teacher assessment of children with learning disabilities.[18] However, when relevant behaviors are not directly observable, performance-based evaluations may be limited. Self-report assessments provide direct insight into individuals' cognitive processes that may not be evident through observation alone.[19] At present, there remains a lack of a self-report assessment based on the PRPP system of task analysis for adults to determine deficits in information processing. Utilizing self-reported assessment is essential for detecting information processing difficulties among people with Long COVID, as it is highly prevalent and affects populations worldwide. The major advantage of self-report assessment is its ability to efficiently gather a vast amount of quantitative data from a large sample size without requiring significant time or financial investment. Consequently, self-report assessments are widely employed as screening instruments in epidemiological research. Moreover, information provided directly by individuals is often more accurate than proxy reports. As a result, certain problems may not be readily observable through behavior alone, yet individuals may perceive subtle changes or unusual experiences that are not immediately apparent to others.[20]

For this reason, the self-report assessment is suitable for identifying the information processing strategies dysfunction in individuals with Long COVID. Based on the points discussed earlier, the objective of this study was to adapt and evaluate the validity and reliability of the self-report assessment; the PRPP-Long COVID in Thai adults with long COVID.

Materials and methods

Study design and participants

The population includes individuals who have previously tested positive for COVID-19 by RT-PCR or Antigen Test Kit (ATK) and had recovered after at least three months. The study focuses on Thai people aged 18 to 59 years who live in Thailand and have an education level of at least secondary school. The sample consisted of 35 individuals who met the above criteria. Five individuals were in the pilot use phase, while 30 were in the internal consistency and intra-rater

reliability examination phases. The inclusion criteria were individuals who previously tested positive for COVID-19 by real-time polymerase chain reaction (RT-PCR) or Antigen Test Kit (ATK) and had recovered for at least three months, age 18 to 59 years, and possessed the ability to read the Thai language. As for exclusion criteria, these were individuals who were diagnosed with central nervous system disorders that result in impaired cognition and poor comprehension, such as cerebrovascular disease, dementia, or traumatic brain injury. Furthermore, this includes those who were diagnosed with psychiatric disorders such as mood disorders, psychotic disorders, or other mental illnesses, and were diagnosed with a substance use disorder that affects the nervous system.

Instrument

The Perceive, Recall, Plan and Perform-Long COVID (PRPP-Long COVID) was adapted from the Perceive, Recall, Plan, and Perform (PRPP) System of Task Analysis: Thai version,[14] a criterion-referenced, performance-based, client-centered assessment designed to assess the effectiveness of information processing strategies patients used in their daily activities. It consists of two stage of analysis. Stage One utilizes standard behavioral task analysis to determine the individual's mastery in specific occupations, and Stage Two Analysis is founded on a preliminary model of human behavior information processing established by Romiszowski.[12] This is necessary to explain the cognitive processes that underlie task performance and the cognitive strategies employed in complex situations. The PRPP system of task analysis comprises four quadrants - perceive, recall, plan, and perform (Figure 1) - each subdivided into three sub-quadrants and 34 information processing strategies ("descriptors"). Observers rate performance using a three-point Likert scale to identify abilities and deficits based on effective task execution.[12] The assessment employs standardized terminology, evaluation procedures, and scoring, with established validity and reliability across diverse populations,[14,21-27] including individuals with traumatic brain injury,[14,23,26] schizophrenia,[21] early psychosis,[27] HIV-associated neurocognitive disorder,[28] and learning disabilities.[22] The Thai version of the PRPP System of Task Analysis was translated from the original instrument and demonstrated high test-retest and inter-rater reliability in Thai patients with acquired brain injury,[14] and has since been applied in patients with stroke,[15] schizophrenia,[16] and children with learning disabilities.[17]

