The Relationship Between Poor Sleep Quality and Neutral Declarative Memory in Hypertensive and Diabetic Individuals

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Abstract

Research has found that hypertensive and diabetic individuals suffer from poor sleep quality and memory deficits, however, these difficulties have been studied separately, with sparse research investigating the relationship between disease state, sleep and memory. The aim of this study was to investigate the relationship between sleep quality and neutral declarative memory in hypertensive and diabetic individuals. A total of (n = 60) participants were recruited. Participants completed an electronic survey which contained the Beck Depression Inventory, Beck Anxiety Inventory, Pittsburgh Sleep Quality Index and the Perceived Stress Scale. To assess immediate and delayed recall, the Brief Test of Adult Cognition by Telephone was administered. Hypertension was defined as having a blood pressure $\leq$ 140/90mmHg, and diabetes as an HbA1C < 8g/%. In the healthy controls and patient groups, participants were matched on all demographic variables except for age and BMI. *t*-test analyses found that the patient group performed significantly worse on immediate and delayed recall subtests compared to healthy controls (p=.046, p =.023). A linear regression analysis revealed that although group predicted memory performance (F(1,44) = 2.97, p = .046; F(1,44) = 4.24, p=.023), it did not predict sleep quality scores (F(1,58) = 0.20, p=.668) or components of sleep quality. Although our study did not find a mediating effect of sleep quality on immediate and delayed recall, we suggest that future studies continue to explore this relationship, to gain insight into how sleep may impact memory function in these individuals, in order to inform better treatment options.

Keywords: Diabetes; Hypertension; Neutral Declarative Memory; Poor sleep quality.

Introduction

Hypertension and diabetes are leading non-communicable diseases that are associated with poor sleep and declarative memory deficits. Poor quality sleep disrupts non-rapid eye movement (NREM) sleep which affects neutral declarative memory consolidation (Javaheri & Redline, 2012). Although there is evidence of a bidirectional relationship between sleep, diabetes and hypertension, this literature review aims to explore the inadequately investigated directional relationship: that hypertension and diabetes result in poor sleep quality which brings about neutral declarative memory deficits.

Non-Communicable Diseases

Non-communicable diseases are the leading cause of death globally, accounting for 71% of all deaths, over 85% of which originate from low- and middle-income countries (LAMIC; WHO, 2021a). Non-communicable diseases are defined as non-infectious, chronic, slow progressing conditions that cause premature death and reduce quality of life (Centers for Disease Control and Prevention, 2013; South African Government, 2021). In South Africa the premature mortality rate (30 -70 years) for the leading non-communicable diseases is 26.2%, with 19% being attributed to cardiovascular diseases and 7% to diabetes (WHO, 2018a; WHO, 2018b).

Hypertension

Hypertension, a major cardiovascular disease affecting 1.13 billion people worldwide, is defined as a systolic blood pressure of above 140 and diastolic blood pressure above 90 with symptoms often including tinnitus, arrhythmias, fatigue, memory deficits and poor sleep quality (Jahn, 2013; WHO, 2019). Major risk factors include being over the age of 60, obesity, heredity

factors and high salt and fat diets (Centers for Disease Control and Prevention, 2013; NHS, 2019; WHO, 2021a).

Diabetes Type 2 (non-insulin-dependent, or adult-onset)

Globally, diabetes affects 8.5% of the population and is on the increase, with Type 2 being the most prevalent form. Type 2 diabetes occurs when the body ineffectively utilises insulin, resulting in hyperglycaemia, which over time, if uncontrolled, can result in death (WHO, 2021b). Major risk factors for the disease include obesity, physical inactivity, diet and tobacco use, with common symptoms including fatigue, poor quality sleep and memory deficits (Pappas et al., 2017; WHO, 2021b).

Poor quality sleep in hypertensive and diabetic individuals contributes to their poor quality of life and subsequent cognitive deficits (Bardage & Isacson, 2001; Jahn, 2013; Tasali et al., 2008). Given the high prevalence of poor quality sleep in these individuals, it is important to understand the role of sleep within these individuals.

Sleep

Sleep is an evolutionarily beneficial biological function that is paramount to optimal functioning and overall health (Czeisler, 2015). Sleep is broadly divided into two physiologically different stages of sleep: rapid eye movement (REM) and NREM (Alger et al., 2014; Patel et al., 2020,). NREM/REM cycles occur every 90 minutes approximately four times each night, with NREM occurring predominantly in the first half of the night and REM sleep increasing into the second half. NREM is broken into N1, N2, and N3, the deepest stage of sleep (also known as slow-wave sleep (SWS); Alger et al., 2014; Patel et al., 2020). REM sleep consists of high brain

activity and reduced muscle tone to prevent movement. Though NREM and REM sleep are important for memory consolidation, in this review we will focus on how N2 and SWS are integral to the consolidation of neutral declarative memory (Alger et al., 2014).

Sleep and Memory

A vast literature suggests that sleep plays a vital role in memory consolidation. The process of memory development follows the model that information must first be encoded, consolidated and retrieved (Watson & Buzaki, 2015).

Declarative memory is that which can be consciously recalled and involves personal experiences (episodic memory) and factual information (semantic memory; Watson & Buzaki, 2015). Neutral declarative memory involves non-emotionally valanced content and the brain regions associated with its consolidation are the hippocampus, entorhinal cortex and medial temporal lobes.

There are two prevailing theories of consolidation with regard to sleep. The Two-Stage theory explains how brain regions activated during declarative memory encoding are reactivated in quick succession during SWS. This is through sharp-wave ripples in the hippocampus, which are hypothesised to transfer memory traces to other cortical areas for long-term potentiation and future recall (Marshall & Born, 2007; Schonauer, 2018). This model is supported by evidence that (a) delta waves and spindle-activity increase during NREM sleep after heavy declarative learning periods (Born & Gais, 2004; Born et al., 2002; Mölle et al., 2002), (b) inducing SWS oscillations through transcranial alternating electrical stimulation during NREM onset increased SWS length and depth and resulted in improved recall for neutral declarative memory (Marshall

et al., 2006), and (c) targeted memory activation during NREM sleep, timed to hippocampal ripples and spindle activity, improved declarative memory recall which was not found during REM sleep (Hu et al., 2020; Ngo et al., 2013).

The second theory by Tononi and Cirelli (2003) describes how SWS plays an indirect role in memory consolidation. This theory posits that sleep is a homeostatic function where sleep pressure builds during the day as a result of overworked synapses (Alger et al., 2014). Sleep then rejuvenates the synapses through a global downscaling of synaptic thresholds, increasing subsequent information storage (Watson & Buzaki, 2015). Mölle et al. (2002) found that higher cognitive demands before sleep were associated with longer and deeper SWS to remove irrelevant information and down-scale overworked brain regions. Thus, memory consolidation is an indirect product of global downscaling during SWS.

These two theories, and thus memory consolidation, rely on good quality sleep with sufficient amounts of N2 and SWS in the first half of the night (Patel et al., 2020). However, poor quality sleep disrupts this process, resulting in poorer cognitive performance.

Poor sleep quality and memory. According to the American Academy of Sleep Medicine, adults regularly need 7 to 8 hours of sleep per night for optimal health, however 35% of adults do not meet this requirement (Perry et al., 2013; Watson et al., 2015). Insufficient sleep has major consequences for one's health, including cognitive deficits.

Many studies have demonstrated that the recall of neutral declarative material was superior after periods of sleep compared to periods of wakefulness in healthy individuals, and

that disrupted sleep was detrimental to memory recall (Born et al., 2006; Ellenbogen et al., 2006; Payne et al., 2012; Plihal & Born, 1997).

These studies demonstrate that sleep has an active and protective effect over neutral declarative memory and that sleep disruptions negate these effects by disrupting consolidation. This is important for hypertensive and diabetic individuals as many suffer from poor quality sleep and memory impairments.

Sleep in Hypertension

Most research within the realm of sleep and hypertension predominantly focusses on how poor quality sleep and less SWS acts as a risk factor for developing the disease. A meta-analysis by Lo et al., (2018) found that poor sleep quality was significantly associated with a greater risk of developing hypertension compared to those with good quality sleep. As Knutson (2010) describes, short, long and poor-quality sleep are associated with higher blood pressure and a higher prevalence of hypertension. This is supported by a meta-analysis by Wang et al., (2021) that found significant association between short-sleepers and hypertension in a sample size of 44,889. Evidence has shown that hypertension itself plays a role in a shorter night's sleep and increases blood pressure (Gangwisch, 2014). Furthermore, Javaheri and Redline (2012) demonstrate that reduced SWS is associated with hypertension as the sympathetic nervous remains active, increasing blood pressure. Nevertheless, there is very limited research demonstrating that those with hypertension have less SWS than healthy controls.

Sleep in Diabetes

Diabetics are 1.4 times more likely to have insomnia compared to nondiabetics (Cappuccio et al., 2010). Tasali et al. (2008) have demonstrated that SWS plays a direct role in the maintenance of normal glucose homeostasis and showed that selective suppression of SWS without a change in total sleep time significantly decreases insulin sensitivity, resulting in reduced glucose tolerance and increased diabetes risk in healthy adults. Furthermore, studies have shown that diabetics have significantly decreased SWS compared to nondiabetic controls independent of age, obesity and severity of sleep apnoea (Pallayova et al., 2010). At this stage, no studies have found that hypertensive or diabetic individuals suffer from less N2 sleep.

Since less SWS is associated with an increased risk of developing hypertension and diabetes, it may be that these individuals are predisposed to have less SWS and thus, declarative memory defcicits (Javaheri & Redline, 2012).

Memory in Hypertension

Hypertension is associated with mild cognitive impairment and dementia, including Alzheimer's disease (Hajjar et al., 2016). Hypertension may cause vessel wall changes in the brain, leading to neurodegeneration that may initiate the process of Alzheimer's disease (Dhikav & Anand, 2011). Therefore, hypertensive individuals are at risk of memory decline and impaired memory formation (Jahn, 2013). In a large-scale neuroimaging study, it was established that hypertension was associated with reduced functional connectivity of the hippocampus (Feng et al., 2020). Furthermore, a study evaluating declarative memory, found that middle-aged hypertensive individuals had a sharper decline in memory tests compared to non-hypertensive

controls, which was mirrored in those with uncontrolled (compared to treated) blood pressure (de Menezes et al., 2021).

Memory in Diabetes

Diabetes is associated with transient or permanent cognitive abnormalities. MRI studies have shown that diabetic individuals have significantly lower cerebral blood flow compared to healthy controls, as well as evidence of cortical and subcortical atrophy, with up to a 10-15% loss in hippocampal volume in elderly diabetic individuals (McCrimmon et al., 2012). Furthermore, diabetes is associated with poorer baseline episodic memory and greater episodic memory decline as well as a 50-100% increased risk of Alzheimer's disease (McCrimmon et al., 2012; Pappas et al., 2017). This is especially true for those with poorly controlled diabetes that exceeds 7g/% HbA1C (Grober et al., 2011; Kanagamuthu et al., 2018; Pappas et al., 2017). Based on the literature, it is clear that hypertensive and diabetic individuals experience both poor sleep quality and memory deficits. However, despite the well-known relationship between sleep and memory, no research has investigated the role that disrupted sleep plays in these individuals' memory deficits.

Research Aim and Question

Research into the relationship between sleep and memory in individuals with hypertension and diabetes is lacking despite evidence of their poor sleep quality and memory deficits. This gap in the literature urgently calls for research as these diseases affect a large proportion of the global population and thus, understanding the relationship between sleep and memory within them could further our understanding of the disease and provide a plan for future

treatment options. We hypothesise that the patient group will have significantly worse sleep quality and neutral declarative memory compared to healthy controls. We also hypothesize that sleep quality should mediate the relationship between cognitive capabilities and disease status.

Method

Designs and Settings

This study forms part of a larger study exploring the relationship between sleep, quality of life, emotion and cognition in hypertension and diabetes. This study is a cross-sectional study assessing the relationship between sleep quality and neutral declarative memory in diabetic and hypertensive individuals. Data was collected online through electronic self-reported survey measures which included the Beck Depression Inventory, Beck Anxiety Inventory, Pittsburgh Sleep Quality Index and the Perceived Stress Scale created on Google Forms and a telephonic cognitive assessment as a result of the COVID-19 pandemic.

Participants

Sixty participants (healthy controls (n =30), hypertensive and diabetic participants (n =30)) were recruited via convenience sampling as the MedPages broadcast to Western Cape physicians was unsuccessful (Appendix A). Five participants had both hypertension and diabetes, however, based on a previous analysis we found no differences between this group and the others. Therefore, based on longest disease duration they were included into one of the two patient groups. All participants completed the online survey and fourty-six (76.67%) completed the telephonic assessment (n = 23) healthy controls and (n = 23) patients (n = 15, hypertensive; n = 8, diabetic). This study aimed to recruit a minimum sample size (n = 30) participants in each

group (healthy controls, hypertensive and diabetic) based on a g*power analysis with Cohen's *f* = 0.175 and power = 0.8 for a linear regression (Sadanand et al., 2015).

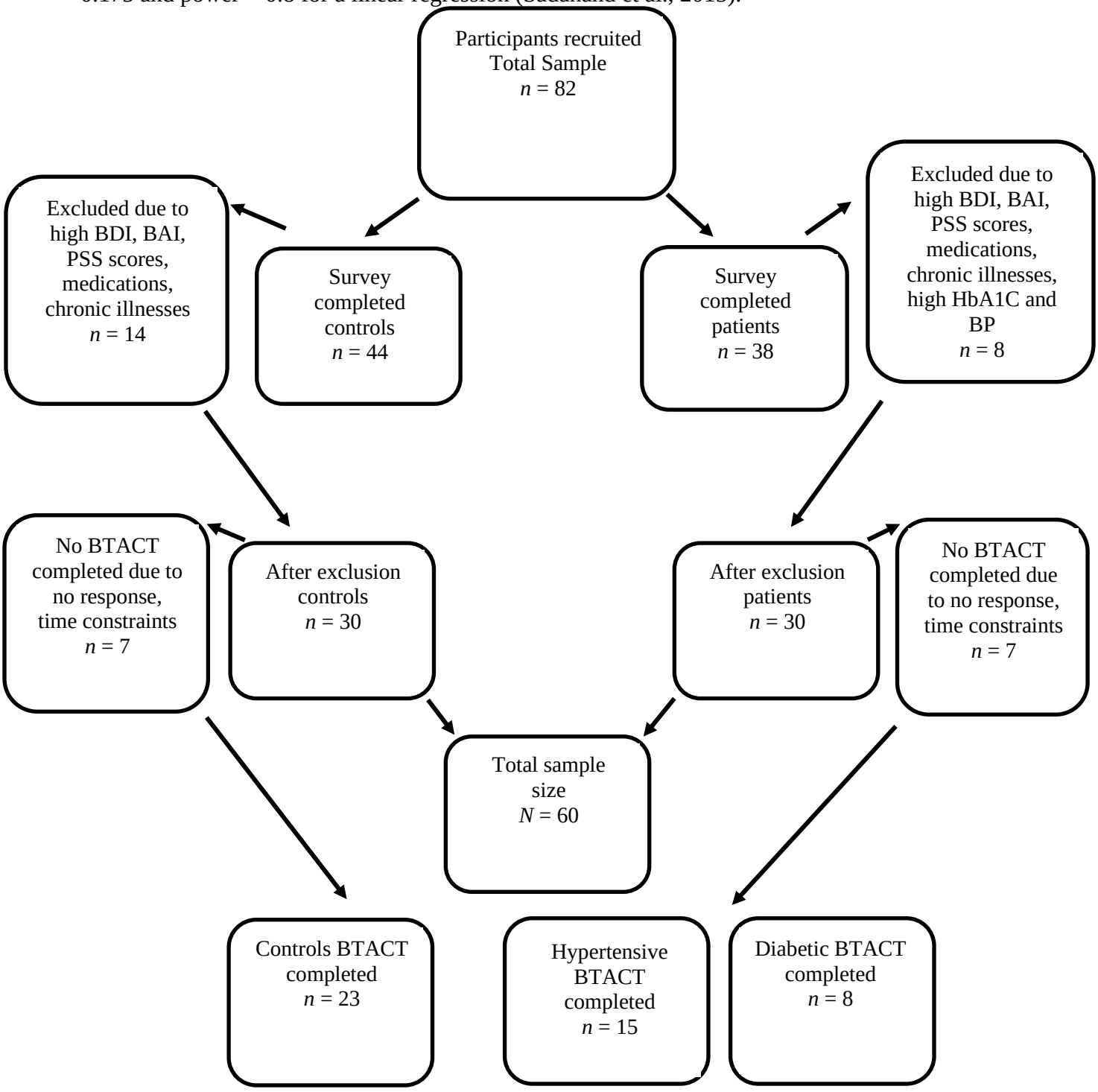


Figure 1. Flow of participants through the recruitment and study processes. To facilitate a case-control design, we selected, based on age, sex, marital status, HLOE and income.

