



**BSc in Psychology**  
**Department of Psychology**

**Cancer-related Cognitive Impairment and  
Sleep Problems in Treatment-naïve Cancer  
Patients**

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## **Foreword**

Submitted in partial fulfillment of the requirements of the BSc Psychology degree, Reykjavik University, this thesis is presented in the style of an article for submission to a peer-reviewed journal.

This thesis was completed in the Spring of 2022 and may therefore have been significantly impacted by the COVID-19 pandemic. The thesis and its findings should be viewed in light of that.

### Abstract

Studies have shown that treatment-naïve breast cancer (BC) patients have shown cancer-related cognitive impairment (CRCI) and sleep problems. In the current study, a subgroup of women with treatment-naïve breast cancer (N = 30) were randomly selected from a larger sample, to compare differences in sleep quality and cognition to healthy controls (HC) (N = 10). The Pittsburgh Sleep Quality Index was used to measure sleep quality. The Trail making test and Psychomotor Vigilance Test was used to measure cognitive function. The PROMIS cognitive function and abilities was used to measure subjective cognitive function. Chi-square analysis was used to analyze the demographic variables (age, marital status and education). The Independent t-test was used in order to measure difference between groups. Pearson correlation coefficient was used to examine the association between sleep quality and cognitive function. The hypothesis posed by this study are (1) Treatment-naïve BC patients, have poorer sleep quality compared to HC, (2) Treatment-naïve BC patients, have worse cognitive function compared to HC, and (3) Treatment-naïve BC patients with sleep problems have worse cognitive function compared to treatment-naïve BC patients without sleep problems. Hypothesis (1), (2) and (3) were not supported, as the results from independent t-test found no significant difference.

*Keywords:* Breast cancer, Cognition, Cancer-related Cognitive impairment, Sleep problems, Sleep quality

### Útdráttur

Fyrri rannsóknir hafa sýnt að meðferðarlausir brjóstakrabbameinssjúklingar hafa sýnt krabbameinstengdenn hugrænann vanda (CRCI) og svefnavandamál. Í þessari rannsókn var hópur kvenna með brjóstakrabbamein (BC) sem hafði aldrei áður fengið meðferð (N = 30) valin af handahófi úr stærra úratki til að bera saman mun á svefngæðum og hugræna virkni við viðmiðunarhóp (HC) (N = 10). Svefngæðakvarðinn (PSQI) var notaður til að mæla huglæg svefngæði. Slóðaprófið (TMT) og Psychomotor Vigilance Test (PVT) voru notuð til að mæla hugræna virkni. PROMIS cognitive function og abilities var notaður til að mæla huglæga hugræna virkni. Kí-kvaðrat próf var notað til að greina lýðfræðilegar breytur (aldur, hjúskaparstöðu og menntun). Óháð t-próf var notað til að mæla mun á milli hópa. Pearson fylgnistuðull var notaður til að skoða tengsl milli svefngæða og hugræna virkni. Tilgáturarnar sem þessi rannsókn setur fram eru (1) Konur með BC, sem hafa ekki verið í meðferð, hafa verri svefngæði samanborið við HC, (2) Konur með BC, sem hafa ekki áður fengið meðferð, hafa verri hugræna virkni samanborið við HC og (3) BC sjúklingar með léleg svefngæði hafa verri hugræna virkni samanborið við BC sjúklinga með góð svefngæði. Tilgáta (1), (2) og (3) voru ekki studdar, þar sem niðurstöður úr óháðu t-prófunum fundu engan marktækan mun.

*Lykilorð:* Brjóstakrabbamein, Hugræn virkni, Krabbameinstengdur hugrænn vandi, Svefn vandamál, Svefngæði