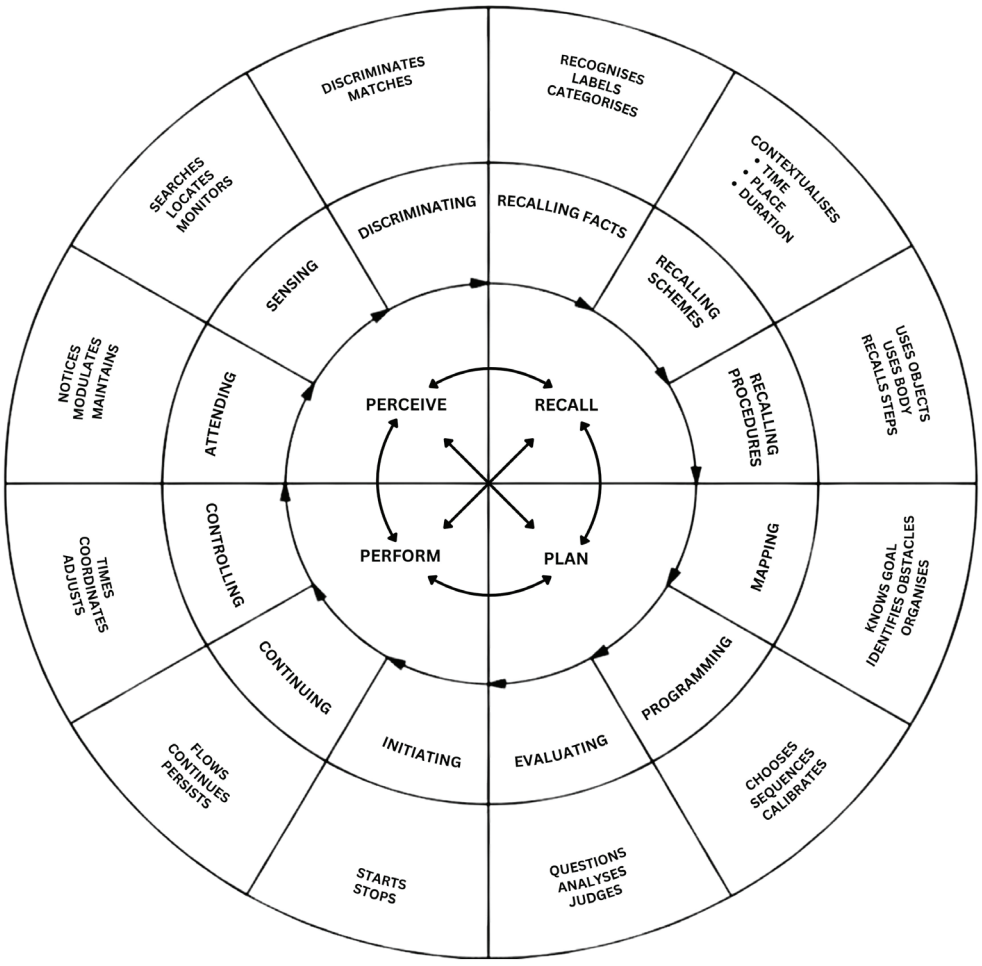


Figure 1*. The PRPP system of task analysis (Stage Two) conceptual model.*[12]

Phase 1: Modification and content validity

Modification of Perceive, Recall, Plan and Perform-long COVID (PRPP-Long COVID)

The modification entailed changing the wording to conform to the self-rating structure based on the PRPP System of Task Analysis's content, as reviewed by two experts who are lecturers in the field of occupational therapy. Additionally, the PRPP-Long COVID utilizes a Likert scale to assess the frequency of behavioral problems, which is rated on a scale of 0 to 4 (0 = never, 1 = rarely, 2 = sometimes, 3 = often, 4 = very often). The Likert scale is a reliable and valid method for quantifying abstract thoughts, feelings, and actions.[29] The frequency of problematic behavior was chosen by the researcher as the measuring scale to represent the degree of difficulty. A higher total score indicates a more self-perceived information processing dysfunction.

Content validity and pilot use

The researcher evaluated the content validity of the PRPP-Long COVID through the Index of Item Objective Congruence (IOC) method with the agreement of three experts who possess extensive experience in utilizing the PRPP system of task analysis. These experts considered it unambiguous and consistent with the intended objectives of the assessment. After that, 5 participants were asked to rate themselves using the PRPP-Long COVID to evaluate comprehension and clarity in the questions. Consequently, the final version of the PRPP-Long COVID was obtained.