Inclusion criteria. Inclusion criteria for all participants included a minimum age of 18 and a maximum age of 65, as there are age-related effects on sleep, cognition and health (Glisky, 2007; Skeldon et al., 2016). Diabetic individuals had a haemoglobin A1C < 8 g/%, above which would indicate uncontrolled diabetes (Cunha & Davis, 2019). Hypertensive individuals had a blood pressure $\leq$ 140/90 mmHg (WHO, 2019). No participants were accepted who had target organ damage, were pregnant, had a BMI above 40kg/m^2, used medication that may disrupt sleep, had epilepsy or a previous history of head injuries.

Exclusion criteria. Participants were excluded from the study if they met the criteria for severe depression on the Beck Depression Inventory, severe anxiety on the Beck Anxiety Inventory and high perceived stress on the Perceived Stress Scale-10. Participants with severe depression and anxiety were excluded as research has shown that they are significantly correlated with poorer sleep quality than those without psychiatric conditions (Becker et al., 2017; Linkowski & Papadimitriou, 2005; Oh et al., 2019). Disrupted sleep in severely depressed individuals also results in impaired consolidation of neutral memories compared to mild to moderate depression which is why those participants will not be excluded (Harrington et al., 2018). Participants with severe stress were excluded as literature has shown that high perceived stress is associated with everyday memory complaints as well as greater age-related differences in measures of episodic memory and executive functioning (Potter et al., 2009). Healthy controls were also excluded if they had any chronic medical conditions, neurological disorders or medicated psychiatric diagnoses.

Study Outcomes. Neutral declarative memory and general cognition were assessed using the Brief Test of Adult Cognition by Telephone (BTACT) and is our dependent variable. Our

independent variables are group (diabetic, hypertensive or control) and sleep quality as measured by the Pittsburgh Sleep Quality Index.

Measures

Sociodemographic questions were administered at the outset (Appendix B). These included questions about participants' age, sex, level of education and income level, chronic illnesses or psychiatric diagnoses. Furthermore, those with hypertension and diabetes were required to answer questions about the medications they take and their disease duration.

Beck Depression Inventory (BDI-II). The Beck Depression Inventory is a self-report measure consisting of 21-items which evaluates the severity of depression amongst adolescents and adults (Beck et al., 1996; Appendix E). It uses a 4-point Likert scale from 0-3, where an individual selects the statement that best describes how they have felt in the last two weeks. Items are summed to create a total score, where 0-3 is classified as minimal depression, 14-19 as mild depression, 20-28 as moderate depression and a score of 29-63 represents severe depression (Smarr & Keefer, 2011). The Beck Depression Inventory has a high internal consistency reliability (Cronbach's a= 0.89), and a high one-week test-retest reliability of 0.93 (Lee et al., 2017).

Beck Anxiety Inventory (BAI). The Beck Anxiety Inventory is a self-report measure, consisting of 21-items, for severe anxiety in psychiatric populations (Beck et al., 1988; Appendix F). The test uses a 4-point Likert scale from 0-3 to assess the extent to which anxiety symptoms have been bothering the participant over the past month. Scoring 0-21 is considered low anxiety, 22-35 moderate anxiety and 36 < as severe anxiety. The inventory has high internal consistency reliability with Cronbach's a = 0.92 (Beck et al., 1988). Test-retest reliability after one week was 0.75 and concurrent validity was moderate (Beck et al., 1988).

Brief Test of Adult Cognition by Telephone (BTACT). The BTACT is a 15-20 minute telephonic cognitive assessment designed to be inclusive of a range of cognitive abilities important to assess cognitive ageing (Tun & Lachman, 2006; Appendix G). The BTACT assess the following cognitive domains: episodic verbal memory (immediate and delayed recall of a 15-word list), working memory (backward digit span test), verbal fluency (category fluency test), inductive reasoning (number series), speed of processing (backward counting task) and task-switching (Go/No-go test; Tun & Lachman, 2006). The telephonic format was designed for efficiently and accurately screening patients (Gurnani & John, 2015). This format is also a more feasible evaluation technique for research studies, especially in the context of the COVID-19 pandemic to overcome the practical challenges of not interacting with vulnerable patients.

The internal consistency reliability of the BTACT is Cronbach's α = 0.82, demonstrating the consistency with which the BTACT measures cognitive ability and indicates an adequate level of reliability (Tun & Lachman, 2006). Test-retest and parallel forms reliability (0.54 - 0.84) were also good (Lachman et al., 2014). Content validity is discussed by Tun and Lachman (2006) as the BTACT utilises a broad range of cognitive tests, integral to cognitive theory, that extends what is measured by well-established tests by going beyond only memory and orientation. Lachman et al. (2014) found 'good evidence' for BTACT construct validity and concurrent validity in looking at its relationship with the Boston Cognitive battery whereby significant moderate correlations (r = 0.42 to 0.54) were found between the corresponding memory subtests (e.g. Category Fluency and Verbal ability). Construct validity was also assessed in comparing telephonic BTACT to in-person neuropsychological testing whereby there was no significant difference in results due to testing method (Lachman et al. (2014). Convergent validity was assessed through correlating BTACT and established neuropsychological test

batteries and was significantly correlated with overall cognition ($r = 0.64$, $p < .001$), episodic verbal memory ($r = 0.66$, $p < .001$), and executive function ($r = 0.56$, $p < .001$; Barber et al., 2021; DiBlasio et al., 2021).

Pittsburgh Sleep Quality Index (PSQI). The PSQI is a measure consisting of 19-self rated questions (Buysse et al., 1988; Appendix H). Sleep quality is assessed through questions examining sleep duration and latency, as well as severity and prevalence of sleep problems over the past month (Buysse et al., 1988). The 19 questions are grouped into seven subgroups each weighted 0-3 which are added to produce a global sleep quality index from 0-21 with higher scores reflecting worse sleep quality.

The scale possesses good internal consistency (Cronbach's $\alpha = 0.83$; Backhaus et al., 2002; Buysse et al., 1988) and a high test-retest reliability ($r = 0.87$; Backhaus et al., 2002). Validity was confirmed as the PSQI could clearly distinguish between controls and insomnia patients (i.e. a good measure to identify sleep problems; Buysse et al., 1988; Carpenter & Andrykowski, 1998; Fiorentini et al., 2007). Validity is also demonstrated through its correlations with objective polysomnographic data of sleep quality. Convergent validity was assessed by Carpenter and Andrykowski (1998) as the PSQI was highly correlated with well-established measures of the same construct (e.g. CES-D; $r = 0.69$) and divergent validity was evident with poor correlations of the PSQI with unrelated constructs (e.g. Profile of Mood States; $r = 0.37$). Finally, construct validity was also assessed by correlations between the PSQI and sleep diaries which were both significant and high ($r = 0.71$-0.81, $p < 0.001$; Backhaus et al., 2002).

The PSQI has also been used in studies of hypertension and diabetes with high PSQI scores being significantly and highly correlated with prevalent hypertension, 87% for poor

sleepers compared to only 35% of good sleepers (Carolina et al., 2008; Fiorentini et al., 2007; Zhang et al., 2019). PSQI scores were also correlated with low scores on the Diabetes Quality of Life measure (Luyster & Dunbar-Jacob, 2011). Fiorentini et al. (2007) discusses that high PSQI scores are significantly associated with hypertension and diabetes. This demonstrates the usefulness of the PSQI within the context of this study.

The Perceived Stress Scale (PSS-10). The Perceived Stress Scale is a self-report questionnaire used for measuring psychological stress (Cohen et al., 1994; Appendix I). It consists of 10 items, 5 of which are positively phrased "In the last month, how often have you felt things were going your way?" and 5 negatively phrased "In the last month, how often have you felt nervous and 'stressed'?''. These items assess general situations where an individual may feel their life has been unpredictable or overloaded in the past month (Lee, 2012). The Perceived Stress Scale is rated on a 5-point Likert scale (0-4) from never to very often. Scores range from 0-40 with higher scores indicating higher perceived stress. A score of 0-13 is categorised as low stress, 14-26 moderate and 27-40 is considered high perceived stress. The Perceived Stress Scale has good internal consistency with (Cronbach's $\alpha = 0.78$) and test-retest reliability ($r = 0.85$; Cohen & Williamson, 1988).

Procedure

Ethical approval was obtained from the Faculty of Health Sciences and the Department of Psychology prior to data collection (Appendices J & K). The MedPages broadcast was sent out to Western Cape general practitioners, cardiologists and endocrinologists, requesting voluntary participation from hypertensive and diabetic individuals. However, this was unsuccessful, therefore, both healthy controls and patient participants were recruited via convenience and snowball sampling through Facebook. Healthy controls were matched on demographic variables

to patient participants which included age, sex, education and income level. Informed consent was obtained from all participants online, before they began the survey (Appendix C and D). Following this, we asked participants to give us five times that they were available for the telephonic assessment (BTACT). Before commencing the assessment, verbal consent was obtained.

Statistical Analysis

Each of the psychological measures were scored using their standardised scoring guidelines. Statistical analysis was completed using RStudio. Firstly, descriptive statistics were obtained for demographic, clinical and BTACT subtest variables and groups were assessed as to whether they were adequately matched on demographic measures. The alpha level was set to 0.05 for significance. We then ran Pearson's *r* correlations between demographic and BTACT variables per group to determine initial relationships between them. To test our first predictions that the patient group would have (a) worse PSQI scores, and (b) poorer immediate and (c) delayed recall scores than healthy controls, we ran *t*-tests. A one-way ANOVA was also performed to determine whether there were cognitive differences due to hypertension classification. In order to test hypothesis (d) that aimed to predict that PSQI scores will mediate between group differences on immediate and delayed recall subtests, we ran a mediation analysis. This was achieved through creating regression models to assess whether group was a predictor of (a) PSQI, (b) immediate and (c) delayed recall scores and whether global PSQI scores predicted memory performance. Regression models were also created for PSQI subcomponent scores to determine if they had mediating effects on memory. The Beck Depression Inventory, Beck Anxiety Inventory and Perceived Stress Scale scores were not included as covariates to determine how they contribute to the variance in BTACT scores, as no

between-group differences were found. Lastly, an ANCOVA was performed due to the significant differences in age and BMI scores to determine whether they contribute to the significant differences found in the *t*-tests.

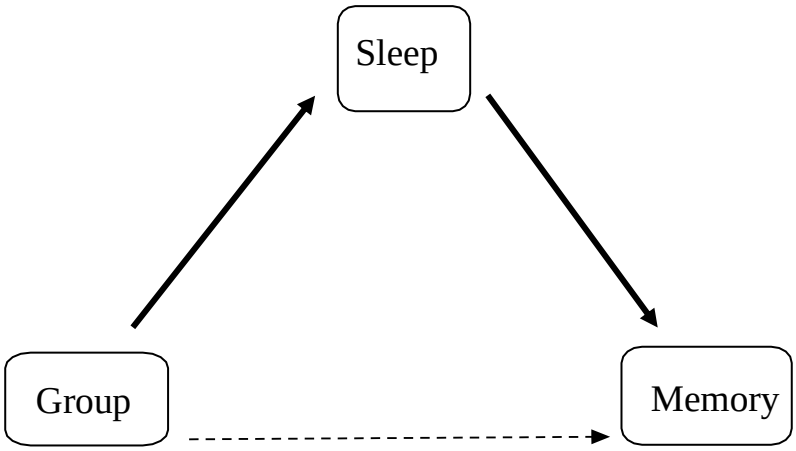


Figure 1. Poor Quality Sleep as measured by the PSQI will mediate the relationship between disease and neutral declarative memory deficits.

Ethical Considerations

Ethical approval was obtained from the Psychology Department at the University of Cape Town as well as the Faculty of Health Sciences (Appendices J & K).

Consent, voluntary participation and confidentiality. Written, informed consent was obtained from all participants before completing the survey. Verbal consent was also obtained before beginning the BTACT. Participants were informed that their participation was voluntary and that they were welcome to withdraw from the study at any time without any consequences. They were also informed that all information received would remain confidential and is only accessible to the researchers involved in the study through password protected documents.

Participation in this study did not pose any considerable risk, however, should participants have felt anxious after completing the survey or cognitive assessment, we would have referred them to a psychologist and details for mental health services were made available.

There was no financial compensation for taking part in this study. The overall benefit was contributing to our knowledge of the relationship between poor sleep quality and neutral declarative memory in people with hypertension and diabetes.

Significance

There are many studies demonstrating the link between hypertension and diabetes and poor sleep and memory deficits. However, there is a clear lack of research into how these three factors interact. This study aimed to explore the possible mediating effect of poor sleep quality, as a result of disease state, on memory ability in hypertensive and diabetic individuals. Suggestions for future research are put forward to pave the way for future treatment interventions for these individuals.

Declaration of Interests

This study declares no conflicts of interest.

Results

Sample Characteristics

Table 1 presents the between-group comparisons of demographic variables for the sample. There were no significant differences between-group differences for sex (p = .292), marital status (p = .223), highest level of education (p = .260) and income (p = .555), indicating that healthy control and patients were adequately matched on these variables. However, significant differences were found between-groups for age, with the patient group being older on average (M = 50.10 vs 40.11, p = < .001). On average patients had significantly higher BMI scores relative to healthy controls (M = 29.49 vs 22.99 respectively, p = <.001).

In our clinical population, 16 participants were hypertensive, 9 were diabetic and 5 had both diseases. Depending on length of disease duration those who had both were moved into the

clinical category in which they had had the disease the longest. This resulted in 20 patients in the hypertension group, and 10 in the diabetic group. Diabetics had on average a longer disease duration compared to hypertensives (17.9 vs 10.2 years). In terms of treatment, hypertensive patients were on an average of 1.75 medications, and all were on at least one anti-hypertensive medication. For those who specified their blood pressure, 3 were classified as normal, 6 were stage one hypertensives (130-139/80-89mmHg) and 3 were classified as stage 2 hypertensives ($\geq$140/90mmHg). On average diabetics were on 2.85 medications in general (including insulin), with 60% using Metformin to control blood glucose levels. The average HbA1C level for diabetics was 6.72g/% ranging from 5-8g/% which is classified as a normal blood glucose level.

Given the smaller number of participants in the patient group compared to the control group, we decided to combine hypertensive and diabetic group (hereon referred to as the Patient group). There were no significant differences between hypertensive and diabetic patients on any of the questionnaires or BTACT outcome variables (all *ps* > .140). Therefore, we combined the two patient groups to form one group.

Table 2 presents between-group differences in the BDI-II, BAI, PSQI and PSS. No significant between-group differences were found (all *ps* > .259); therefore, any between-group differences in cognition would not be attributed to these variables.

As per our hypothesis we expected the patient group to have poorer quality sleep as measured by the PSQI (i.e., higher scores). However, this was not the case as the healthy controls and patients had similar mean PSQI scores (p = .962) which both fell above the value indicating poor sleep quality (a score of 5; Smyth, 2020).