### **Cancer-related Cognitive Impairment and Sleep Problems in Treatment-naïve Breast Cancer Patients**

Breast cancer (BC) is one of the most common cancers among women in the world (Ferlay et al., 2015). It was estimated that there were around 2.3 million new cases (11,7 percent) in the year 2020, and therefore breast cancer has become the most frequently diagnosed cancer worldwide, followed by lung cancer (11,4 percent) (Sung et al., 2021). On average, 239 women are diagnosed with breast cancer every year and 47 women die of breast cancer on average every year, in Iceland (Brjóstakrabbamein, e.d). The 5 year relative survival for breast cancer in Iceland is approximately 88% (Brjóstakrabbamein, e.d). Breast cancer can be treated in a variety of ways (Sharma et al., 2010). Generally, the first and most frequently used treatment in Iceland is the BC surgery (Brjóstakrabbamein, e.d). BC surgery is where the doctors remove cancerous tissue from the body surgically (Sharma et al., 2010). Following breast cancer surgery, doctors frequently use chemotherapy (Sharma et al., 2010). Life prospects after breast cancer diagnosis have substantially improved in recent years, and early detection has played a significant role in this development (Jørgensen & Bewley, 2015). Earlier breast cancer research has placed a greater emphasis on the biological side-effects, while psychologic side-effects have received less attention. With the increased survival rate of BC patients, the focus towards the psychological side effects has been of greater concern, as many BC survivors have reported that the psychological side effects they experienced during treatment, have been found to continue to affect them years after treatment (Palesh et al., 2018; Koppelmans et al., 2012). These side effects are cancer-related cognitive impairment (CRCI), sleep problems and fatigue, to name a few (Palesh et al., 2018; Fontes et al., 2017; Schmidt et al., 2016; Koppelmans et al., 2012).

When compared to healthy controls, BC patients have higher rate of sleep problems (Savard et al., 2009) and pre-existing sleep problems may worsen following a breast cancer

diagnosis and treatments (Savard et al., 2001). Studies have also found that BC patients have sleep problems at baseline, prior to any treatment (Fontes et al., 2017). One of the commonly known sleep problems is poor sleep quality. A prospective cohort study found that 36 percent of patients reported poor sleep prior to chemotherapy. Poor quality sleepers increased up to 58 percent during chemotherapy, and decreased to 32.1 percent after completion of chemotherapy (Fakih et al., 2018). However, the study included a small sample size, which makes it harder to generalize the results, furthermore, they did not compare the patients with healthy controls. A prospective study by Fontes et al. (2017), with 502 patients who had been newly diagnosed with breast cancer, found that during baseline, before any cancer treatment, 60.2 percent of the patients had poor sleep quality. A one-year follow-up after baseline revealed that 47.2 percent of patients had decreased sleep quality (Fontes et al., 2017). Findings have indicated that poor sleep quality may be associated with an increased the risk of BC progression among patients (Liang et al., 2019). Furthermore, it has been put forward that sleep quality is a predictor of self-reported cognitive impairment. This only applies to certain components of sleep quality (daytime dysfunction, sleep efficiency and sleep disturbance) (Henneghan et al., 2018). Circadian rhythm has also been found to be linked to changes in cognitive abilities (Foster & Kreitzman, 2014).

CRCI is one of the most distressing and commonly reported side effects among breast cancer patients (Schmidt et al., 2016). Research has shown that the cognitive domains that breast cancer and its treatment has most commonly an effect on are; memory (long-term, short-term and working memory), attention, processing speed, and concentration (Lange et al., 2020; Ono et al., 2015). Research has found cognitive impairment among survivors up to 20 years after treatment (Koppelmans et al., 2012). The prevalence of CRCI is high, these problems have been identified in as much 75% of breast cancer patients. However, the prevalence can vary between timepoints, before chemotherapy (30%), during chemotherapy

(75%) and after completion of treatment (35%) (Janelins et al., 2014). Wefel et al. (2004) found that 33% of BC patients, prior to undergoing BC treatment, had cognitive impairment (Wefel et al., 2004). Furthermore, a prospective study, where they studied treatment-naïve breast cancer patients, discovered that during baseline, 28% of BC patients had cognitive impairment, compared to 8% of healthy controls (Lange et al., 2020). Despite that BC patients have shown CRCI during baseline, before any treatment (Fontes et al., 2017; Lange et al., 2020), previous studies have mostly focused on CRCI in relation to chemotherapy, and as a result, it has been commonly known as “chemo brain” (Hermelink, 2015; Fakhri et al., 2018; Mounier et al., 2020).