Phase 2: Examination of internal consistency and Intra-rater reliability

Participants

Thirty eligible individuals with long COVID participated in the internal consistency and intra-rater reliability phases. The sample size was calculated using the R statistical package to estimate the intra-class correlation coefficient (ICC) with a 95% confidence interval width (CIW) of 0.05 and an estimate of 0.85. [30]

Internal consistency

The final version of the PRPP-Long COVID was used to assess 30 participants via the Google form channel. The scores of the self-rating assessment were determined by the internal consistency using Cronbach's alpha coefficient statistic.

Intra-rater reliability

Thirty participants were assessed by the PRPP-Long COVID twice via a Google form. The time interval for rating scores between the first and second times was seven days to reason the effect of recall bias.[31] The scores from the first and second assessments were analyzed to determine intra-rater reliability.

Statistical analysis

SPSS for Windows (version 17.0; SPSS Inc, Chicago, IL) was used for all statistical analyses. Descriptive statistics were used to calculate demographic characteristics, and the Cronbach alpha coefficient was used to estimate the internal consistency. Intra-class correlation coefficients (ICCs) using the ICC (3,1) model (two-way mixed-effects, single measurement) were utilized to determine the intra-rater reliability of the PRPP-Long COVID.

Ethical considerations

This research project has been sanctioned by the Human Research Ethics Committee of Mahidol University, as evidenced by document number COE No.MU-CIRB 2023/035.2002, granted in February 2023. The researcher ensured the protection of the rights of the participants, and the data collected from the sample were kept confidential. They were not utilized to identify individual respondents specifically, as all answers were incorporated into the overall research analysis.

Results

Content validity and pilot use

IOC values for each question demonstrate a high level of agreement (IOC=0.67-1.00). This indicates that every question in the self-assessment tool for cognitive impairment in adults with long COVID aligns well with the intended objectives of the evaluation. The results are shown in Table 1. Moreover, the pilot use process showed that the sample group demonstrated high satisfaction with the clarity and comprehensibility of the questions and the scoring criteria.

Table 1. Index of Item Objective Congruence (IOC) of the PRPP-Long COVID (N=30).

PRPP-Long COVID	Item	IOC	PRPP-Long COVID	Item	IOC
Perceive quadrant			*Recall quadrant*		
Attending sub-quadrant			Recalling Facts sub-quadrant		
Notices	Item 1	1	Recognizes	Item 9	1
Modulates	Item 2	1*	Labels	Item 10	1
Maintains	Item 3	1	Categories	Item 11	1
Sensing sub-quadrant			Recalling schemes sub-quadrant		
Searches	Item 4	1	Contextualizes to time	Item 12	1
Locates	Item 5	0.67	Contextualizes to place	Item 13	1
Monitors	Item 6	1*	Contextualizes to duration	Item 14	1
Discriminating sub-quadrant			Recalling procedures sub-quadrant		
Discrimination	Item 7		Uses objects	Item 15	0.67
Matches	Item 8		Uses body	Item 16	1
			Recalls steps	Item 17	1*
Plan quadrant			*Perform quadrant*		
Mapping sub-quadrant			Initiating sub-quadrant		
Knows goal	Item 18	1	Starts	Item 27	0.67
Identifies obstacles	Item 19	1	Stops	Item 28	1
Organizes	Item 20	0.67			
Programming sub-quadrant			Continuing sub-quadrant		
Chooses	Item 21	1	Flows	Item 29	1
Sequences	Item 22	0.67	Continues	Item 30	1
Calibrates	Item 23	1	Persists	Item 31	1
Evaluating sub-quadrant			Controlling sub-quadrant		
Questions	Item 24	1*	Times	Item 32	0.67
Analyzes	Item 25	0.67	Coordinates	Item 33	1*
Judges	Item 26	1*	Adjusts	Item 34	1

Note: *The IOC value has been adjusted according to experts' recommendations.