Table 1
Group Demographic Variables (N = 60)

	Group				
	Control	Patient			
Variable	(*n* = 30)	(*n* = 30)	t / χ^2	*p*	*d*
Age[a]	40.11 (13.26)	50.10 (11.88)	1.19	< .001***	0.67
Sex			1.11	.292	0.14
Female	20 (66.7)	16 (53.3)			
Male	10 (33.3)	14 (46.7)			
Marital Status			3	.223	0.22
Single	10 (33.3)	6 (20)			
Married	18 (60)	18 (60)			
Divorced	2 (6.7)	6 (20)			
HLOE			1.27	.260	0.15
Secondary	7 (23.3)	11 (36.7)			
Tertiary	23 (76.7)	19 (63.3)			
BMI	22.99 (3.42)	29.49 (6.01)	7.79	< .001***	1.33
Income (in ZAR)			-[a]	.601	0.31
1000-2499	0 (0)	1 (3.3)			
2500-5499	0 (0)	3 (10)			
5500-9999	1 (3.3)	1 (3.3)			
10000-19999	3 (10)	4 (13.3)			
20000-40000	4 (13.3)	6 (20)			
40000-60000	9 (30)	6 (20)			
60000 – 100000	3 (10)	2 (6.7)			
> R100 000	10 (33.3)	7 (23.3)			

Note. For Age and BMI means are provided with standard deviations in parenthesis, t-tests were performed and the test statistic is *t*. For Sex, Marital Status, HLOE and Income data is provided as *n* with proportions in parentheses, chi-squared tests were performed for these variables and the test statistic is χ^2. HLOE = Highest Level of Education, BMI = body mass index. [a]A Fisher's Exact test was performed. ***$p < .001$.

It was decided to perform t-tests for the PSQI component scores which revealed that between control and patient groups sleep quality, sleep duration, daytime dysfunction and sleep duration (raw scores) were significantly different (p = .021, .033, .048, .005). For the sleep

duration (raw scores), it is also notable that the control group slept on average almost an hour longer than the patient group (*M* = 6.7 vs 6.1).

Table 2
Group Psychological Variables (N = 60)

	Group				
	Controls	Patients			
Variable	(*n* = 30)	(*n* = 30)	*t*	*p*	*d*
BDI-II	8.93 (6.22)	8.23 (6.64)	0.42	.854	0.11
BAI[b]	6.83 (6.42)	8.03 (6.89)	-0.70	.481	0.09
PSQI total	7.13 (3.65)	7.53 (3.53)	-0.43	.962	0.11
Sleep quality	1.10 (0.71)	1.50 (0.78)	-2.08	.021	-0.54
Sleep latency	1.13 (1.07)	1.07 (1.11)	0.24	.407	0.06
Sleep duration	0.93 (0.64)	1.27 (0.74)	-1.87	.033	-0.48
Sleep efficiency	0.87 (1.04)	0.77 (1.01)	0.38	.354	0.10
Sleep disturbances	1.23 (0.43)	1.43 (0.57)	-1.54	.065	-0.40
Sleep medication use	0.70 (1.18)	0.37 (0.89)	1.24	.111	0.32
Daytime dysfunction	1.13 (0.78)	0.77 (0.89)	1.69	.048	0.44
Sleep efficiency (%)	83.61 (13.76)	83.95 (14.1)	-0.09	.462	-0.03
Sleep duration (raw score)	6.78 (0.92)	6.12 (1.04)	2.64	.005	0.68
PSS	15.36 (6.11)	13 (7.91)	1.29	.259	0.34

Note. Means are presented with standard deviations in parentheses. [b]For this variable a Mann-Whitney test was performed and the test statistic is *z*. In this case, the effect size is *r*. BDI-II = Beck Depression Inventory Second Edition, BAI = Beck Anxiety Inventory, PSQI = Pittsburgh Sleep Quality Index, PSS = Perceived Stress Scale. Where participants left out a survey question for a particular measure, we calculated their score and used it as it was, so long as the maximum score for that question would not put them in the severe category for the measure (BDI-II, BAI and PSS). In the sample two participants left out a question for the BDI, two for the BAI and one for the PSQI.

Associations between BTACT subtests and demographic variables across groups

Correlations between BTACT subtests and demographic variables within each group were computed. Within the control group, significant negative correlations were found between

age and immediate and delayed recall (r = -.473, p = .01; and r = -.538, p < .001). This was not significant for the patient group (r = .07, p = .752; and r = -.095, p = .668). Within the patient group there was a trend towards immediate recall correlating with PSQI scores (r = .305, p = .078).

Between-group comparisons of BTACT subtests

Before conducting statistical tests, for the BTACT, assumptions of normality were checked. Data for the BTACT subtests were normally distributed, as seen through histograms and Q-Q plots, except for the Red-Green and Number Series subtests. Thus, for the latter two subtests, non-parametric tests were performed. No outliers were found that needed to be excluded from the analysis.

Table 3 presents the between-group comparisons for the BTACT. Significant between-group differences were found for (a) immediate recall (p = .046), and (b) delayed recall (p = .023). The means indicate that the patient group performed worse on measures of immediate and delayed recall compared to healthy controls with medium effects sizes for Cohen's d (.51 and .61). There were no other between-group differences on the BTACT (all ps > .126).

Table 3
Comparison of Group Performance on the BTACT (N = 46)

	Group				
	Control	Patient			
Variable	(*n* = 23)	(*n* = 23)	*t*	*p*	*d*
Episodic memory					
Immediate Recall	7.73 (2.33)	6.65 (1.92)	0.51	.046*	0.51
Delayed Recall	5.8 (2.36)	4.47 (2.06)	0.32	.023*	0.61
Working memory					
Digit Span-Backwards	7.46 (1.86)	6.73 (2.78)	2.59	.222	0.23
Executive functioning					
Category Fluency	22.63 (4.69)	19.6 (4.81)	0.02	.126	0.34
Red-Green (total score)[c]	70.79 (1.61)	70.8 (1.37)	-0.01	.496	< 0.01
Reasoning					
Number Series[a]	3.21 (1.28)	2.73 (1.38)	-0.42	.336	0.06
Speed of processing					
Counting Backwards	60.21 (10.28)	62.4 (8.35)	0.86	.388	0.08

Note. Means are presented with standard deviations in parentheses. BTACT = Brief Test of Adult Cognition by Telephone. [c]For these variables a Mann-Whitney was performed and the test statistic is *z.* In this case, the effect size is *r*. *$p < .05$.

Associations between BTACT subtests and clinical variables

Correlations between BTACT subtests and clinical variables were computed. Neither diabetes disease duration nor hypertension disease duration were correlated with any BTACT outcome variables (all *ps* > .074). HbA1C levels were not correlated with any BTACT outcome variables (all *ps* > .070).

Hypertension group comparisons

A one-way ANOVA was performed to determine whether BTACT subtests differed according to BP classification There were trends towards significant main effects for (a) immediate recall ($p = .082$), (b) delayed recall ($p = .081$) and category fluency ($p = .06$). To

explore these trends, we ran pairwise post-hoc comparisons. Patients with stage two hypertension performed significantly better than patients with normal blood pressure for immediate recall (p = .045). Patients with stage two hypertension also performed significantly better than patients with stage one hypertension for delayed recall (p = .034). Lastly, patients with normal blood pressure performed significantly better than those with stage one hypertension for category fluency (p = .024).

Table 4
Comparison of Hypertensive Stage on the BTACT (N = 12)

	Group					
Variable	Normal (n = 3)	Stage one (n = 6)	Stage two (n = 3)	f	p	η^2
Immediate Recall	6 (1.73)	6.1 (2.25)	9 (1)	$F(2, 9) = 2.21$	.082	0.33
Delayed Recall	5 (1.73)	3.33 (2.73)	6.67 (1.15)	$F(2, 9) = 2.24$	.081	0.33
Category Fluency	24.67 (5.03)	18.83 (3.37)	21.67 (2.08)	$F(2, 9) = 2.71$	.06	0.38

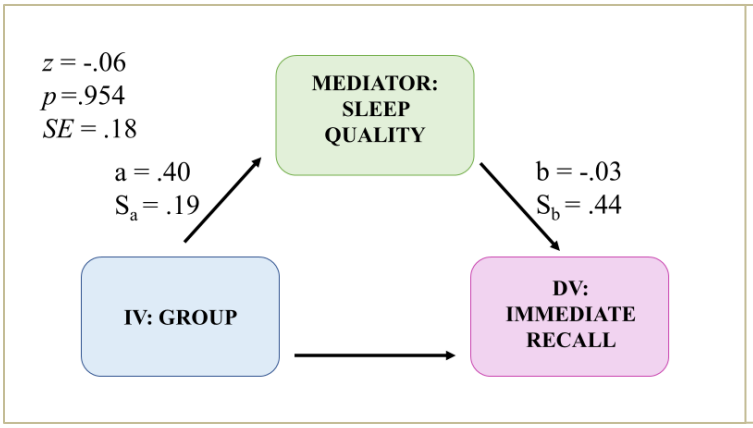
Note. Means are presented with standard deviations in parentheses.

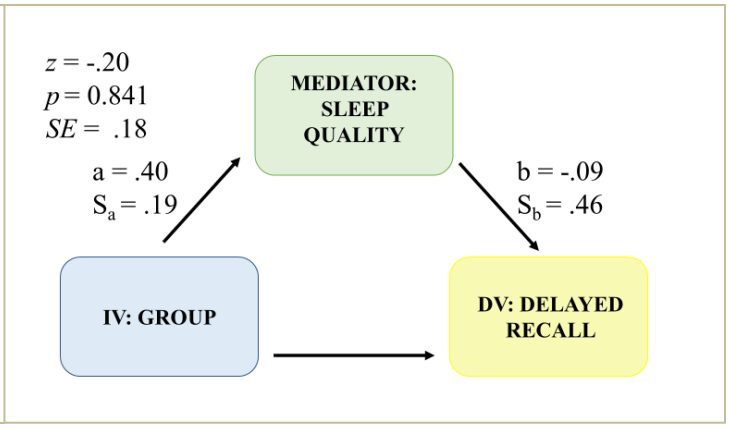
Mediation analysis

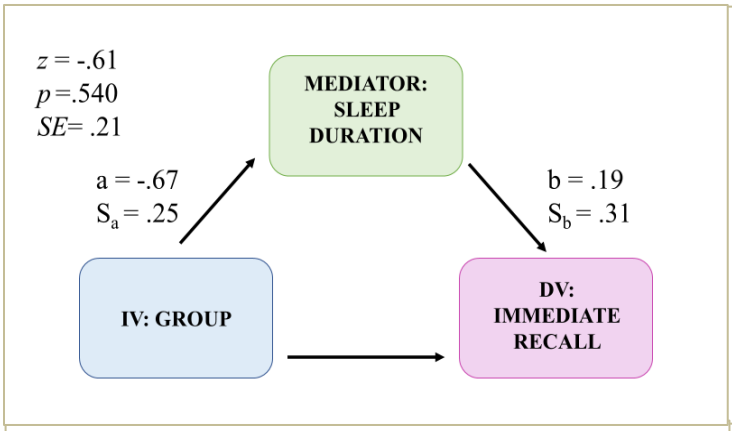
We then ran a mediation analysis to determine whether global PSQI scores (sleep quality) mediated the association between group and BTACT immediate and delayed recall. Group was a significant predictor of BTACT immediate recall ($F(1, 44) = 2.97$, p = .046) and delayed recall ($F(1, 44) = 4.24$, p = .023). Both these models were relatively weak explaining only 6.3% of the variance in immediate recall scores and 8.8% of the variance in delayed recall scores. In continuation to determine whether global PSQI scores mediate group differences in BTACT subtest scores, a regression model demonstrated that group was not a significant predictor of global PSQI scores ($F(1, 58) = 0.20$, p =.668). Thus, the mediation analysis could not be

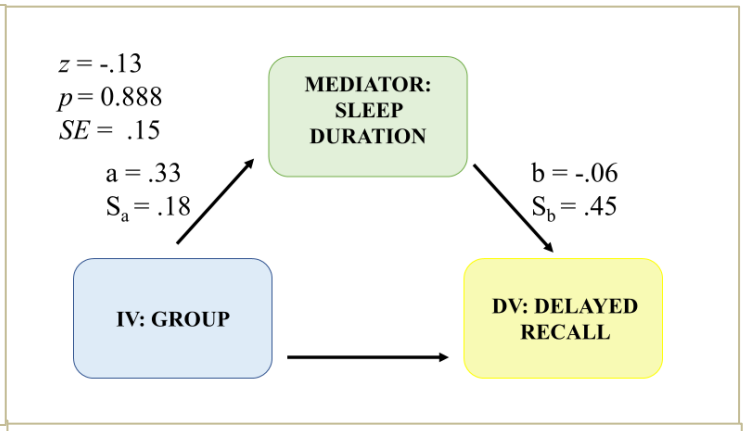
completed and global PSQI scores are not a mediator for between-group differences in immediate and delayed recall scores.

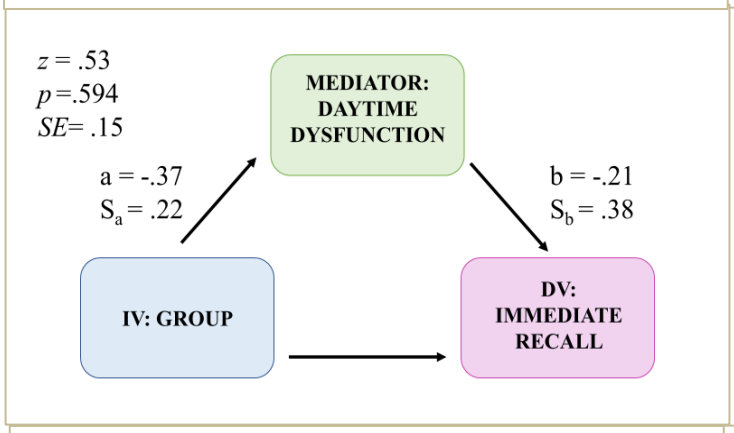
We then ran mediation analysis for PSQI component scores to determine whether specific PSQI subcomponents had mediating effects for immediate or delayed recall. PSQI subcomponents were selected based of off their significance in previous *t*-tests. These included sleep quality, sleep duration, daytime dysfunction and sleep duration (raw scores) (p = .021, .033, .048, .005). As above, group is a predictor of BTACT immediate and delayed recall performance and from the *t*-test the components that were chosen can be said to be predicted by group. However, these models were relatively weak in that group explained 11% or less of the variance in PSQI subcomponent scores (r^2s < 0.107). It was then important determine whether the PSQI subcomponent scores predicted immediate or delayed recall scores to complete the mediation analysis. For immediate recall the regression models all demonstrated that PSQI subcomponent scores were not significant predictors of this subtest (p = .123, .120, .105, .101; r^2s < 0.072; Appendix L). For delayed recall the regression models also demonstrated that PSQI subcomponent scores were not significant predictors of this subtest (p = .068, .069, .065, .067; r^2s < 0.09; Appendix L). Therefore, our mediation analyses revealed no mediating effects for these any of the PSQI subcomponents for either immediate or delayed recall (Figure 2).