Sleep problems and CRCI can have a significant impact on the BC patients quality of life and the capacity to function in everyday life (Fortner et al., 2002; Von et al., 2013). Poor sleep quality has been found to have an effect on breast cancer patients mental health, as well as being associated with increased pain and decreased energy (Fortner et al., 2022). cRCI has been found to impact social relationships, self-confidence, and the ability to return to their daily activities. CRCI and poor sleep quality, before surgery, and any treatment, have not been sufficiently studied. Early detection in relation to sleep problems and CRCI is of great importance, as it would give the BC patients a chance to improve their sleep with the help of professionals, before surgery and any treatment, as well as possibly minimize or prevent cognitive impairment. The hypothesis posed by this study are (1) Treatment-naïve BC patients, have poorer sleep quality compared to HC, (2) Treatment-naïve BC patients, have worse cognitive function compared to HC, and (3) Treatment-naïve BC patients with sleep problems have worse cognitive function compared to treatment-naïve BC patients without sleep problems.

## **Method**

### **Participants**

The current study randomly selected 30 BC, after making sure that they had completed the cognitive tests prior to their surgery date, and 11 HC, from a larger ongoing study. The HC participants were randomly drawn from an ongoing study, Trauma, mental health and disclosure of sexual violence, with no history of cancer. Exclusion criteria for BC patients and HC was if they were under the age of 18 years; pregnant; pre-existing anaemia; history of bipolar/mania disease and unable to read or understand Icelandic. Participants were informed that they were under no obligation to participate in the study and that they could withdraw at any time. The participants received no compensation or reward for their participation. During data analysis, box plot was used and an outlier among HC participants was discovered and removed from the data, therefore the final number of participants in HC was  $N = 10$ . Details of the characteristics regarding the demographic variables are shown in Table 1, for both BC and HC. The participants were divided into age groups, where the age range from 55-64 was most common among BC with 42.9% ( $N = 6$ ). Most common age range among the HC was 55-64 with 30.0% ( $N = 3$ ) and 65-74 with 30.0% ( $N = 3$ ). Mean age of the participants was  $M = 59.42$  ( $SD = 11.82$ ). Among BC, 39% ( $N = 16$ ) did not state their age, and was therefore defined as „missing“ in the SPSS analysis. As seen in Table 1, majority of BC 70% ( $N = 21$ ) participants were in relationship or married as well as 70.0% ( $N = 7$ ) of HC participants. Most common level of education for both groups was „University, where BC had 43.3% ( $N = 13$ ), and HC had 60.0% ( $N = 6$ ), of the participants.

## **Materials**

**The Pittsburgh Sleep Quality Index (PSQI).** Subjective sleep quality was assessed with The Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989). PSQI has been found to be reliable, valid and a standardized measure of subjective sleep quality. PSQI is a self-report questionnaire that evaluates overall sleep quality and sleep disturbances over a one month interval (Buyssey et al., 1989). PSQI consists of 19 self-reported questions. The 19

individual questions make seven component scores; subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction (Buyssey et al., 1989). Each component has 0 to 3 points, where a score of “0” implies no difficulty, whereas a score of “3” indicates extreme difficulty. These seven component scores are then added together to produce a global PSQI score, which ranges from 0 to 21, with a cut off point of 5. Scores higher than the cut-off point 5 indicate poor sleep (Buyssey et al., 1989). An Icelandic translation of the PSQI, by Jakob Smári and Edda Björk Þórðardóttir, was used in this current student, with the Cronbach’s  $\alpha = 0.82$  (Þórðardóttir, 2016).

**PROMIS cognitive function and abilities 8a.** Subjective cognitive function was assessed with PROMIS cognitive function and abilities 8a. The questionnaire is composed of eight items, where each of the items are rated on a five point Likert scale which ranges from “never” or “not at all” to “very often (several times a day)” or very much” throughout the last seven days (Lai et al., 2014). Higher scores indicated greater subjective cognitive function. By combining the responses of participants to each item, a total raw score ranging from zero to forty is computed. After that, the entire raw score is converted to a T-score metric with a mean of fifty and standard deviation of ten (HealthMeasures, 2018). The test has high internal consistency with Cronbach  $\alpha = 0.97$  (Becker et al., 2014).

**Psychomotor Vigilance Test (PVT).** The Psychomotor Vigilance Test is a neuropsychological assessment. The test measures alertness and vigilant attention by recording response time. A yellow stimulus counter appears inside a rectangular box on the computer screen (Dorrian et al., 2004). The visual stimuli is at random inter-stimulus intervals, which changes from 2 to 10 seconds at random. The counter stops and presents the reaction time in milliseconds as soon as the participants responds and is displayed for 1 second. A valid response was if the PVT response was equal to or greater than 100 ms, and

response which was less than 100 ms were considered as false starts (errors of commission).