The characteristics of the participants are presented in Table 2. The participants were 30 individuals who were infected with COVID-19. Of these, 7 were male (23.30%) and 23 were female (76.70%). The mean age of the sample was 29.30 (SD=9.85, range=21-59). The mean period after infection with COVID-19 was 3.30 months (SD=0.54, range=3-5). Most participants held a bachelor's degree (80.00%).

Table 2. Demographic characteristics (N=30).

Characteristics	Participants	Percentage
Sex		
Female	23	76.70
Male	7	23.30
Education		
Secondary Education	2	6.70
Bachelor's Degree	24	80.00
Master's Degree	4	13.30
	Mean (SD)	**Range**
Age (years)	29.30 (9.85)	21-59
The period after being infected with COVID-19 (months)	3.30 (0.54)	3-5

The internal consistency of the 34 items of the PRPP-Long COVID was evaluated using Cronbach's alpha. The results indicated a high level of reliability, with α=0.93. Furthermore, Cronbach's alpha values for each quadrant (Perceive, Recall, Plan, and Perform) were found to be at a moderate to high level of reliability,[32] ranging from 0.70 to 0.86. These findings are presented in Table 3.

Table 3. Internal consistencies of the PRPP-Long COVID (N=30).

Internal consistencies	Cronbach's alpha
Perceive	0.70
Recall	0.78
Plan	0.86
Perform	0.80
All Items	**0.93**

The intra-rater reliability of the PRPP-Long COVID was determined using the intraclass correlation coefficients (ICC), and the results indicate moderate to good reliability for quadrant (ICC=0.75-0.86), moderate to good reliability for sub-quadrant (ICC=0.63-0.84), and moderate to good reliability for items (ICC=0.55-0.88). Specifically, items 27 which are flow descriptors showed the highest reliability (ICC=0.88), while items 1, 24 exhibited showed the lowest reliability (ICC=0.55). Overall, the findings suggest that the PRPP-Long COVID has acceptable intra-rater reliability as shown in Table 4.

Table 4. Intra-rater reliability of the PRPP-Long COVID (N=30).

ITEMS	ICC ICC (2,1) (95% CI)	95% CI	ITEMS	ICC ICC (2,1) (95% CI)	95% CI
Perceive quadrant	0.86	0.70-0.93	***Recall quadrant***	0.82	0.62-0.92
Attending sub-quadrant	0.84	0.66-0.92	Recalling facts sub-quadrant	0.81	0.61-0.91
Item 1	0.55	0.06-0.79	Item 9	0.64	0.24-0.83
Item 2	0.73	0.44-0.87	Item 10	0.87	0.73-0.94
Item 3	0.86	0.70-0.93	Item 11	0.79	0.55-0.90
Sensing sub-quadrant	0.77	0.52-0.90	Recalling schemes sub-quadrant	0.76	0.49-0.89
Item 4	0.77	0.50-0.89	Item 12	0.68	0.32-0.85
Item 5	0.81	0.61-0.91	Item 13	0.60	0.15-0.81
Item 6	0.58	0.14-0.80	Item 14	0.65	0.26-0.83
Discriminating sub-quadrant	0.81	0.59-0.91	Recalling procedures sub-quadrant	0.83	0.65-0.92
Item 7	0.66	0.29-0.84	Item1 5	0.62	0.18-0.82
Item 8	0.85	0.69-0.93	Item 16	0.75	0.48-0.88
			Item 17	0.71	0.39-0.86

Table 4. Intra-rater reliability of the PRPP-Long COVID (N=30) (continued).