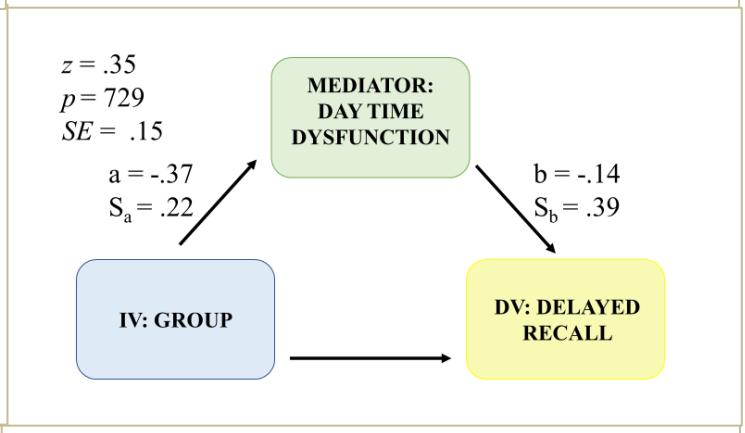

z = -.06
p =.954
SE = .18
MEDIATOR: SLEEP QUALITY
a = .40
S_a = .19
b = -.03
S_b = .44
IV: GROUP
DV: IMMEDIATE RECALL

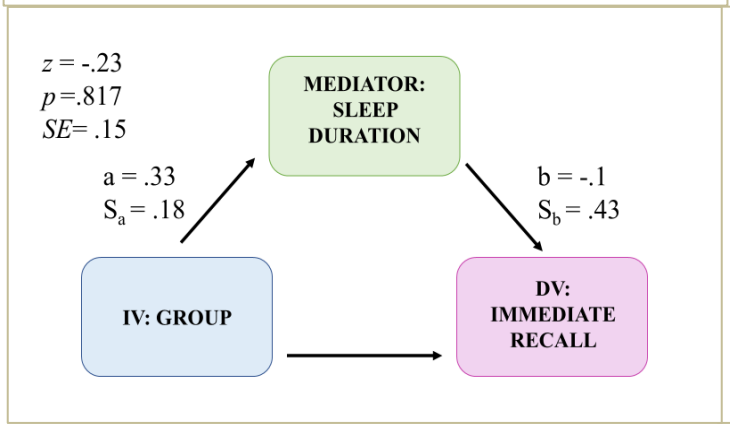

z = -.20
p = 0.841
SE = .18
MEDIATOR: SLEEP QUALITY
a = .40
S_a = .19
b = -.09
S_b = .46
IV: GROUP
DV: DELAYED RECALL


z = -.61
p =.540
SE= .21
MEDIATOR: SLEEP DURATION
a = -.67
S_a = .25
b = .19
S_b = .31
IV: GROUP
DV: IMMEDIATE RECALL


z = -.13
p = 0.888
SE = .15
MEDIATOR: SLEEP DURATION
a = .33
S_a = .18
b = -.06
S_b = .45
IV: GROUP
DV: DELAYED RECALL


z = .53
p =.594
SE= .15
MEDIATOR: DAYTIME DYSFUNCTION
a = -.37
S_a = .22
b = -.21
S_b = .38
IV: GROUP
DV: IMMEDIATE RECALL


z = .35
p = 729
SE = .15
MEDIATOR: DAY TIME DYSFUNCTION
a = -.37
S_a = .22
b = -.14
S_b = .39
IV: GROUP
DV: DELAYED RECALL


z = -.23
p =.817
SE= .15
MEDIATOR: SLEEP DURATION
a = .33
S_a = .18
b = -.1
S_b = .43
IV: GROUP
DV: IMMEDIATE RECALL

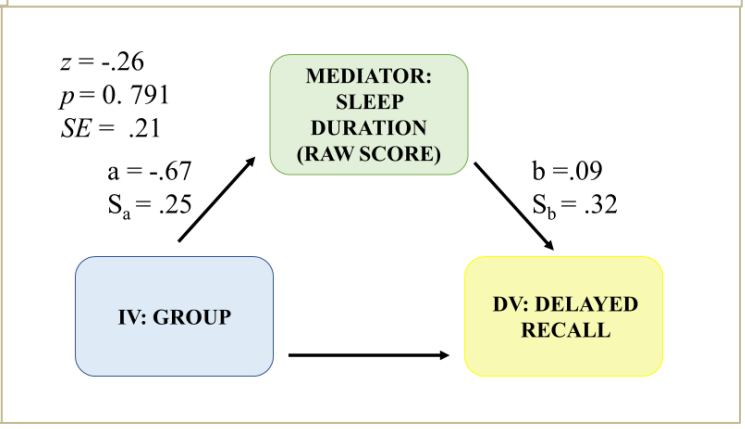

z = -.26
p = 0. 791
SE = .21
MEDIATOR: SLEEP DURATION (RAW SCORE)
a = -.67
S_a = .25
b =.09
S_b = .32
IV: GROUP
DV: DELAYED RECALL

Figure 2. Mediation analysis figures for PSQI components and immediate or delayed recall group.

Finally, we ran an ANCOVA to determine whether age or BMI, due to their previous significance between-groups, were contributing to between-group significance in immediate and delayed recall subtests. After controlling for age and BMI, Group was no longer a significant predictor of immediate (p = .153) or delayed recall (p = .101).

Discussion

Hypertension and diabetes are leading non-communicable diseases associated with poor sleep and declarative memory deficits. However, limited research investigates sleep and memory in these patient groups, and none have looked at how sleep quality impacts memory despite well-known associations between sleep and memory consolidation. This study assessed the cognitive functioning and sleep quality of individuals with hypertension and diabetes compared to healthy controls from South Africa using the BTACT and PSQI. This is the first study to investigate whether disrupted sleep might serve as a mechanism underlying the memory deficits observed in patients with hypertension and diabetes. Analyses confirmed that patients had significantly poorer immediate and delayed memory recall compared to healthy controls. However, there were no differences in terms of sleep quality. These results suggest that while memory is deficient in patients, sleep is not disrupted, nor related to memory deficits.

The influence of hypertension and diabetes on cognition

As predicted by our hypothesis, the patient group performed significantly worse in the immediate and delayed recall subtests than healthy controls and were associated with medium effect sizes. Hypertension is associated with mild cognitive and memory impairment as well as increased dementia risk (Hajjar et al., 2016; Jahn, 2013). This is proposed to result from arterial

wall changes in the brain which act as a catalyst for neurodegeneration (Dhikav & Anand, 2011). Furthermore, hypertension has been associated with poorer functional connectivity in the hippocampus which is central to memory operations (Feng et al., 2020). Diabetic individuals have generally been associated with poorer baseline episodic memory, greater episodic memory decline and an increased Alzheimer's risk (McCrimmon et al., 2012). These deficits result from acute and chronic disturbances in blood glucose homeostasis. A large study by Barreto et al. (2020) found that diabetes as well as age ($\geq$ 45) were significant predictors of poor memory performance for learning, recall and word recognition.

Our findings surrounding immediate and delayed recall differences as well as a lack of between-group differences in other cognitive domains are supported by other studies. Declarative memory is the most common cognitive domain affected in individuals with diabetes (Borod et al., 2009). This is supported by a meta-analysis conducted by Sadanand et al. (2015), who also found that working memory and category fluency were not affected in individuals with diabetes. Individuals with hypertension have also been found to perform significantly worse on memory recall, category fluency, processing speed tests, working memory and visuospatial abilities (Bortolotto et al., 2017a; de Menezes et al., 2021; Freitas et al., 2018). Although we found no significant differences between healthy controls and the patient group on any other cognitive domains, we found significant differences for immediate and delayed recall, which supports our hypotheses.

As discussed by de Menezes et al. (2021) it was found that individuals with uncontrolled hypertension had sharper declines in memory tests compared to those with treated, and therefore, controlled hypertension. Additionally, though not sufficiently explored, de Menezes et al. (2021) and Giggey et al. (2005) remark that anti-hypertensive medication and higher levels of education

may protect against the harmful neurobiological effects of hypertension and therefore, cognitive decline. Our study contradicts these findings as significant effects were found despite all individuals being on a blood pressure control regimen (e.g., Prexum, Losartan and Fortzaar) and 63.3% having completed a tertiary education.

Regarding the diabetic individuals within the study, we ensured their HbA1C levels were well controlled (below 8g/%). In this study, HbA1C levels were not associated memory performance. It is generally found that higher HbA1C levels are associated with poorer baseline episodic memory and greater episodic memory decline compared to healthy controls (Pappas et al., 2017). Kanagamuthu et al. (2018) found that only HbA1C levels above 7 resulted in statistically significant differences compared to controlled diabetics (HbA1C < 7) for the Mini Mental State Exam which assesses memory functioning. Grober et al. (2011) supports these results when they found that poor memory and global executive function was was associated with inadequately controlled diabetes compared to better cognitive functioning. Our study contradicts these findings in that the patient group performed significantly worse than healthy controls on immediate and delayed recall subtests despite having controlled HbA1C levels.

Severity of hypertension has previously been associated with cognitive decline (Bortolotto, et al., 2017b). However, our study found that stage two hypertensives performed significantly better than those with normal blood pressure for immediate recall as well as for delayed recall in comparison to stage one hypertensives. This contradicts research by Bortolotto, et al. (2017b) whereby those with hypertension stage two performed significantly worse than these groups in memory recall ability. However, these differences should be interpreted tentatively due to the very small sample size of hypertensive patients who had data on blood pressure.

The influence of hypertension and diabetes on sleep

Most literature has found that hypertensive and diabetic individuals have poorer sleep quality than healthy controls (Knutson, 2010; Pallayova et al., 2010). This contradicts our findings as no significant differences were found. In the case of hypertension poor sleep quality is associated with higher blood pressure. In our study we controlled for higher blood pressure, only recruiting those $\leq$ 140/90mmHg. It may be that only those with uncontrolled blood pressure higher than our cut off value have significantly poorer sleep quality. Diabetic individuals have also been shown to have poorer sleep quality. In a study by Dunbar-Jacob and Luyster (2011) 55% of the diabetic sample (n = 300) were poor sleepers which is also supported by Abujbara et al. (2019) where 81% of 1211 diabetic individuals were classified as having poor sleep via the PSQI. Abujbara et al. (2019) found that uncontrolled HbA1C ($\geq$ 7) was significantly associated with poorer sleep quality ($p < .001$) than controlled HbA1C (< 7). In our study HbA1C levels were highly controlled with the average indicating normal blood glucose levels (6.72g/%). This may explain why the patient group did not have significantly poorer sleep quality compared to healthy controls, despite research indicating otherwise. Furthermore, the PSQI is a subjective measure of sleep quality and thus, patients may have underreported or healthy controls may have overreported poor sleep quality in our sample which may have obscured relevant results.

The influence of sleep on memory in hypertensives and diabetics

Our mediation analysis to confirm our main hypothesis that sleep (PSQI scores) mediate performance on immediate and delayed recall subtests per group was not supported. Currently there is no literature to support or disconfirm our hypothesis. Our lack of findings may be attributed to the limitations of our study.

Although we aimed to match the healthy controls and patient groups on demographic variables, the groups were not perfectly matched in terms of age or BMI, as healthy controls were significantly younger and in the healthy BMI range (18.5-24.9 kg/m^2) compared to patients ($\geq$ 25). This could be due to the fact that hypertension and diabetes usually onset later in life ($\geq$ 55 years, $\geq$ 45 years) and are strongly associated with BMIs above $25kg/m^2$ (Bays et al., 2007; National Institute of Health, 2021; World Health Organisation, 2019). These clinical populations would have contributed to patients being significantly older and having higher BMIs than the healthy controls. A further contribution to the significant age and BMI differences was the limited pool of healthy controls to match to patient participants (30% were between 22-30 years old, and 70% were below $25kg/m^2$ for BMI), resulting in inadequately matched groups.

Within our correlational analysis we found significant negative associations between age and immediate and delayed recall for the control group. This finding was expected as when one ages, cognitive performance declines, especially memory ability (Corley et al., 2009). However, this was not found for the patient group as their disease state may have contributed to their memory decline over and above age-related contributions to poor memory scores. This is supported by Eisdorfer and Wilkie (1971) who comment that cognitive decline associated with ageing may be secondary to pathological disease processes.

Limitations

This study is not without its limitations. Firstly, the overall and group sample sizes that were required (N = 90) as per the power analysis were not met (N = 60). Therefore, our study was likely underpowered. Contributing to recruitment of a limited sample size was: late ethical approval to collect patient data and failure of the MedPages broadcast. Limited time and means

of recruitment resulted in obtaining non-matched groups in terms of age and BMI whereby healthy controls should have had a higher proportion of older adults.

Additionally, many possible participants declined the survey or did not complete it due to its long nature. This may have contributed towards a sampling bias which may have resulted in acquiring healthy controls who had unusually poor sleep quality. In hindsight, implementing a PSQI cut off score of 5 for controls would have prevented this.

Secondly, though the BTACT was useful under COVID-19 conditions it only contains limited neutral declarative memory subtests. Perhaps, a more thorough in-person neuropsychological memory assessment would have proved more useful. Additionally, time of day effects, referring to fluctuations in cognitive performance over the course of the day as a result of one's circadian rhythm, may have affected results (Althaus et al., 2010). For example, immediate and delayed recall have shown to better in the morning as opposed to the afternoon or evening, and many participants were only available after work in the evenings (Baddeley et al., 2007; Clarisse & Testu, 1999).

Finally, a key limitation of the study was its reliance on a subjective measure of sleep and sleep quality (PSQI) as opposed to an objective measure of sleep quality such as polysomnography. An objective measure of sleep may yield different results in terms of between-group differences and mediating effects on memory and cognition.

Conclusion

This study demonstrated that individuals with hypertension and diabetes perform significantly worse on immediate and delayed memory recall in comparison to healthy controls. We also found that severity of hypertension negatively influenced performance on tests of immediate and delayed recall in comparison to normal blood pressure individuals. However, we

found no difference in sleep between patients and controls, and no mediating effect of sleep on memory performance. This study adds to the very limited research on the relationship between sleep and neutral declarative memory in hypertensive and diabetic individuals. Future research should focus on recruiting larger sample sizes, assessing for mediating effects and comparing controlled and uncontrolled disease states to healthy controls. Additionally, studies should prioritise utilising objective measures of assessing sleep as well as more in-depth neuropsychological tests. Due to the limitations of this study, it acts as a first step towards understanding complex sleep and memory relationships in these clinical populations. Further research is required to understand the underlying mechanisms of their poor sleep and memory complaints in order to implement targeted treatment interventions.

References

Abujbara, M., Ajlouni, K., Banimustafa, R., Batieha, A., & Barakat, S. (2019). Sleep quality in patients with type 2 diabetes mellitus. *Journal of clinical medicine research*, *11*(4), 261–266. https://doi.org/10.14740/jocmr2947w.

Alger, S. E., Chambers, A. M., Cunningham, T., & Payne, J. D. (2014). The role of sleep in human declarative memory consolidation. *Current Topics in Behavioral Neurosciences*, *25*. https://doi.org/10.1007/7854_2014_341.

Althaus, M., de Sonneville, L. M., & van der Heijden, K. B. (2010). Time-of-day effects on cognition in preadolescents: a trails study. *Chronobiology International*, *27*(9-10), 1870-94. https://doi.org/10.3109/07420528.2010.516047.

Backhaus, J., Junghanns, K., Broocks, A., Reiman, D., & Hohagen, F. (2002). Test–retest reliability and validity of the Pittsburgh Sleep Quality Index in primary insomnia, *Journal of Psychosomatic Research*, *53*(3), 737-740, https://doi.org/10.1016/S0022-3999(02)00330-6.

Baddeley, A. D., Hatter, J., Scott, D., & Snashall, A. (2007). Memory and time of day. *Quarterly Journal of Experimental Psychology*, *22*, 605-609. https://doi.org/10.1080/14640747008401939.

Barber, J. K., Bodien, Y. G., Dams-O'Connor, K., Dikmen, S., Nelson, L. D., … & Yue, J. K. (2021). Validity of the Brief Test of Adult Cognition by Telephone in Level 1 Trauma Center Patients Six Months Post-Traumatic Brain Injury: A TRACK-TBI Study. *Journal of Neurotrauma*, 38(8), 1048-1059. https://doi.org/10.1089/neu.2020.7295.

Bardage, C., & Isacson, D. G. (2001). Hypertension and health-related quality of life: an epidemiological study in Sweden. *Journal of clinical epidemiology*, *54*(2), 172-181. https://doi.org/10.1016/s0895-4356(00) 00293-6.