An exclusion from the analysis was if the participants pressed the incorrect button or not releasing the button within 3 seconds. The performance measures assessed and used in this current study were; Response Speed (mean 1/RT), Lapses (Number of lapses) (Basner et al., 2011). The task had a time limit of 5 minutes (Roach et al., 2006).

**The Computerized Trail-Making Test (C-TMT).** The Trail-Making Test is a neuropsychological assessment. The C-TMT includes two parts, part-A and part-B. Where part-A measures visual search and psychomotor speed and part-B measures divided attention, cognitive flexibility and working memory (Kortte et al., 2002). TMT-A consists of 25 randomly assigned circled numbers from 1-25. TMT-B consists of both number and letters, randomly assigned, where the participants choose the numbers in correct numerical order, and the letters in correct alphabetical order (1, A, 2, B etc.) (Bowie & Harvey, 2006). The score for part A and B are separate. The primary outcome measure from C-TMT is the direct score, which is the total time to complete each part (A and B), as well as any additional error times (Christidi et al., 2015).

## **Procedure**

BC patients, who were scheduled to receive surgery, were introduced to the study through the nurses at the University Hospital. BC patients interested in participating would sign a form authorizing the research team to contact them. Due to COVID, the data collection from the parent study was exclusively online. The data was collected via REDCap. The participants would receive an email with a REDCap link, where they would sign the consent form. While answering the questionnaire on REDCap, the possibility of unpleasant thoughts and feelings might have surfaced. The participants were offered the opportunity to speak with a psychologist once for free. Each participant was assigned their own participant number that was connected to REDCap. By submitting REDCap, participants were automatically

transferred and logged in to the website through their participant number, where the computerized cognitive test and questionnaires were located. The tests were only available between 8:00-20:00 o'clock, this is due to the effect the biological clocks can have on cognitive abilities (Foster & Kreitzman, 2014). The BC participants had to take part in the study before BC surgery.

Participants got instructions regarding the neuropsychological tests before participating. Participants had to react in PVT by pushing a button as quickly and accurately as possible. Before participating in the C-TMT, the participants had a practice session for each test (parts A and B), after which they were given the choice to take one more practice session or move on to the main TMT task. The participants were instructed to press the circled numbers, with their computer mouse, in correct numerical order (1,2,3, etc.) as fast and accurately as possible.

### **Study design**

The present study is a sub-study from a larger ongoing study, which was authorized by the National Bioethics Committee (Permission from the Data Protection Authority and the Bioethics Committee (VSN-18199), with women newly diagnosed with BC scheduled to receive surgery. The present study was between subject design. For the first analysis the independent variable had two levels, having breast cancer or not, and the dependent variables were cognitive function and sleep quality. For the second analysis the independent variable had two levels, poor quality sleepers and good quality sleepers, where the dependent variable was cognitive function.

### **Statistical analysis**

The data was analyzed with IBM SPSS Statistics, with the significance level of  $p < 0.05$ . Missing values were excluded from the analysis in IBM SPSS statistics. Chi-square tests were used in order to examine the relationship between the demographic variables, (e.g

age, education, and marital status (in relationship/married vs single). Independent t-test was used in order to compare the means of the two groups, BC and HC, and determine whether there was a significant difference between them in regards to sleep quality and cognitive function. Independent t-test was used to compare the means of good quality sleepers and poor quality sleepers in regards to cognitive function. Pearson Correlation coefficient was used in order to examine the association between sleep quality and cognitive function, including both BC and HC, furthermore, to examine the association between cognitive function and good and poor quality sleepers.

### Results

The results from the Chi-square tests showed that there was not a statistically significant difference between the groups in regards to age  $X^2(4, N = 24) = 0.55, p = .969$ , education,  $X^2(2, N = 40) = 1.13, p = .568$ , or marital status,  $X^2(1, N = 40) = 0.00, p = 1.00$ .