ITEMS	ICC ICC (2,1) (95% CI)	95% CI	ITEMS	ICC ICC (2,1) (95% CI)	95% CI
Plan quadrant	0.77	0.52-0.89	***Perform quadrant***	0.75	0.47-0.88
Mapping sub-quadrant	0.80	0.58-0.91	Initiating sub-quadrant	0.83	0.65-0.92
Item 18	0.64	0.23-0.83	Item 27	0.88	0.74-0.94
Item 19	0.75	0.47-0.88	Item 28	0.75	0.47-0.88
Item 20	0.82	0.62-0.91	Continuing sub-quadrant	0.76	0.50-0.88
Programming sub-quadrant	0.75	0.48-0.88	Item 29	0.68	0.33-0.85
Item 21	0.70	0.37-0.86	Item 30	0.73	0.42-0.87
Item 22	0.66	0.29-0.83	Item 31	0.67	0.30-0.84
Item 23	0.57	0.09-0.80	Controlling sub-quadrant	0.63	0.22-0.83
Evaluating sub-quadrant	0.67	0.33-0.84	Item 32	0.58	0.10-0.80
Item 24	0.55	0.08-0.78	Item 33	0.64	0.23-0.83
Item 25	0.62	0.22-0.82	Item 34	0.66	0.29-0.84
Item 26	0.68	0.34-0.85			

Discussion

In this study, we focused on examining the psychometric properties of the PRPP-Long COVID, which was modified from the perceive, recall, plan, and perform (PRPP) system of task analysis: Thai version. The results revealed that the PRPP-Long COVID had acceptable validity and reliability. As for content validity, the index of item objective congruence (IOC) from 3 experts showed that all items had a high value of IOC (Table 1). This indicates that the PRPP-Long COVID can identify various cognitive strategic problems in individuals with Long COVID and also reveals difficulties regarding principles of information processing theory and the fundamental strategy application model developed for the PRPP System of Task Analysis.[12] This study placed special emphasis on identifying the information processing strategies needed for effectively carrying out daily activities in adulthood, particularly with regard to education or work. A previous study of the effects of Long COVID on cognitive function found that long COVID influenced memory loss, especially short-term memory. Additionally, it can lead to difficulties in attention, overall thinking, executive functioning, and problem-solving. Furthermore, it can affect the speed of thought, cause confusion, and even cause agnosia. In adulthood, there are levels of symptoms ranging from mild to severe in equal proportions. This condition has the greatest impact on work function. In addition, it affects other lifestyle activities that require advanced and complex processing, including making serious decisions, communicating thoughts, having conversations with others, and driving.[8]

In terms of internal consistency investigation, the Cronbach's alpha coefficients among the 34 items in each quadrant were high (Table 3). This finding aligns with previous studies, which examined the internal consistency of the PRPP System of Task Analysis. For example, a study by Van Keulen-Rouweler *et al*.[33] assessed the ability to perform occupation and information processing skills in elderly Parkinson's patients or students with learning difficulties using the methods of Lowe.[18] This study demonstrated a high level of internal consistency in the PRPP assessment. Therefore, the results confirm the homogeneity of items in the PRPP quadrants and sub-quadrants that involve the problematic informational processing strategies in people with Long COVID.

For intra-rater reliability examination, the results revealed a significantly moderate to high correlation (See Table 4). Several factors have contributed to the stability of the PRPP-Long COVID. Firstly, there is the clarity and simplicity in the item wording, eliminating any potential confusion for the respondents. Secondly, the contents of PRPP-Long COVID were created based on symptoms commonly associated with impaired information processing in individuals who had COVID-19, drawing from a thorough analysis of past research.[8] As a result, all inquiries about items are related to the level of difficulty in information processing during daily activities in adulthood. These are supported by Streiner *et al*.[34] who argue that the reliability of the questionnaire or self-rating assessment depends on the interface between the instrument, the specific group of respondents, and the situation at hand. The PRPP-Long COVID had a high degree of interface with respondents (individuals who had Long COVID) and the situation (strategies used to perform complex and advanced skilled activities in adulthood).[34] Therefore, this contributed to acceptable reliability in the participants in this study. Finally, the intra-rater interval of 7 days was deemed suitable, as many researchers have selected a range of 2 days to 2 weeks.