Barreto, S. M., Duncan, B. B., Diniz, M. F. H. S., Passos, V. M. A., Schmidt, M. I., & Teixeira, M. M. (2020). Association between diabetes and cognitive function at baseline in the Brazilian Longitudinal Study of Adult Health (ELSA- Brasil). *Scientific Reports, 10***(**1596). https://doi.org/10.1038/s41598-020-58332-9.

Bays, H. E., Chapman, R. H., Grandy, S., & SHIELD Investigators' Group (2007). The relationship of body mass index to diabetes mellitus, hypertension and dyslipidaemia: comparison of data from two national surveys. *International journal of clinical practice*, *61*(5), 737–747. https://doi.org/10.1111/j.1742-1241.2007.01336.x

Beck, A. T., Epstein, N., Brown, G., & Steer, R. A. (1988). An inventory for measuring clinical anxiety: Psychometric properties. *Journal of Consulting and Clinical Psychology*, *56*, 893-897. https://doi.org/10.1037//0022-006x.56.6.893.

Beck, A. T., Steer, R. A., & Brown, G. (1996). Beck depression inventory–II. *Psychological Assessment*.

Becker, N. B., Jesus, S. N., Joao, K. A. D. R., Viseu, J. N., & Martins, R. I. S. (2017). Depression and sleep quality in older adults: a meta-analysis. *Psychology, Health and Medicine, 22*(8), 889-895, https://doi.org/10.1080/13548506.2016.1274042.

Born, J., & Gais, S. (2004). Declarative memory consolidation: mechanisms acting during human sleep. *Learning & memory*, *11*(6), 679–685. https://doi.org/10.1101/lm.80504.

Born, J., Gais, S., Helms, K., & Mölle, M. (2002). Learning-dependent increases in sleep spindle density. *Journal of Neuroscience*. *22***,** 6830-6834. https://doi.org/10.1523/JNEUROSCI.22-15-06830.2002.

Born, J., Gais, S., & Lucas, B. (2006). Sleep after learning aids memory recall. *Learning & memory, 13, 259-262.* https://doi.org/10.1101/lm.132106.

Borod, J. C., Bruehl, H., Convit, A., Javier, D., Sweat, V., … & Yau, P. L. (2009). Emotional and neutral declarative memory impairments and associated white matter microstructural abnormalities in adults with type 2 diabetes. *Psychiatry Research: Neuroimaging*, 174(3), 223-230. https://doi.org/10.1016/j.pscychresns.2009.04.016.

Bortolotto, L. A., Bor-Seng-Shu, E., Costa-Hong, V. A., Machado, M. F., Memória, C. M., … & Yassuda, M.S. (2017a). Impact of hypertension on cognitive performance in individuals with high level of education. *Brain Nerves, 1*(2), 1-6. https://doi.org/1015761/JBN.1000110

Bortolotto, L. A., Costa-Hong, V. A., Machado, M. F., Memória, C. M., Moraes, N. C., … & Muela, H. C. (2017b). Hypertension severity is associated with impaired cognitive performance. *Journal of the American Heart Association*, *6*(1), https://doi.org/10.1161/JAHA.116.004579.

Buysse, D. J., Reynolds, C. F., Monk, T. M., Berman, S. R., & Kupfer, D. J. (1988). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research, 28*(2), 193-213, https://doi.org/10.1016/0165-1781(89)90047-4.

Cappuccio, F. P., D'Elia, L., Strazzullo, P., & Miller, M. A. (2010). Quantity and quality of sleep and incidence of type 2 diabetes: a systematic review and meta-analysis. *Diabetes Care, 33*(2), 414-420. https://doi.org/10.2337/dc09-1124

Carolina, M., da Cunha, B., Lúcia, M., Vanderlei, Z., & Hass, J. (2008). Sleep quality in type 2 diabetics. *Revista. Latino-Am. Enfermagem, 1*6 (5), https://doi.org/10.1590/S0104-11692008000500009.

Carpenter, J. S., & Andrykowski, M. A. (1998). Psychometric evaluation of the Pittsburgh Sleep Quality Index. *Journal of Psychosomatic Research, 45*(1), 5-13, https://doi.org/10.1016/S0022-3999(97)00298-5.

Centers for Disease Control and Prevention. (2013). *Introduction to NCD Epidemiology.* https://www.cdc.gov/globalhealth/healthprotection/fetp/training_modules/1/Intro-to-Epi_PPT__Final_09252013.pdf

Clarisse, R., & Testu, F. (1999). Time-of-day and day-of-week effects on mnemonic performance. *Chronobiology International, 16*(4), 491-503. https://doi.org/10.3109/07420529908998723.

Cohen, S., Kamarck, T., & Mermelstein, R. (1994). Perceived stress scale. *Measuring stress: A guide for health and social scientists, 10*, 1-2.

Cohen, S., & Williamson, G. (1988). Perceived stress in a probability sample of the U.S. *The Social Psychology of Health. Thousand Oaks, CA: Sage.* https://doi.org/10.4236/psych.2017.810105.

Corley, J., Deary, I. J., Gow, A. J., Harris, S. E., Houlihan, L. M., … & Starr, J. M. (2009). Age-associated cognitive decline. *British Medical Bulletin, 92*, 135–152. https://doi.org/10.1093/bmb/ldp033.

Cunha & Davis. (2019). Hemoglobin A1c test (HbA1c, A1c, Hb1c) for diabetes. *Medicine Net,* https://www.medicinenet.com/hemoglobin_a1c_test/article.htm

Czeisler, C. A. (2015). Duration, timing and quality of sleep are each vital for health, performance and safety. *Sleep Health: Journal of the National Sleep Foundation, 1*(1), 5-8. https://doi.org/10.1016/**j**.sleh.2014.12.008.

de Menezes, S. T., Giatti, L., Brant, L. C. C., Griep, R. H., Schmidt, M. I., Duncan, B. B. … & Barreto, S. M. (2021). Hypertension, prehypertension, and hypertension control: Association with decline in cognitive performance in the ELSA-Brasil cohort. *Hypertension, 77*(2), 672-681. https://doi.org/10.1161/HYPERTENSIONAHA.120.16080

Dhikav, V., & Anand, K. (2011). Potential predictors of hippocampal atrophy in alzheimer's disease. *Drugs & aging, 28*(1), 1-11. https://doi.org/10.2165/11586390-000000000-00000.

DiBlasio, C. A., Cook, E. W., Novack, T. A., Dams-O'Connor, K., & Kennedy, R. (2021). Convergent validity of in-person assessment of inpatients with traumatic brain injury using the Brief Test of Adult Cognition by Telephone (BTACT). *Journal of Head Trauma Rehabilitation, 36*(4), 226-232. https://doi.org/10.1097/HTR.0000000000000677.

Dunbar-Jacob, J., & Luyster, F. (2011). Sleep quality and quality of life in adults with type 2 diabetes. *Sleep Quality and Quality of Life, 37*(3). https://doi.org/10.1177/0145721711400663.

Eisdorfer, C., & Wilkie, F. (1971). Intelligence and blood pressure in the aged. *Science, 28*;172(3986), 959-62. https://doi.org/10.1126/science.172.3986.959.

Ellenbogen, J. M., Hulbert, J. C., Stickgold, R., Dinges, D. F., & Thompson-Schill, S. L. (2006). Interfering with theories of sleep and memory: sleep, declarative memory, and associative interference. *Current Biology, 16,* 1290-1294, https://doi.org/10.1016/j.cub.2006.05.024

Feng, R., Rolls, E. T., Cheng, W., & Feng, J. (2020). Hypertension is associated with reduced hippocampal connectivity and impaired memory. *EBioMedicine, 61,* 103082. https://doi.org/10.1016/**j**.ebiom. 2020.103082.

Fiorentini, A., Valente, R., Perciaccante, A., & Tubani, L. (2007). Sleep's quality disorders in patients with hypertension and type 2 diabetes mellitus. *International Journal of Cardiology, 114*(2), E50-E52, https://doi.org/10.1016/j.ijcard.2006.07.213.

Freitas, D., Gouveia, B. R., Gouveia, E. R., Jurema, J., Kliegel, M., … & Machado, F. T. (2018). The relation of hypertension to performance in immediate and delayed cued recall and working memory in old age: The role of cognitive reserve. *Journal of Aging and Health, 30*(8), 1171-1187. https://doi.org/10.177/0898264317.

Gangwisch, J. E. (2014). A review of evidence for the link between sleep duration and hypertension. *American journal of hypertension, 27*(10), 1235-1242. https://doi.org/10.1101/lm.132106.

Giggey, P. P., Thayer, J. F., Waldstein, S. R., & Zonderman, A. B. (2005). Nonlinear relations of blood pressure to cognitive function: The Baltimore longitudinal study of aging. *Hypertension, 45,* 374-379. https://doi.org/10.1161/01.HYP.0000156744.44218.74.

Glisky, E. L. (2007). Changes in cognitive function in human aging. *Brain aging: Models, methods, and mechanisms, 1*. http://doi.org/10.1037/0882-7974.12.

Grober, E., Hall, C. B., & Hahn, S. R. (2011). Memory impairment and executive dysfunction are associated with inadequately controlled diabetes in older adults. *Journal of Primary Care & Community Health, 2*(4), 229 –233. https://doi.org/10.1177/2150131911409945.

Gurnani, A., & John, S. E. (2015). Regression-Based Norms for a Bi-factor Model for Scoring the Brief Test of Adult Cognition by Telephone (BTACT). *Archives of Clinical Neuropsychology*, 30(3), 280-291. https://doi.org/10.1093/arclin/acv005

Hajjar, I., Goldstein, F. C., Martin, G. S., & Quyyumi, A. A. (2016). Roles of arterial stiffness and blood pressure in hypertension-associated cognitive decline in healthy adults. *Hypertension, 67*(1), 171-175. https://doi.org/10.1161/HYPERTENSIONAHA.115.06277.

Harrington, M. O., Nedberge, K. M., & Durrant, S. J. (2018). The effect of sleep deprivation on emotional memory consolidation in participants reporting depressive symptoms.

Neurobiology of Learning and Memory, *152*, 10-19, https://doi.org/10.1016/j.nlm.2018.04.013.

Hu, X., Cheng, L. Y., Chiu, M. H., & Paller, K. A. (2020). Promoting memory consolidation during sleep: A meta-analysis of targeted memory reactivation. *Psychological Bulletin, 146*(3), 218–244. https://doi.org/10.1037/bul0000223

Jahn, H. (2013). Memory loss in Alzheimer's disease. *Dialogues in clinical neuroscience*, *15*(4), 445. https://doi.org/10.1016/j.beem.2010.07.001.

Javaheri, S., & Redline, S. (2012). Sleep, slow-wave sleep, and blood pressure. *Current hypertension reports*, *14*(5), 442-448. https://doi.org/10.1007/s11906-012-0289-0.

Kanagamuthu, R., Mohanraj, S., Muthiah, S., & Shree Lakshmi, K. N. (2018). Assessment of memory and cognitive functions in controlled and uncontrolled Type 2 diabetes mellitus patients. *National Journal of physiology, pharmacy and pharmacology*, *9*(2), 140-144.

Knutson, K. L. (2010). Sleep duration and cardiometabolic risk: a review of the epidemiologic evidence. *Best practice & research Clinical endocrinology & metabolism*, *24*(5), 731-743. https://doi.org/10.1016/j.beem.2010.07.001.

Lachman, M. E., Agrigoroaei, S., Tun, P. A., & Weaver, S. L. (2014). Monitoring cognitive functioning: psychometric properties of the brief test of adult cognition by telephone. *Assessment*, *21*(4), 404–417. https://doi.org/10.1177/1073191113508807

Lee, E. H. (2012). Review of the psychometric evidence of the perceived stress scale. *Asian nursing research*, *6*(4), 121-127. https://doi.org/10.1016/j.anr.2012.08.004

Lee, E. H., Lee, S. J., Hwang, S. T., Hong, S. H., & Kim, J. H. (2017). Reliability and validity of the Beck Depression Inventory-II among Korean adolescents. *Psychiatry investigation*, *14*(1), 30. https://doi.org/10.4306/pi.2017.14. 1.30.

Linkowski, P., & Papadimitriou, G. N. (2005). Sleep disturbance in anxiety disorders. *International review of psychiatry*, *17*(4), 229-236. https://doi.org/10.1080/09540260500104524.

Lo, K., Woo, B., Wong, M., & Tam, W. (2018). Subjective sleep quality, blood pressure, and hypertension: A meta-analysis. *The Journal of Clinical Hypertension*. *20*(3), 592-605. https://doi.org/10.1111/jch.13220.

Luyster, F. S., & Dunbar-Jacob, J. (2011). Sleep quality and quality of life in adults with type 2 diabetes. *The Diabetes Educator*, *37*(3), 347-355. https://doi.org/10.1177/0145721711400663.

Marshall, L., & Born, J. (2007). The contribution of sleep to hippocampus-dependent memory consolidation. *Trends in Cognitive Sciences*, *1*1(10), 442-450, https://doi.org/10.1016/j.tics.2007.09.001.

Marshall, L., Helgadóttir, H., Mölle, M., & Born, J. (2006). Boosting slow oscillations during sleep potentiates memory. *Nature*, *444*, 610-613. https://doi.org/10.1038/nature05278.

McCrimmon, R. J., Ryan, C. M., & Frier, B. M. (2012). Diabetes and cognitive dysfunction. *The Lancet*, *379*(9833), 2291-2299. https://doi.org/10.1016/S0140-6736(12)60360-2.

Mölle, M., Marshall, L., Gais, S., & Born, J. (2002). Grouping of spindle activity during slow oscillations in human non-rapid eye movement sleep. *Journal of Neuroscience*, *22*(24) 10941-10947. https://doi.org/10.1523/JNEUROSCI.22-24-10941.2002.

National Institute of Health. (2021). *What is diabetes?* National Institute if Diabetes and Digestive and Kidney Diseases. https://www.niddk.nih.gov/health-information/diabetes/overview/what-is-diabetes/type-2-diabetes

Ngo, H. V. V., Martinetz, T., Born, J., & Mölle, M. (2013). Auditory closed-loop stimulation of the sleep slow oscillation enhances memory. *Neuron*, *78*, 545-553, https://doi.org/10.1016/J.NEURON.2013.03.006.

NHS. (2019, October 23). *Causes: High Blood Pressure*. https://www.nhs.uk/conditions/high-blood-pressure-hypertension/causes/

Oh, C., Kim, H. Y., Na, H. K., Cho, K. H., & Chu, M. K. (2019). The effect of anxiety and depression on sleep quality of individuals with high risk for insomnia: A population-based study. *Frontiers in Neurology, 10*, 849. https://doi.org/10.3389/fneur.2019.00849.

Pallayova, M., Donic, V., Gresova, S., Peregrim, I., & Tomori, Z. (2010). Do differences in sleep architecture exist between persons with type 2 diabetes and nondiabetic controls?. *Journal of diabetes science and technology*, *4*(2), 344-352. https://doi.org/10.1177/193229681000400215

Pappas, C., Andel, R., Infurna, F. J., & Seetharaman, S. (2017). Glycated haemoglobin (HbA1c), diabetes and trajectories of change in episodic memory performance. *Journal of Epidemiology Community Health*, *71*(2), 115-120. https://doi.org/10.1136/jech-2016-207588.

Patel, A. K., Reddy, V., & Araujo, J. F. (2020). Physiology, sleep stages. *StatPearls [Internet]*.https://www.ncbi.nlm.nih.gov/books/NBK526132/

Payne, J. D., Tucker, M. A., Ellenbogen, J. M., Wamsley, E. J., Walker, M. P., & Schacter, D. L. (2012). Memory for Semantically Related and Unrelated Declarative Information: The Benefit of Sleep, the Cost of Wake. *PLoS ONE*, 7(3), 33079. https://doi.org/10.1371/journal.pone.0033079.