**Table 1**

*Descriptive statistics on demographic variables for BC and HC*

		Breast cancer		Healthy controls		$\chi^2$	$p$
		N	%	N	%		
Age						0.55	.969
	35-44	1	7.1	1	10.0		
	45-54	3	21.4	2	20.0		
	55-64	6	42.9	3	30.0		
	65-74	3	21.4	3	30.0		
	75-84	1	7.1	1	10.0		
Education						1.31	.568
	University	13	43.3	6	60.0		
	High school/Trade school	10	33.3	3	30.0		
	Elementary or less	7	23.3	1	10.0		
Marital status						0.00	1.00
	Relationship/Married	21	70.0	7	70.0		
	Single/Divorced	9	30.0	3	30.0		

In order to test the hypothesis that treatment-naïve BC patients have worse sleep quality compared to HC, an independent t-test was conducted and found no statistical

difference in any of the measures except for the PSQI component “Habitual sleep efficiency” ( $p = .013$ ) (see Table 2). The PSQI global score was higher among the BC patients, compared to HC, suggesting a trend toward the hypothesis, even though not significant,  $t(24) = 1.57$ ,  $p = .130$ . Furthermore, BC patients scored higher on the PSQI component “Sleep quality”, compared to HC, showing a trend toward the hypothesis, even though not significant,  $t(25) = 1.24$ ,  $p = .228$ . BC patients had a higher score for the PSQI component “Sleep latency”, compared to HC, showing a trend toward the hypothesis, even though not significant,  $t(38) = 1.45$ ,  $p = .157$ . HC had higher mean compared to BC for the PSQI component “Use of sleep medication”, the difference was not significant,  $t(38) = 0.22$ ,  $p = .830$ .

**Table 2.**

*Independent t-test results from PSQI global score and components for BC and HC*

	Breast cancer			Healthy controls			<i>t</i>	<i>p</i>
	N	M	SD	N	M	SD		
PSQI global score	30	7.97	3.63	10	6.40	2.37	1.27	.212
1. Sleep quality	30	1.40	0.90	10	1.10	0.57	1.24	.228
2. Sleep latency	30	1.40	0.97	10	0.90	0.88	1.45	.157
3. Sleep duration	29	1.31	1.23	10	1.00	0.67	1.00	.326
4. Habitual sleep efficiency	28	1.43	1.26	9	0.67	0.50	2.62	.013*
5. Sleep disturbance	23	1.30	0.47	9	1.22	0.44	0.45	.655
6. Use of sleeping medication	30	1.00	1.26	10	1.10	1.29	0.22	.830
7. Daytime dysfunction	30	0.57	0.50	10	0.60	0.52	0.18	.858

*Note.* \*.  $p < 0.05$ .

In order to test the hypothesis that treatment-naïve BC patients have worse cognitive function compared to HC, an independent t-test was conducted and found no statistical

difference in any of the measures (see Table 3 and Figure 1). The groups did not significantly differ in total time in seconds in both C-TMT-A,  $t(33) = 1.85$ ,  $p = .074$ , and C-TMT-B,  $t(19) = 0.90$ ,  $p = .381$  (see Table 3). The BC patients had poorer performance on C-TMT-A and B, suggesting a trend toward the hypothesis, even though not significant. When analyzing the performance parameters in PVT, BC patients had more Lapses ( $M = 7.23$ ,  $SD = 9.82$ ), than HC ( $M = 6.60$ ,  $SD = 7.53$ ), suggesting a trend towards the hypothesis, even though not significant,  $t(20) = 0.21$ ,  $p = .834$ .

**Table 3.**

*Independent t-test results for the neuropsychological tests and PROMIS for BC and HC*