It is generally accepted that this duration provides an adequate compromise between unexpected clinical change and recall bias.[35]

These findings align with the study by Aubin *et al*. which employed the PRPP assessment to examine the information processing deficits experienced by schizophrenia patients during both simple and complex cooking tasks.[36] They assessed the intra-rater reliability of the PRPP assessment by evaluating the participants' performance on the task. The results revealed that the total score of the PRPP assessment demonstrated a high degree of intra-rater reliability. However, the intra-rater reliability of each quadrant of the assessment showed a moderate value. Likewise, in the study by Lindenschot *et al*., the intra-rater reliability of the PRPP assessment was investigated in children with mitochondrial disease, revealing a high reliability.[37] Furthermore, the result of the present study also utilized the PRPP Questionnaire, which applied the PRPP@SCHOOL-1 to children with learning difficulties.[18] The contents of the PRPP@SCHOOL-1 are consistent with the problematic information processing identified in children with learning disabilities when they participate in naturalistic contexts, including home and school. In this study, the investigators examined the test-retest reliability of the PRPP@SCHOOL-1 parent questionnaire version. Therefore, we confirm that the PRPP-Long COVID is reliable and consistent for application for adult Thais with Long COVID. In clinical practice, it is crucial to recognize that when information processing deficits are identified, the information obtained can be utilized to receive occupational therapy rehabilitation services that involve analyzing and synthesizing activities aimed at restoring cognitive skills that are appropriate and consistent with the individual's information processing impairments, with the ultimate goal of regaining the ability to perform practical daily activities. In addition, the PRPP-Long COVID can be modified and utilized as a multidisciplinary professional guide for evaluation and intervention planning.

Limitations

This study has some limitations. The first is the distribution of the participants. In this study, most participants were female in early adulthood. Differences in biological mechanisms between males and females, as well as variations in health perception and symptom reporting, may have influenced the study outcomes. Future studies should involve participants with a more balanced proportion of genders and ages. The second limitation is the period after recovery from COVID-19 infection. Previous research has found that Long COVID can occur up to 6-9 months after recovery from COVID-19 infection. However, in the present study, the period after recovery from COVID-19 was found to be within 3-5 months. Therefore, future studies should involve participants who cover the period after recovery from coronavirus infection at 3-9 months to gain a more comprehensive understanding of information processing problems in people with Long COVID. Lastly, the lack of information regarding the symptoms and severity of COVID-19 infections, as well as the use of medication and treatment modalities, may significantly impact the degree of information processing disorder. Therefore, future studies should consider these factors more thoroughly to better understand the relationship between COVID-19 and information processing disorders.

Conclusion

The findings from this study demonstrated that the Perceive, Recall, Plan, and Perform (PRPP) in adults with Long COVID (PRPP-Long COVID) has acceptable psychometric properties, including content validity, internal consistency, and intra-rater reliability. This suggests that the PRPP-Long COVID is appropriate for evaluating information processing impairment in individuals with Long-COVID in the Thai context. If the self-report assessment reveals problematic information processing, it can help individuals recognize their abilities and facilitate access to specialized treatment. In addition, the assessment can serve as an outcome measure for planning occupational therapy interventions aimed at improving occupational performance.

Future direction and clinical implementation

Future research should further examine the PRPP-Long COVID across larger and more diverse populations who experience information processing impairments. Longitudinal studies could explore its predictive value for functional recovery and quality of life among individuals with Long COVID. Clinically, the PRPP-Long COVID can be integrated into occupational therapy practice as both a screening and outcome measure for cognitive information-processing deficits. Its use can guide personalized intervention planning, monitor progress, and enhance communication among multidisciplinary rehabilitation teams in managing cognitive sequelae of Long COVID.

Ethical approval

The study adhered to the ethical standards of the Declaration of Helsinki and complied with all relevant institutional and national guidelines for human research. Ethical approval was obtained from the Human Research Ethics Committee of Mahidol University (COE No.MU-CIRB 2023/035.2002). All participants were informed of the study's objectives and procedures, provided written consent prior to participation, and were free to withdraw at any time without any consequences.

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Conflict of interest

The authors declare no conflicts of interest related to the research, authorship, or publication of this article.