Perry, G. S., Patil, S. P., & Presley-Cantrell, L. R. (2013). Raising awareness of sleep as a healthy behavior. *Preventing chronic disease*, *10*. https://doi.org/10.5888/pcd10.130081

Plihal, W., & Born, J. (1997). Effects of early and late nocturnal sleep on declarative and procedural memory. *Journal of Cognitive Neuroscience*, 9 (4), 534–547. https://doi.org/10.1162/jocn.1997.9.4.534

Potter, G. G., Hartman, M., & Ward, T. (2009). Perceived stress and everyday memory complaints among older adult women. *Anxiety, Stress, & Coping*, *22*(4), 475-481. https://doi.org/10.1080/10615800802449610

Sadanand, S., Balachandar, R., & Bharath, S. (2015). Memory and executive functions in persons with type 2 diabetes: a meta-analysis. *Diabetes and Metabolism Research and Reviews*, *32*(2), 132-142. https://doi.org/10.1002/dmrr.2664.

Schonauer, M. (2018). Sleep spindles: Timed for memory consolidation. *Current Biology Dispatches*. Medical Psychology and Behavioral Neurobiology, University of Tu ̈bingen, Silcherstr, 5. https://doi.org/10.1016/j.cub.2018.03.046

Skeldon, A. C., Derks, G., & Dijk, D. J. (2016). Modelling changes in sleep timing and duration across the lifespan: changes in circadian rhythmicity or sleep homeostasis?. *Sleep medicine reviews*, *28*, 96-107. https://doi.org/10.1016/j.smrv.2015.05.011

Smarr, K. L., & Keefer, A. L. (2011). Measures of depression and depressive symptoms: beck depression inventory-II (BDI-II), Center for Epidemiologic Studies Depression Scale (CES-D), geriatric depression scale (GDS), hospital anxiety and depression scale (HADS), and patient health Questionnaire-9 (PHQ-9). *Arthritis care & research*, *63*(S11), S454-S466. https://doi.org/10.1002/acr.20556

Smyth, C. A. (2020). *Evaluating Sleep Quality in Older Adults: The Pittsburgh Sleep Quality Index can be used to detect sleep disturbances or deficits*. Lippincott Nursing Center. https://www.nursingcenter.com/ce_articleprint?an=00000446-200805000-00028

South African Government. (2021). *What is a noncommunicable disease?* https://www.gov.za/faq/health-non-communicable-diseases/what-non-communicable-disease

Tasali, E., Leproult, R., Ehrmann, D., & Van Cauter, E. (2008). Slow-wave sleep and the risk of type 2 diabetes in humans. *Proceedings of the National Academy of Sciences*, *105* (3) 1044-1049; https://doi.org/10.1073/pnas.0706446105

Tononi, G., & Cirelli, C. (2003). Sleep and synaptic homeostasis: a hypothesis. *Brain research bulletin*, *62*(2), 143-150. https://doi.org/10.1016/j.brainresbull.2003.09.004

Tun, P. A., & Lachman, M. E. (2006). Telephone assessment of cognitive function in adulthood: the Brief Test of Adult Cognition by Telephone. *Age and Ageing*, *35*(6), 629-632. https://doi.org/10.1093/ageing/afl095

Wang, L., Hu, Y., Wang, X., Yang, S., Chen, W., & Zeng, Z. (2021). The association between sleep duration and hypertension: a meta and study sequential analysis. *Journal of Human Hypertension*. *35*, 621-626. https://doi.org/10.1038/s41371-020-0372-y.

Watson, B. O., & Buzaki, G. (2015). What is the brain good for? Sleep, memory & brain rhythms. *Daedalus*, *144*(1), 67-82. https://doi.org/10.1162/DAED_a_00318.

Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., & Heald, J. L. (2015). Joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society on the recommended amount of sleep for a healthy adult: methodology and discussion. *Sleep*, *38*(8), 1161-1183. https://doi.org/10.5664/jcsm.4758.

World Health Organisation. (2018a). *World Health Statistics 2018: Monitoring health for the SDGs.* https://apps.who.int/iris/handle/10665/272596.

World Health Organisation. (2018b). *Noncommunicable Diseases (NCD) Country Profiles, 2018: South Africa* [Powerpoint Presentation]. https://www.who.int/nmh/publications/ncd-profiles-2018/en/

World Health Organisation. (2019, September 13). *Hypertension.* https://www.who.int/news-room/fact-sheets/detail/hypertensiona.

World Health Organisation. (2021a, April 13). *Noncommunicable Diseases. https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases*

World Health Organisation. (2021b, April 13). *Diabetes*. https://www.who.int/en/news-room/fact-sheets/detail/diabetes.

Zhang, H., Li, Y., Zhao, X., Mao, Z., Abdulai, T., Liu, X., Tu, R., Wang, Y., Qian, X., Jiang, J., Tian, Z., Luo, Z., Dong, X., Wang, C., & Bie, R. (2019). The association between PSQI score and hypertension in a Chinese rural population: the Henan Rural Cohort Study. *Sleep Medicine, 58,* 27-34. https://doi.org/10.1016/j.sleep.2019.03.001.

Appendix A: MedPages Broadcast

Dear Doctor

Re: **Telephonic questionnaire to determine hypertensive and diabetic patients' quality of life, sleep, emotion and cognition.**

It is well known that **sleep is essential for optimal physical, emotional and cognitive well-being.** We also know that patients with **diabetes and hypertension** frequently experience poor quality of life, sleep problems, depression and anxiety, and cognitive impairment. Despite the knowledge that poor sleep may be an underlying mechanism linked to reduced quality of life, mood and cognitive problems, very little research has been done to holistically understand this relationship in patients with diabetes and hypertension. Because of the important relationships between sleep, health, emotion and cognition, disrupted sleep could be a useful target for treatment interventions, which may reduce the severity of negative emotional and cognitive symptoms, and improve patient's quality of life.

We are requesting that you invite your patient with diabetes or hypertension to participate in a telephonic interview. In this interview, we will be asking your patients to answer some questions about their sleep, quality of life, emotions and cognition. Since we know that sleep is an important predictor of physical, emotional and cognitive health, we wish to determine to what extent patients with diabetes and hypertension report problems in these domains.

We are looking for **patients between the ages of 18 – 65 years**, who **do not have any target organ damage**. Further, we would like to recruit **patients with diabetes who have a HbA1C < 8 g/%**, and **patients with hypertension who have a BP <140/90 mmHg.**

We should be grateful only once your patients agree to participate in this study that you will communicate their contact details with Dr M. Henry (m.henry@uct.ac.za or mhmish@gmail.com). This way their privacy and confidentiality will be assured. Alternatively, you may give patients my contact details (cell phone number: 0722727107; email: mhmish@gmail.com) and they can contact me directly. On initial contact I or a research assistant will take telephonic informed consent.

Overall, our objectives are two-fold, namely to (1) assess to what extent patients self-report problems with their quality of life, sleep, emotion regulation and cognition, and (2) determine the role that sleep plays in predicting patients physical and emotional well-being and their cognitive functioning.

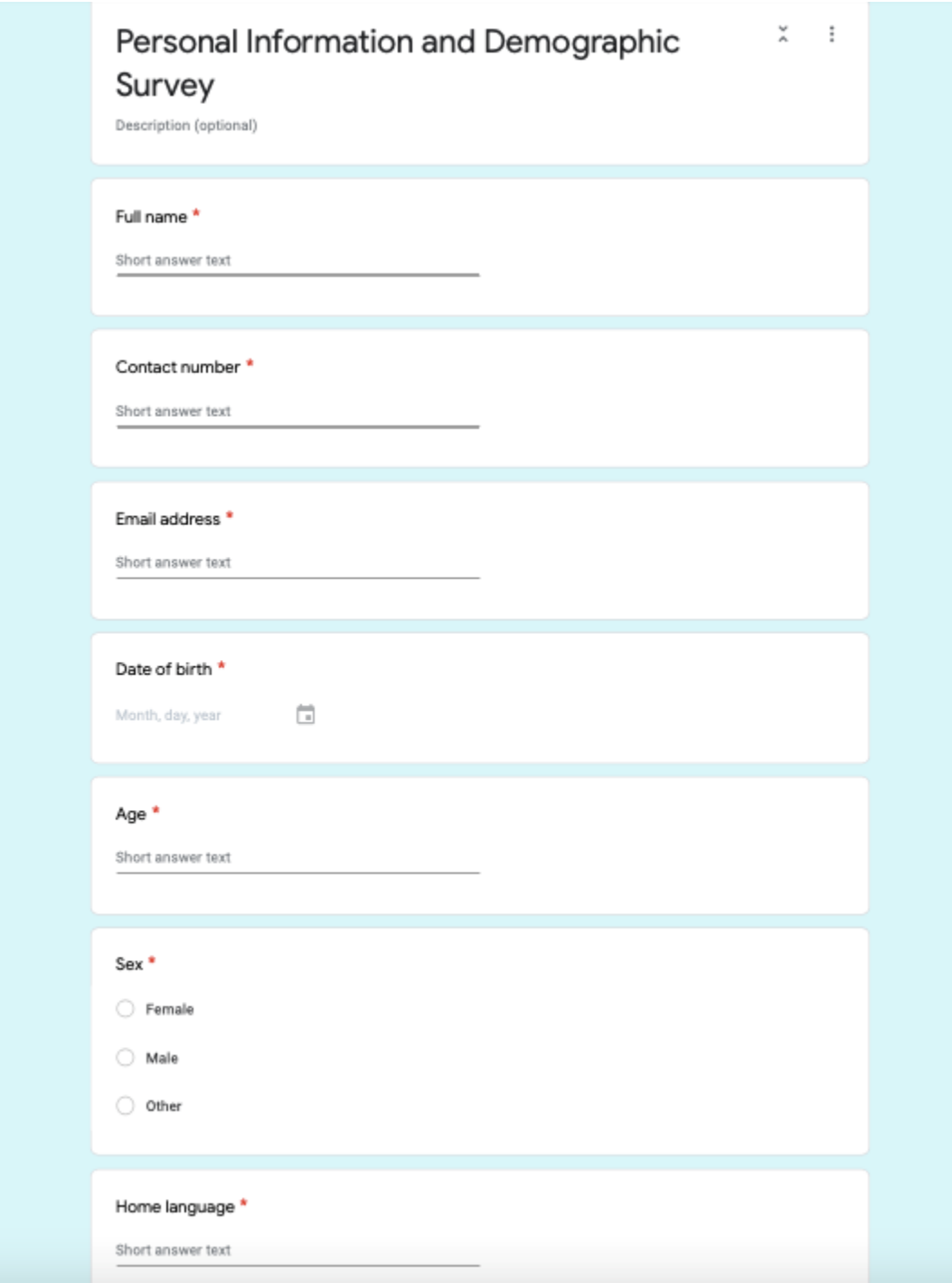
My sincere thanks,

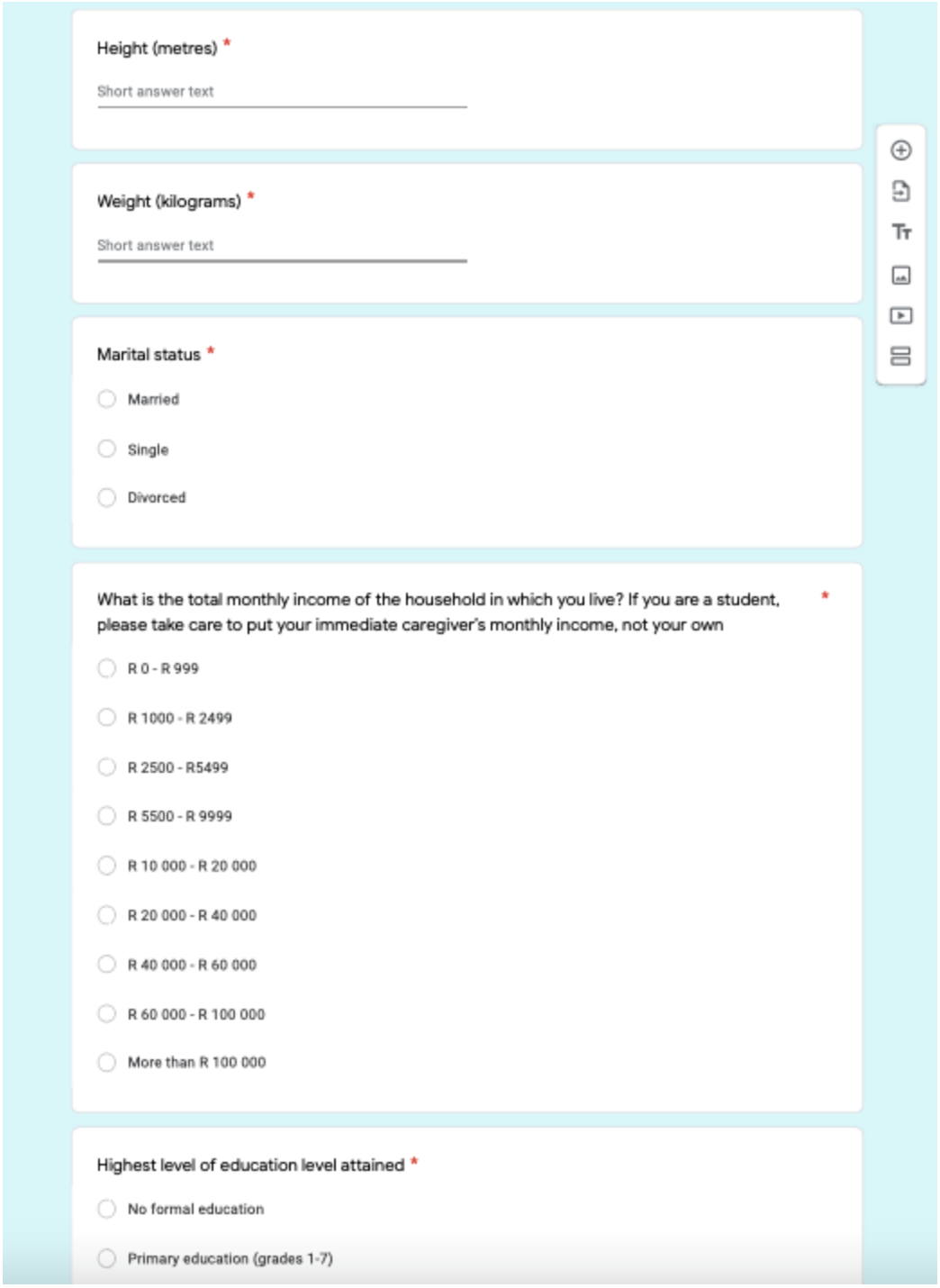
Dr Michelle Henry

Email address: m.henry@uct.ac.za

0722727107

Appendix B: Personal Information and Demographic Survey





Height (metres) *

Short answer text

Weight (kilograms) *

Short answer text

Marital status *

- Married
- Single
- Divorced

What is the total monthly income of the household in which you live? If you are a student, please take care to put your immediate caregiver's monthly income, not your own *

- R 0 - R 999
- R 1000 - R 2499
- R 2500 - R5499
- R 5500 - R 9999
- R 10 000 - R 20 000
- R 20 000 - R 40 000
- R 40 000 - R 60 000
- R 60 000 - R 100 000
- More than R 100 000

Highest level of education level attained *

- No formal education
- Primary education (grades 1-7)

- ○ Secondary education (grades 8-12)
- ○ Tertiary education (college/university)

Do you smoke? If so, how many a day? *

Short answer text

Do you drink alcohol? If so, how many units per week? (example: one unit = one glass of wine) *

Short answer text

Are you pregnant?