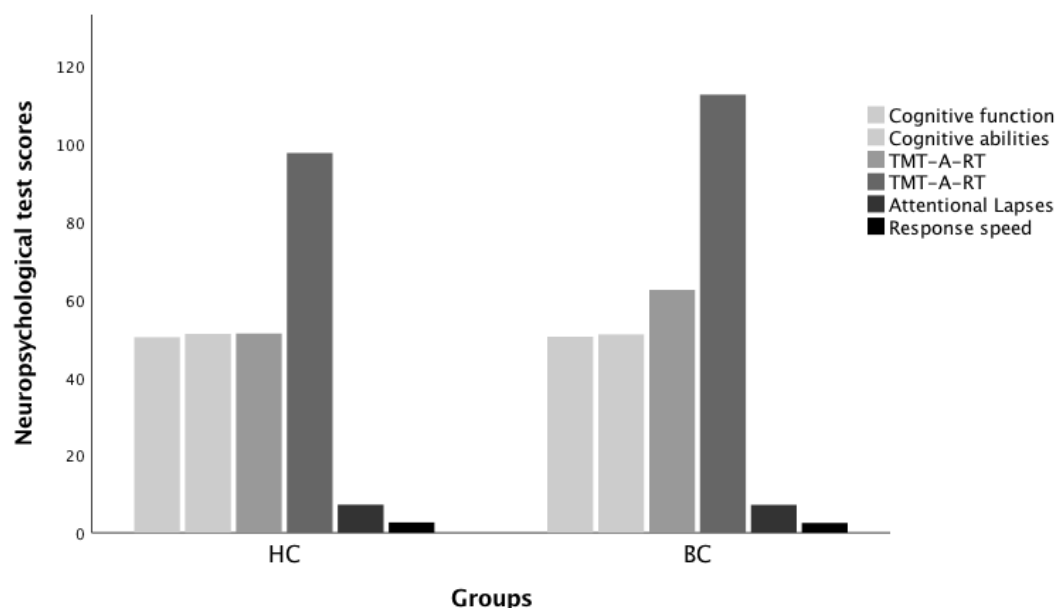
		Breast cancer			Healthy controls				
		N	M	SD	N	M	SD	<i>t</i>	<i>p</i>
PROMIS									
	Cognitive function	29	50.92	9.66	10	51.61	7.72	0.20	.839
	Cognitive abilities	29	50.61	10.43	10	52.79	9.14	0.59	.561
PVT									
	Lapses	30	7.23	9.82	10	6.60	7.53	0.19	.854
	Response Speed	30	2.45	0.95	10	2.65	0.50	0.64	.526
C-TMT-A	Total time	30	64.54	31.67	9	51.25	12.82	0.71	.480
C-TMT-B	Total time	30	113.02	56.80	9	97.74	40.45	0.91	.369

In order to examine the association between poor sleep quality and subjective cognitive impairment among treatment-naïve BC patients and HC, a Pearson correlation coefficient was used. The results indicated a significant negative correlation between subjective cognitive abilities and PSQI global score  $r(37) = -.351$ ,  $p = 0.28$ , Sleep quality,  $r(37) = -.437$ ,  $p = .005$ , Sleep disturbances,  $r(30) = -.544$ ,  $p < .001$  and Daytime dysfunction,  $r(37) = -.446$ ,  $p = .004$ . Furthermore, there was a significant negative correlation between

subjective cognitive function and Sleep disturbance,  $r(29) = -.569, p < .001$ , and Daytime dysfunction,  $r(37) = -.427, p = .007$ .

**Figure 1.**

*Comparison of neuropsychological test scores for subjective and objective cognitive function between groups.*



In order to test the hypothesis that treatment-naïve BC patients with sleep problems have worse cognitive function compared to BC patients without sleep problems, an independent t-test was conducted and found no statistical difference in any of the measures (see Table 4). The independent t-test results indicated that good quality sleepers ( $M = 51.51$ ,  $SD = 4.07$ ) had better subjective cognitive function compared to poor quality sleepers ( $M = 50.73$ ,  $SD = 10.94$ ),  $t(27) = 0.18, p = .857$ , along with better subjective cognitive abilities ( $M = 55.92$ ,  $SD = 6.74$ ) compared to poor quality sleepers ( $M = 48.92$ ,  $SD = 10.93$ ),  $t(17) = 2.03, p = .059$ , suggesting a trend towards the hypothesis, even though not significant (see Table 4). Good quality sleepers showed worse performance on C-TMT-B ( $160.18$ ,  $SD = 92.24$ ),

compared to Poor quality sleepers ( $M = 98.66$ ,  $SD = 31.77$ ), the difference was not significant,  $t(6) = 1.73$ ,  $p = .130$ .