CRediT authorship contribution statement

Sutinun Juntorn: conceptualization, methodology, data curation, formal analysis, writing: original draft, supervision, project administration; **Peeraya Munkhetvit:** conceptualization, methodology, data curation, formal analysis, writing: original draft, supervision, project administration, correspondence; **Peeradech Thichanpiang:** writing: review and edit; **Thitiya Wangkawan:** data curation; **Pawared Ontong:** data curation.

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Appendix

PRPP-Long COVID	Item
Perceive quadrant	
Notices	1. Do you neglect incoming stimuli and/or react more slowly than usual to incoming stimuli, for example, by not noticing lights flashing or reacting more slowly to different warning sounds?
Modulates	2. Do you have difficulty to shift your attention from one point to another?
Maintains	3. Do you have difficulty maintaining interest in completing activities?
Searches	4. Do you have difficulty finding things by sight, hearing, smell, or touch?
Locates	5. Do you have difficulty telling the location of objects or equipment that are needed during activities?
Monitors	6. Have you neglected the changes in stimuli that occur during activities, e.g., not noticing a kettle boiling?
Discrimination	7. Do you find it difficult to distinguish between similar objects, e.g., a 1 Baht coin and a 2 Baht coin?
Matches	8. Do you find it difficult to match objects, e.g., socks, chopsticks, spoons, and forks?
Recall quadrant	
Recognizes	9. Do you have difficulty remembering familiar sounds, smells, feelings, signs, and names of people or places?
Labels	10. Do you find naming familiar people, objects, and places difficult?
Categories	11. Do you find it difficult to group objects with the same function, e.g., kitchen utensils, stationery, or things in the same group, such as flowers, animals, etc.?
Contextualizes to time	12. Do you often forget when you must do that activity?
Contextualizes to place	13. Do you often forget where you must do certain activities?
Contextualizes to duration	14. Do you often spend time doing activities too quickly, causing errors, or too slowly, causing the work to be finished beyond schedule?
Uses Objects	15. Do you often make mistakes when using complex tools, e.g., electronic devices? Electrical appliances or programs in the computer?
Uses Body	16. Do you feel like you have clumsy body movements or difficulty using your body parts to work effectively, e.g., typing on the keyboard more slowly or having poor picking up things?
Recalls Steps	17. Do you not remember the steps in doing activities as well as before?

PRPP-Long COVID	Item
Plan quadrant	
Knows Goal	18. Do you feel that you have no goals in your activities or are neglecting your work goals?
Identifies Obstacles	19. Do you often ignore or are you unaware that there are obstacles to your activities?
Organizes	20. Do you have difficulty organizing things to suit the space and make it convenient for activities?
Chooses	21. Do you have difficulty choosing parts of the body or objects and equipment that are appropriate for your activities?
Sequences	22. Do you find it difficult to perform activities correctly according to the steps and continuously change actions without interruption?
Calibrates	23. Do you find it difficult to adapt, increase, or decrease the speed or force of your movements to the situation?
Questions	24. Do you neglect or not ask questions when problems arise during activities?
Analyzes	25. Do you have difficulty finding, identifying problems, and analyzing solutions to deal with obstacles while doing activities?
Judges	26. Do you have difficulty deciding on a plan or method, including using substitute materials and equipment to solve immediate problems, or have you decided to choose an inappropriate solution?
Perform quadrant	
Starts	27. Do you slow to start unfamiliar activities or hesitant to start them?
Stops	28. Can you not stop doing the activity even when you have completed all the steps, or regularly finish an activity even though it has not yet been completed?
Flows	29. Do you often perform activities inconsistently or stumble intermittently in each step?
Continues	30. Do you have difficulty completing activities consistently within the given time frame?
Persists	31. Do you often give up when obstacles arise?
Times	32. Do you find it difficult to adjust the speed of your movements to suit the activity?
Coordinates	33. Do you often have problems with movement and a lack of precision in activities that require precision, such as writing, sports, or music?
Adjusts	34. Do you have difficulty adjusting your movements to suit the activity?