- ○ Yes
- ○ No

Have you ever had a head injury? If yes, please specify

Long answer text

Have you ever had a stroke? If yes, please specify

Long answer text

Do you have dementia? *

- ○ Yes
- ○ No

Do you have epilepsy? *

- ○ Yes
- ○ No

Do you have target organ damage? *

Long answer text

Do you have any other physical conditions? If yes, please specify *

Long answer text

Do you suffer from depression? *

- Yes
- No

Do you suffer from anxiety? *

- Yes
- No

Do you suffer from any chronic illnesses (physical or psychological)? If yes, please specify *

Short answer text

Are you on any type of medication/medical treatment for the other chronic illness? If yes, please specify which medication/medical treatment *

Long answer text

List all medication you are currently taking *

Long answer text

Section 4 of 14

Section B: For diabetic patients only

Description (optional)

When were you first diagnosed with diabetes?

Short answer text

What forms of treatment are you currently on for your diabetes?

Long answer text

Provide more information about treatment...

Long answer text

How long have you been on this treatment?

Short answer text

What was your last measured HbAlc?

Short answer text

When was this measurement taken?

Month, day, year

Do you suffer from any other chronic illnesses (physical or psychological)? If yes, please specify

Long answer text

Are you on any type of medication/medical treatment for the other chronic illness/es? If yes, please specify which medication/medical treatment

Long answer text

Section 5 of 14

Section C: For hypertensive patients only

Description (optional)

When were you first diagnosed with hypertension?

Short answer text

What forms of treatment are you currently on for your hypertension?

Long answer text

Provide more information about treatment...

Long answer text

How long have you been on this treatment?

Long answer text

What was your last measured blood pressure?

Long answer text

When was this measurement taken?

Month, day, year

Do you suffer from any other chronic illnesses (physical or psychological)? If yes, please specify

Long answer text

Are you on any type of medication/medical treatment for the other chronic illness/es? If yes, please specify which medication/medical treatment

Long answer text

Appendix C: Consent Form for Hypertensive and Diabetic Participants

Consent to participate in research study:

The role of poor quality sleep in predicting cognitive and neural declarative memory deficits in hypertensive and diabetic individuals

As researchers specialising in psychology (Dr Michelle Henry/Professor Kevin Thomas) and endocrinology (i.e. relating to hormones)(Associate Professor Ian Ross) at the University of Cape Town and Groote Schuur Hospital, we wish to determine the relationship between sleep, quality of life, emotion and thinking. Two psychology Honours students (Julia Tubaro and Abby Sivertsen) will be assisting with data collection for their project.

Why are you being invited to take part?

We are calling on you as you have diabetes/hypertension.

Why is this research been done? What is it trying to find out?

We wish to ask you several questions relating to your self-reported sleep, quality of life, emotion and thinking, and some personal and medical questions. This research is trying to understand how sleep impacts quality of life, emotion regulation and thinking processes in order to inform better treatment options for patients living with hypertension and diabetes. Patients with hypertension/diabetes will be compared to control participants.

To take part in this study you must:

- be between the ages of 18 to 65 years
- not be pregnant
- not have any other chronic illnesses
- be free from neurological disorders and psychiatric illness
- have a BMI less than 40kg/m2
- not be on any medication that could affect your sleep

How long will it take to participate in the study?

The Google Form and telephonic interview will take roughly 1 hour to complete. The questionnaires will take approximately 30-40 minutes to complete. The cognitive assessment will take approximately 15 minutes to complete over the telephone.

What procedures are involved?

The Google Form and telephonic interview will take roughly 1 hour to complete

Are there are any risks and discomforts in taking part in this research?

We do not think that any of these questions pose any physical or psychological risk. If you do however feel vulnerable or anxious after having answered any of the questions, we can refer you to our psychologist.

Are there any benefits to you if you take part in this research?

There is no financial compensation for taking part in this research. However, you may learn a bit more about your own quality of life, sleep, emotion and thinking. You will also be assisting in our knowledge of how sleep quality affects quality of life, thinking and emotions, and this information is potentially useful in our understanding of how to improve patients' well-being. You are encouraged to ask questions if you are unsure about anything.

What other choices do you have?

Should you not wish to participate in the study, it will in no way affect the treatment that you are supposed to receive from your doctor. If, after starting the questionnaire, you no longer wish to participate, you may withdraw your consent at any stage and without it affecting your treatment in any way.

What happens if you do not want to take part in this research?

Participation in this study is completely voluntary. It is your right to refuse to take part in this research. If you do not want to take part in this research, it will in no way affect you or the treatment that you are supposed to receive.

What happens at the end of the research?

All your information and your answers to this study will be kept completely private. Your information will be recorded under a number and will not be linked to your name. Only researchers working on this project will know your personal details and information will not be communicated to anyone apart from them. If we publish the results of this study, we will not communicate any of your personal and private information .

Questions?

If you have any questions about the study, now or in the future, you can call Michelle Henry on 0216501804 or on m.henry@uct.ac.za. If you have questions or concerns about your rights as a research participant, you can contact the Chair of the Human Research Ethics Committee of the Faculty of Health Sciences at the University of Cape Town on 021 650 1236 or hrecenquiries@uct.ac.za.

The participant is aware of the nature and purpose of the study. They have been informed about the procedures, confidentiality agreement, risks and benefits and, they are encouraged to ask further questions should they have any.

Researcher's Signature ……... Date……

Do you agree to participate and consent to have your results used for the purpose of the research thesis and publication in an accredited journal? Are you aware that you are free to withdraw from this study at any given time should you feel the need to do so, and in doing so it will not affect you or your treatment in any way, whatsoever?

Participants verbal consent ……... Date……

Witness name and signature…… Date……

Appendix D: Consent Form for Controls

Consent to participate in research study:

The role of poor quality sleep in predicting cognitive and neural declarative memory deficits in hypertensive and diabetic individuals

As researchers specialising in psychology (Dr Henry/Associate Professor Kevin Thomas) and endocrinology (i.e. relating to hormones) (Associate Professor Ian Ross) at the University of Cape Town and Groote Schuur Hospital, we wish to determine the relationship between sleep, quality of life, emotion and thinking. Two psychology honours students (Julia Tubaro and Abby Sivertsen) will be assisting with data collection for their project.

Why are you been invited to take part?

We are calling on you as a control participant.

Why is this research been done-what is it trying to find out?

We wish to ask you several questions relating to your self-reported sleep, quality of life, emotion and thinking, and some personal and medical questions. This research is trying to understand how sleep impacts quality of life, emotion regulation and thinking processes in order to inform better treatment options for patients living with hypertension and diabetes. Control participants will be compared to patients with hypertension/diabetes.

To take part in this study you must:

- be between the ages of 18 to 65 years
- not be pregnant
- not have any chronic illnesses
- be free from neurological disorders and psychiatric illness
- have a BMI less than 40kg/m2
- not be on any medication that could affect your sleep
- not have severe target organ damage

How long will it take to participate in the study?

The Google Form and telephonic interview will take roughly 1 hour to complete. The questionnaires will take approximately 30-40 minutes to complete. The cognitive assessment will take approximately 15 minutes to complete over the telephone.

What procedures are involved?

The Google Form and telephonic interview will take roughly 1 hour to complete.

Are there are any risks and discomforts in taking part in this research?

We do not think that any of these questions pose any physical or psychological risk. If you do however feel vulnerable or anxious after having answered any of the questions we can refer you to our psychologist.

Are they any benefits to you if you take part in this research?

There is no financial compensation for taking part in this research. However, you may learn a bit more about your own quality of life, sleep, emotion and thinking. You will also be assisting in our knowledge of how sleep quality affects quality of life, thinking and emotions, and this information is potentially useful in our understanding of how to improve patients' well-being. You are encouraged to ask questions if you are unsure about anything.

What other choices do you have?

Should you not wish to participate in the study you do not have to. If after starting the questionnaire, you no longer wish to participate, you may withdraw your consent at any stage.

What happens if you do not want to take part in this research?

Participation in this study is completely voluntary. It is your right to refuse to take part in this research. If you do not want to take part in this research, it will in no way affect you or the treatment that you are supposed to receive.

What happens at the end of the research?

All your information and your answers to this study will be kept completely private. Your information will be recorded under a number and will not be linked to your name. Only researchers working on this project will know your personal details and information will not be communicated to anyone apart from them. If we wish to publish the results of this study, we will not communicate your personal and private information whatsoever.

Questions?

If you have any questions about the study, now or in the future, you can call Michelle Henry on 0216501804 or on m.henry@uct.ac.za. If you have questions or concerns about your rights as a research participant, you can contact the Chair of the Human Research Ethics Committee of the Faculty of Health Sciences at the University of Cape Town on 021 650 1236 or hrecenquiries@uct.ac.za.

The participant is aware of the nature and purpose of the study. They have been informed about the procedures, confidentiality agreement, risks and benefits and, they are encouraged to ask further questions should they have any.

Researcher's Signature ……... Date……

Do you agree to participate and consent to have your results used for the purpose of the research thesis and publication in an accredited journal? Are you aware that you are free to withdraw from this study at any given time should you feel the need to do so?

Participants verbal consent ……... Date……

Witness name and signature…… Date……

Appendix E: Beck Depression Inventory (BDI- II)

BDI - II

Instructions: This questionnaire consists of 21 groups of statements. Please read each group of statements carefully. And then pick out the one statement in each group that best describes the way you have been feeling during the past two weeks, including today. Circle the number beside the statement you have picked. If several statements in the group seem to apply equally well, circle the highest number for that group. Be sure that you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

1. Sadness
   0. I do not feel sad.
   1. I feel sad much of the time.
   2. I am sad all the time.
   3. I am so sad or unhappy that I can't stand it.

2. Pessimism
   0. I am not discouraged about my future.
   1. I feel more discouraged about my future than I used to.
   2. I do not expect things to work out for me.
   3. I feel my future is hopeless and will only get worse.

3. Past Failure
   0. I do not feel like a failure.
   1. I have failed more than I should have.
   2. As I look back, I see a lot of failures.
   3. I feel I am a total failure as a person.

4. Loss of Pleasure
   0. I get as much pleasure as I ever did from the things I enjoy.
   1. I don't enjoy things as much as I used to.
   2. I get very little pleasure from the things I used to enjoy.
   3. I can't get any pleasure from the things I used to enjoy.

5. Guilty Feelings
   0. I don't feel particularly guilty.
   1. I feel guilty over many things I have done or should have done.
   2. I feel quite guilty most of the time.
   3. I feel guilty all of the time.

6. Punishment Feelings
   0. I don't feel I am being punished.
   1. I feel I may be punished.
   2. I expect to be punished.
   3. I feel I am being punished.

7. Self-Dislike
   0. I feel the same about myself as ever.
   1. I have lost confidence in myself.
   2. I am disappointed in myself.
   3. I dislike myself.

8. Self-Criticalness
   0. I don't criticize or blame myself more than usual.
   1. I am more critical of myself than I used to be.
   2. I criticize myself for all of my faults.
   3. I blame myself for everything bad that happens.

9. Suicidal Thoughts or Wishes
   0. I don't have any thoughts of killing myself.
   1. I have thoughts of killing myself, but I would not carry them out.
   2. I would like to kill myself.
   3. I would kill myself if I had the chance.

12. Loss of Interest
   0. I have not lost interest in other people or activities.
   1. I am less interested in other people or things than before.
   2. I have lost most of my interest in other people or things.
   3. It's hard to get interested in anything.

13. Indecisiveness
   0. I make decisions about as well as ever.
   1. I find it more difficult to make decisions than usual.
   2. I have much greater difficulty in making decisions than I used to.

10. Crying
0. I don't cry anymore than I used to.
1. I cry more than I used to.
2. I cry over every little thing.
3. I feel like crying, but I can't.

11. Agitation
0. I am no more restless or wound up than usual.
1. I feel more restless or wound up than usual.
2. I am so restless or agitated, it's hard to stay still.
3. I am so restless or agitated that I have to keep moving or doing something.

16. Changes in Sleeping Pattern
0. I have not experienced any change in my sleeping.
1a I sleep somewhat more than usual.
1b I sleep somewhat less than usual.
2a I sleep a lot more than usual.
2b I sleep a lot less than usual.
3a I sleep most of the day.
3b I wake up 1-2 hours early and can't get back to sleep.

17. Irritability
0. I am not more irritable than usual.
1. I am more irritable than usual.
2. I am much more irritable than usual.
3. I am irritable all the time.

18. Changes in Appetite
0. I have not experienced any change in my appetite.
1a My appetite is somewhat less than usual.
1b My appetite is somewhat greater than usual.
2a My appetite is much less than before.
2b My appetite is much greater than usual.
3a I have no appetite at all.
3b I crave food all the time.

3. I have trouble making any decisions.

14. Worthlessness
0. I do not feel I am worthless.
1. I don't consider myself as worthwhile and useful as I used to.
2. I feel more worthless as compared to others.
3. I feel utterly worthless.

15. Loss of Energy
0. I have as much energy as ever.
1. I have less energy than I used to have.
2. I don't have enough energy to do very much.
3. I don't have enough energy to do anything.

19. Concentration Difficulty
0. I can concentrate as well as ever.
1. I can't concentrate as well as usual.
2. It's hard to keep my mind on anything for very long.
3. I find I can't concentrate on anything.

20. Tiredness or Fatigue
0. I am no more tired or fatigued than usual.
1. I get more tired or fatigued more easily than usual.
2. I am too tired or fatigued to do a lot of the things I used to do.
3. I am too tired or fatigued to do most of the things I used to do.

21. Loss of Interest in Sex
0. I have not noticed any recent change in my interest in sex.
1. I am less interested in sex than I used to be.
2. I am much less interested in sex now.
3. I have lost interest in sex completely.

Total Score: _____

Appendix F: Beck Anxiety Inventory (BAI)

Below is a list of common symptoms of anxiety. Please carefully read each item in the list. Indicate how much you have beenbothered by that symptom during the past month, including today, by circling the number in the corresponding space in thecolumn next to each symptom.

	Not at all	Mildly, but it didn't bother me much	Moderately - it wasn't pleasant at times	Severely - it bothered me a lot
Numbness or tingling	0	1	2	3
Feeling hot	0	1	2	3
Wobbliness in legs	0	1	2	3
Unable to relax	0	1	2	3
Fear of worst happening	0	1	2	3
Dizzy or lightheaded	0	1	2	3
Heart pounding / racing	0	1	2	3
Unsteady	0	1	2	3
Terrified or afraid	0	1	2	3
Nervous	0	1	2	3
Feeling of choking	0	1	2	3
Hands trembling	0	1	2	3
Shaky / unsteady	0	1	2	3
Fear of losing control	0	1	2	3
Difficulty in breathing	0	1	2	3
Fear of dying	0	1	2	3
Scared	0	1	2	3
Indigestion	0	1	2	3
Faint / lightheaded	0	1	2	3
Face flushed	0	1	2	3
Hot / cold sweats	0	1	2	3

Appendix G: Brief Test of Adult Cognition by Telephone (BTACT)

MIDLIFE COGNITION: BIOPSYCHOSOCIAL MECHANISMS
TELEPHONE INTERVIEW
NIA Grant No. PO1 AG20166

MIDUS II Cognitive Battery
Brief Test of Adult Cognition by Telephone (BTACT)
P. A. Tun and M. E. Lachman
Brandeis University
Revised Dec. 18, 2003

In this phone interview I will ask you to try and do some exercises that involve remembering and making judgments about words and numbers. Before we begin, I need to tell you a few things. Your participation is completely voluntary. If you prefer not to answer any question, just let me know and we will go on to the next question. The information that you give me will be confidential and used for statistical analysis only. It will be identified only by computer code and at no time will your name or other identifying information be attached to the survey results. Therefore, I won't be able to give any specific feedback. After the whole study is completed we will send you a summary of our overall findings.

These tasks are not harmful in any way. The exercises will take about 15 minutes. Do you have any questions about your participation is this study?"

We will be tape recording the interview today so that we can score the exercises later. Do I have your permission to go ahead with this?

(If participant seems distracted, or there is noise or commotion in background such as young children, TV or radio, or other people talking, say "It is important that you are able to concentrate without being distracted while we do these exercises. Would it be better for me to call you back another time?" If so, make an appointment for another time.)