**Table 4.**

*Independent t-test results for the neuropsychological tests, PROMIS and PSQI questionnaire for BC (good quality vs poor quality sleepers)*

		Poor quality sleepers			Good quality sleepers				
		N	M	SD	N	M	SD	<i>t</i>	<i>p</i>
PROMIS									
	Cognitive function	22	50.73	10.94	7	51.51	4.07	0.28	.783
	Cognitive abilities	22	48.92	10.93	7	55.92	6.74	1.59	.124
PVT									
	Lapses	23	7.22	9.65	7	7.29	11.18	0.19	.854
	Response Speed	23	2.49	0.88	7	2.33	1.21	0.38	.710
C-TMT-A	Total time	23	59.56	24.28	7	80.90	47.74	0.71	.480
C-TMT-B	Total time	23	98.66	31.77	7	160.18	92.24	0.91	.369

In order to examine the association between poor sleep quality and subjective cognitive impairment among treatment-naïve BC patients the Pearson correlation coefficients was used (see Table 5). There was a significant negative correlation between subjective cognitive function and sleep disturbance  $r(20) = -.620$ ,  $p = .002$ , and a significant negative correlation between subjective cognitive abilities and Sleep quality  $r(27) = -.396$ ,  $p = .034$ , Sleep disturbance,  $r(21) = -.549$ ,  $p = .007$  and Daytime dysfunction  $r(27) = -.481$ ,  $p = .008$ .

**Table 5.**

*Correlation coefficients between PROMIS cognitive function and abilities and the PSQI components among BC.*

	Correlation coefficients									
	PCF	PCA	PGS	SQ	SL	SD	HSE	SD	USM	DD
PCF	-	.884**	-.021	-.213	.068	.110	.143	-.620**	.126	-.346
PCA	.884**	-	-.302	-.396*	-.008	-.070	-.084	-.549**	-.176	-.481**
PGS	-.021	-.302	-	.439*	.249	.816**	.745**	.537**	.482**	.594**
SQ	-.213	-.396*	.439*	-	.605**	-.013	-.023	.404	-.061	.474**
SL	.068	-.008	.249	.605**	-	-.161	-.051	.150	-.198	.155
SD	.110	-.070	.816**	-.013	-.161	-	.853**	.356	.443*	.347
HSE	.143	-.084	.745**	-.023	-.051	.853**	-	.312	.243	.322
SD	-.620**	-.549**	.537**	.404	.150	.356	.312	-	-.044	.444*
SM	.126	-.176	.482**	-.061	-.198	.443*	.243	-.044	-	.272
DD	-.346	-.481**	.594**	.474**	.155	.347	.322	.444*	.272	-

*Note.* \*\*.  $p < 0.01$ . \*.  $p < 0.05$ . PCF and A = PROMIS cognitive function and abilities. PGS = PSQI global score. SQ = Sleep quality. SL = Sleep latency. HSE = Habitual sleep efficiency. SD = Sleep disturbances. USM = Use of sleep medication. DD = Daytime dysfunction.

### Discussion

The aim of the present study was to examine the difference in sleep quality and cognition between treatment-naïve breast cancer patients and healthy controls and the effects of sleep quality on cognitive function. The primary hypothesis was that breast cancer patients would show poorer performance on objective and subjective neuropsychological measures, as well as poorer sleep quality, compared to healthy controls. Moreover, poor quality sleepers would show poorer performance on objective and subjective neuropsychological measures compared to good quality sleepers. The results showed that the groups did not significantly differ in relation to age, education, or marital status, indicating that they do not depend on each other.

The hypothesis that treatment-naïve breast cancer patients have worse sleep quality compared to HC was not supported, as the results were non-significant. The findings indicated that the majority of the participants in both groups have poor sleep quality. The findings indicate that BC patients do not have poorer sleep quality compared to HC, as the results were non-significant. The non-significant results are not in accordance with previous findings (Fontes et al., 2017). Perhaps this could be explained by the small sample size, as well as unequal samples between groups. Furthermore, the sleep quality was assessed by a self-report questionnaire, which contains faults as it is based on subjective perception. The findings revealed that there was a significant difference between sleep efficiency among BC patients compared to HC. BC patients had significantly poorer sleep efficiency compared to HC, indicating that BC patients spend less time asleep while in bed. Previous findings indicated that specific components of sleep quality are a predictor of self-reported cognitive impairment. One of those components was sleep efficiency (Henneghan et al., 2018). The results from the PSQI questionnaire showed that BC patients scored higher on the PSQI global score, showing a trend towards the hypothesis, even though not significant.

The hypothesis that treatment-naïve breast cancer patients have worse cognitive function compared to healthy controls was not supported, as the results were non-significant. Overall, a better performance was observed among HC compared to BC, showing a trend towards the hypothesis, even though not significant. The non-significant results are not in accordance with previous findings (Lange et al., 2020). BC patients had more lapses compared to HC in PVT, showing a trend toward the hypothesis, even though not significant. Breast cancer patients had a worse subjective cognitive function compared to HC, showing a trend towards the hypothesis, even though not significant. Perhaps these findings could be explained by the small sample size of the current study, as well as only two neuropsychological tests and one questionnaire to evaluate cognitive function.

BC patients scored slightly better than the norm in subjective cognitive function and abilities, indicating that BC patients perceived cognitive function is average. This is not in accordance with the hypothesis, as this indicates that BC patients are not significantly lower than the norm. Perhaps this may be explained by the small sample being selected at random, as one of the disadvantages of having a random sample is that there is a possibility of missing out on a particular group by chance. Larger sample size may prevent this from occurring. Even though the difference was not significant, there was an association between subjective cognitive abilities and sleep quality between BC and HC. These findings indicate that BC patients with worse subjective cognitive abilities may have poorer sleep quality. Furthermore, subjective cognitive function was associated with Sleep disturbance and Daytime dysfunction, indicating that BC patients with worse subjective cognitive function may have greater sleep disturbances and impairment in daytime dysfunction.

The hypothesis that BC patients with poor sleep quality have worse cognitive function compared to BC patients with good sleep quality was not supported. The results from the neuropsychological tests were also not consistent with the hypothesis as a better performance

was observed among Poor sleepers compared to Good sleepers. However, a lower score was observed for BC for the subjective cognitive function and abilities compared to HC, which indicates that BC patients have a worse subjective cognitive function, showing a trend towards the hypothesis, even though not significant. Including more participants in the study might have increased the likelihood of significant results. The findings revealed that majority of the BC patients were poor quality sleepers. Previous studies have found an association between poor sleep quality and BC progression (Liang et al., 2019), mental health, increased pain, and decreased energy (Fortner et al., 2022). These previous findings, as well as the findings of the current study, state the importance of early detection in relation to poor sleep quality in order to improve their sleep with the help of professionals and possibly prevent BC progression, decrease in mental health, as well as pain management and keeping the energy reserves up. Even though the difference was not significant, there was an association between subjective cognitive function and sleep disturbances. Furthermore, there was an association between subjective cognitive abilities and sleep quality, sleep disturbance, and daytime dysfunction. This indicates that BC patients with worse subjective cognitive function may have worse sleep disturbance. Also, having worse subjective cognitive abilities, patients may have worse sleep quality, sleep disturbance, and daytime dysfunction.

### **Limitations and strengths**

Certain limitations of the study should be addressed. The insufficient sample size for a statistical measure, as well as an unequal sample size in BC compared to HC. COVID-19 may have had affected the participation of participants and therefore influenced the insufficient sample size. It should also be taken into account when evaluating the results that sleep quality was only assessed using a self-report measure. There were also few neuropsychological tests, and therefore measuring too few cognitive modalities. Cognitive

impairment regarding those specific cognitive modalities that were measured, may not have been present in this current sample.

The strength of the study was the accuracy of the neuropsychological tests that were used, as they measure only specific cognitive modalities. Also, the study included both objective and subjective cognitive function, where the subjective cognitive function is measured through a certain time period and the objective cognitive function at one time point. The objective cognitive function was not measured in a controlled environment, which may be a strength, as it likely to reflect cognitive function in real daily life. Furthermore, the study included a comparison groups of healthy controls.

### **Future directions**

Future studies may include a bigger sample size as it may increase the likelihood of significant results. It may also be essential to have an equal sample size for both groups. It may maximize the statistical power to detect differences in means for the overall sample size. The current study only included one timepoint. Future studies may include another time point after surgery, which may strengthen the study by comparing to HC and another time point. They may also include more neuropsychological tests assessing more diverse cognitive modalities.

### **Conclusion**

Overall, there is no difference in objective and subjective cognitive function and sleep quality between BC patients and HC. Furthermore, BC patients with poor sleep quality did not differ in subjective and objective cognitive function compared to BC patients with good sleep quality. However, the results showed a trend toward hypothesis (1), (2), and (3), which states the importance of future research to address the limitations of the current study.

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