First I would like to make sure that you are able to hear me clearly. Please repeat these numbers after me: 2, 8, 3, 6, 9. ***(If not loud enough, ask person to speak up clearly.)*** Could you hear me clearly?

Now you will hear some words and numbers. Please do not use a paper and pencil for any of the questions. We suggest that you close your eyes while you are doing these to help you concentrate. Some of the questions will be easy for you, and some will be harder. We do not expect anyone to get all of these correct - just do the best you can.

WORD LIST RECALL (1.5 minutes on average)
Rey Auditory-Verbal Learning Test (Lezak, 1983)

I am going to read a list of 15 words. Listen carefully. When I am finished, you are to repeat as many of the words as you can remember. It doesn't matter in what order you repeat them. Just try to remember as many as you can. I will say each word only one time, and I cannot repeat any words. You will have up to one and a half minutes, and I will not say anything until I tell you that your time is up. Do you have any questions? Are you ready?

(Read with one second interval between each word)

DRUM
CURTAIN
BELL
COFFEE
SCHOOL
PARENT
MOON
GARDEN
HAT
FARMER
NOSE
TURKEY
COLOR
HOUSE
RIVER

Now tell me as many words as you can remember.

*(Record words recalled **correctly by entering the one or two letter code**, as well as repetitions of same word and intrusions).*

If person stops before 1 1/2 minutes is up, say, "There's still time left, can you think of any more?"

Good, now let's go on.

DIGITS BACKWARD (2.5 minutes)
WAIS III (Wechsler, 1997)

I am going to say some strings of numbers, and when I am done I would like you to repeat them backwards, in the reverse order from which I said them. So if I said "3, 8", you would say "8, 3". Do you understand? The sets will get larger as we go.
(Read in monotone, 1 sec per number..Drop your voice on the last digit to indicate it is time to respond. If they get the first trial on one level, move on to the next level. Discontinue after 2 trials missed on a level).

(1)	2 - 4 (4 - 2)	_____
	5 - 7 (7 - 5)	_____
2.	6 - 2 - 9 (9 - 2 - 6)	_____
	4 - 1 - 5 (5 - 1 - 4)	_____
3.	3 - 2 - 7 - 9 (9 - 7 - 2 - 3)	_____
	4 - 9 - 6 - 8 (8 - 6 - 9 - 4)	_____
4.	1 - 5 - 2 - 8 - 6 (6 - 8 - 2 - 5 - 1)	_____
	6 - 1 - 8 - 4 - 3 (3 - 4 - 8 - 1 - 6)	_____
5.	5 - 3 - 9 - 4 - 1 - 8 (8 - 1 - 4 - 9 - 3 - 5)	_____
	7 - 2 - 4 - 8 - 5 - 6 (6 - 5 - 8 - 4 - 2 - 7)	_____
6.	8 - 1 - 2 - 9 - 3 - 6 - 5 (5 - 6 - 3 - 9 - 2 - 1 - 8)	_____
	4 - 7 - 3 - 9 - 1 - 2 - 8 (8 - 2 - 1 - 9 - 3 - 7 - 4)	_____
7.	9 - 4 - 3 - 7 - 6 - 2 - 5 - 8 (8 - 5 - 2 - 6 - 7 - 3 - 4 - 9)	_____
	7 - 2 - 8 - 1 - 9 - 6 - 5 - 3 (3 - 5 - 6 - 9 - 1 - 8 - 2 - 7)	_____

Good, now let's go on.

CATEGORY FLUENCY (1.5 minutes)
Drachman & Leavitt (1972)

** NOTE: these instructions were rewritten 12/18/03

Now I am going to give you a category and you will name things that belong in that category. Let's practice with the category "fruit". You could say peach, or pear. Can you think of any other fruits? (*wait for 2 correct items*). In a moment I will give you another category. When I say begin, you will name all the things from this **new** category you can think, as fast as you can. You will have one minute to do this. I will let you know when your time is up. The new category is animals. Do you have any questions? Ready?

Begin. ***(Time for one minute)***. If person stops before 1 minute is up, say" There's still more time, can you think of any more?"

(If person asks whether birds, fish, insects, reptiles, etc. are acceptable, say yes.)

1 – 15 sec.

15- 30 sec.

30- 45 sec.

45-60 sec.

Good, now let's go on.

RED/GREEN TEST **(3-3.5 minutes)**

Next I am going to see how quickly you can respond to the words RED and GREEN. Every time I say RED you will say STOP, and every time I say GREEN you will say GO. Try to be accurate, but respond as quickly as you can. So when I say RED you will say…
And when I say GREEN you will say…
Do you have any questions? Let's begin. This will last about 1 minute.

(Do 20 trials. Allow 1 second between response and next cue. Record accuracy with 1 for correct answers, 0 for incorrect or self-corrections, 2 for invalid trials.)

RED/GREEN TASK: BASELINE NORMAL

ALLOW 1 SECOND BETWEEN TRIALS

1	GREEN	GO
2	RED	STOP
3	G	GO
4	R	STOP
5	R	STOP
6	G	GO
7	R	STOP
8	G	GO
9	R	STOP
10	G	GO
11	R	STOP
12	G	GO
13	G	GO
14	R	STOP
15	R	STOP
16	G	GO
17	R	STOP
18	G	GO
19	G	GO
20	R	STOP

Now you will do just the reverse of what you have been doing. So when you hear RED you will say GO, and when you hear GREEN you will say STOP. Do you have any questions? When I say RED you will say… and when I say GREEN you will say…
Try to be accurate, but answer as quickly as you can.

(Do 20 trials. Allow one second between response and next cue. Record accuracy with 1 for correct answers, 0 for incorrect or self-corrections, 2 for invalid trials.)

RED/GREEN TASK: BASELINE SWITCHED
ALLOW 1 SECOND BETWEEN TRIALS

1	GREEN	STOP
2	RED	GO
3	G	STOP
4	R	GO
5	R	GO
6	G	STOP
7	R	GO
8	G	STOP
9	R	GO
10	G	STOP
11	R	GO
12	G	STOP
13	G	STOP
14	R	GO
15	R	GO
16	G	STOP
17	R	GO
18	G	STOP
19	G	STOP
20	R	GO

Now we are going to mix up these two types of responses. When I give the cue NORMAL, you will respond the way you did at first: red means stop, green means go. But when I say REVERSE , you will give the reverse responses: RED means GO, GREEN means STOP. We will alternate between the NORMAL and the REVERSE every few trials. Let's try a few for practice.

NORMAL	RED	STOP
	GREEN	GO
	RED	STOP
REVERSE	GREEN	STOP
	RED	GO
	RED	GO
NORMAL	GREEN	GO
	RED	STOP
	GREEN	GO
REVERSE	GREEN	STOP
	RED	GO

Do you have any questions? . Try to be accurate, but answer as quickly as you can. This will take about one minute.

(Allow one second between cue word (normal or switch) and stimulus color item. Also allow one second between subject's response and the next stimulus item. Record correct, incorrect, and invalid trials.)

RED/GREEN TASK: EXPERIMENTAL TRIALS

1 ALLOW 1 SEC	NORMAL	GREEN	GO
2 INTERVALS		RED	STOP
3		G	GO
4	REVERSE	R	GO
5		R	GO
6		G	STOP
7		R	GO
8		R	GO
9	NORMAL	R	STOP
10		G	GO
11		R	STOP
12		G	GO
13		G	GO
14		R	STOP
15	REVERSE	G	STOP
16		G	STOP
17		R	GO
18		G	STOP
19	NORMAL	G	GO
20		R	STOP
21		G	GO
22		G	GO
23		R	STOP
24	REVERSE	G	STOP
25		G	STOP
26		R	GO
27		G	STOP
28		R	GO
29	NORMAL 4	R	STOP
30		G	GO
31		R	STOP
32		G	GO

Good, now let's do something different.

NUMBER SERIES (2.5 minutes)
(Based on Salthouse & Prill, 1987)

In the next exercise I will read you a series of numbers that may get larger or smaller in value. At the end you will try to figure out what the next number would be. So if the numbers were 2,4,6,8,10, the next number would be 12. After I say each number I will pause for as long as you need, and then you should say "okay" when you are ready for me to go on to the next number in the group. So if I said 2, you should say "okay" when you are ready for me to go on to the next number, then I say 4, you say okay, 6, okay, 8, okay, 10, and at the end I will ask you what you think the next number would be. In this case the next number would be 12, as each number has increased by 2.

Let's try one for practice: 35 (okay), 30 (okay), 25 (okay), 20 (okay), 15 (okay) **AND** the next number would be….???? (The answer should be 10 as each number has decreased by 5). There will be different patterns, and some of these will be harder than others, so just do the best you can. If you are not sure of the answer, it is okay to guess. Do you have any questions?
*(Pause after each of the first 4 items for okay response; after the last item, say **AND** the next number is…?).*

1. 18, 20, 24, 30, 38…….(48) _____

Okay. Are you ready for another? The next set is:

2. 81, 78, 75, 72, 69…….(66) _____

Okay. Are you ready for another? The next set is

3. 7, 12, 16, 19, 21……..(22) _____

Okay. Are you ready for another? The next set is

4. 28, 25, 21, 16, 10…….(3) _____

Okay. Are you ready for another? The next set is

(5) 20, 37, 18, 38, 16…….(39) _____

Good, let's move on.

BACKWARD COUNTING (45 seconds)

Next, I would like to see how fast you can count backwards. When I give the signal to begin, start counting backwards from 100 out loud, as fast as you can. So you will say 100, 99, 98 and so on. You will have half a minute. Do you have any questions? I will let you know when the time is up.

Begin *(Time for 30 seconds)*

Record final number reached, and number of errors.

Good, now one more question.

SHORT-DELAY WORD RECALL (40 seconds on average)

Do you remember the very first list of 15 words that I read to you in the beginning? It was the very first thing we did. (WAIT FOR SUBJECT TO RESPOND YES. MAKE SURE THEY UNDERSTAND THAT IT IS THE WORD LIST, NOT THE CATEGORY FLUENCY TEST). I want you to tell me as many of the words from that list as you can. You will have up to one minute. I will tell you when your time is up. *(Record words recalled, including intrusions and repetitions .) If person stops before 1 minute is up, say,* "there is still more time can you think of any more?"

DRUM
CURTAIN
BELL
COFFEE
SCHOOL
PARENT
MOON
GARDEN
HAT
FARMER
NOSE
TURKEY
COLOR
HOUSE
RIVER

Thank you very much for your help. We appreciate you taking the time to help us with this research project.
THANK YOU!

(Encouraging comments to be used if the person expresses concern about performance:

During the test: "Just do the best you can."

Remember, we do not expect anyone to get all of these questions correct."

"Don't worry. We have deliberately made these questions challenging. If people could get them all right, we would not learn anything. We're trying to find which questions are harder than others.")

Appendix H: Pittsburgh Sleep Quality Index (PSQI)

Subject's Initials_____ID#_____Date_____Time_____AM PM

PITTSBURGH SLEEP QUALITY INDEX

INSTRUCTIONS:
The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?

   BED TIME _____

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

   NUMBER OF MINUTES _____

3. During the past month, what time have you usually gotten up in the morning?

   GETTING UP TIME _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

   HOURS OF SLEEP PER NIGHT _____

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Wake up in the middle of the night or early morning

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Have to get up to use the bathroom

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Cannot breathe comfortably

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

e) Cough or snore loudly

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

f) Feel too cold

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

g) Feel too hot

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

h) Had bad dreams

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

i) Have pain

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

j) Other reason(s), please describe_____

_____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

6. During the past month, how would you rate your sleep quality overall?

Very good _____

Fairly good _____

Fairly bad _____

Very bad _____

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all _____

Only a very slight problem _____

Somewhat of a problem _____

A very big problem _____

10. Do you have a bed partner or room mate?

No bed partner or room mate _____

Partner/room mate in other room _____

Partner in same room, but not same bed _____

Partner in same bed _____

If you have a room mate or bed partner, ask him/her how often in the past month you have had . . .

a) Loud snoring

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

b) Long pauses between breaths while asleep

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

c) Legs twitching or jerking while you sleep

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

d) Episodes of disorientation or confusion during sleep

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

e) Other restlessness while you sleep; please describe_____

_____

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

Appendix I: Perceived Stress Scale (PSS-10)

Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts **during the last month**. In each case, you will be asked to indicate by circling *how often* you felt or thought a certain way.

Name _____ Date _____

Age _____ Gender (*Circle*): **M F** Other _____

0 = Never 1 = Almost Never 2 = Sometimes 3 = Fairly Often 4 = Very Often

1. In the last month, how often have you been upset because of something that happened unexpectedly?	0	1	2	3	4
2. In the last month, how often have you felt that you were unable to control the important things in your life?	0	1	2	3	4
3. In the last month, how often have you felt nervous and "stressed"?	0	1	2	3	4
4. In the last month, how often have you felt confident about your ability to handle your personal problems?	0	1	2	3	4
5. In the last month, how often have you felt that things were going your way?	0	1	2	3	4
6. In the last month, how often have you found that you could not cope with all the things that you had to do?	0	1	2	3	4
7. In the last month, how often have you been able to control irritations in your life?	0	1	2	3	4
8. In the last month, how often have you felt that you were on top of things?	0	1	2	3	4
9. In the last month, how often have you been angered because of things that were outside of your control?	0	1	2	3	4
10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	0	1	2	3	4

Appendix J: Department of Psychology Ethical Approval

UNIVERSITY OF CAPE TOWN

Department of Psychology

University of Cape Town Rondebosch 7701 South Africa
Telephone (021) 650 3417
Fax No. (021) 650 4104

21 July 2021

Michelle Henry
Department of Psychology
University of Cape Town
Rondebosch 7701

Dear Michelle

I am pleased to inform you that ethical clearance has been given by an Ethics Review Committee of the Faculty of Humanities for your study, *The role of sleep disruption in predicting quality of life, emotion regulation and cognition in non-communicable diseases*. The reference number is PSY2021-028.

I wish you all the best for your study.

Yours sincerely

Lauren Wild (PhD)
Associate Professor
Chair: Ethics Review Committee

Appendix K: Faculty of Health Sciences Ethical Approval

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room G50- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-enquiries@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

12 October 2021

HREC REF: 515/2021

Dr M Henry
Centre for Higher Education Development
Room 5.04 Hoerikwaggo Building-UCT
Email: m.henry@uct.ac.za
Student: SVRABI001@myuct.ac.za & TBRJUL002@myuct.ac.za

Dear Dr Henry

PROJECT TITLE: THE ROLE OF SLEEP DISRUPTION IN PREDICTING QUALITY OF LIFE, EMOTION REGULATION AND COGNITION IN NON-COMMUNICABLE DISEASES-HONS CANDIDATES-MS ABBY SIVERTSEN & MS JULIA TUBARO

Thank you for your response letter, addressing the issues raised by the Faculty of Health Sciences Human Research Ethics Committee (HREC).

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, dated 17 March 2020; 06 July 2020 & 01 July 2021.

Approval is granted for one year until the 30 October 2022.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the students: Ms Abby Sivertsen & Ms Julia Tubaro will also be involved in this study.

Please quote the HREC REF 515/2021 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
NHREC-registration number: REC-210208-007

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Appendix L: Table 4

Table 5

Table of Regression Analyses for PSQI subcomponents and memory subtests (N = 46)

	Immediate		Delayed	
Variable	*f*	*p*	f	*p*
Sleep quality	$F(2, 43) = 1.45$	.123	$F(2, 43) = 2.09$	.068
Sleep duration	$F(2, 43) = 1.48$	.120	$F(2, 43) = 2.08$	.069
Daytime dysfunction	$F(2, 43) = 1.62$	.105	$F(2, 43) = 2.14$	.065
Sleep duration (raw score)	$F(2, 43) = 1.66$	.101	$F(2, 43) = 2.11$	.067