DOCTOR OF CLINICAL PSYCHOLOGY (DCLINPSY)

Doctorate in Clinical Psychology: Main Research Portfolio

1) The Effects of Mindfulness-Based Interventions on Executive Function in non-clinical Adults: A Systematic Review and Meta-Analysis; 2) Exploring Representation of People of Global Ethnic Majority in the Memory Service: A Retrospective Analysis of 7-Years of Referral Data; 3) Exploring the Impact of Intensive Care Shifts on Nurses' Executive Function: An Observational Study.

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[Main Portfolio: 1) The Effects of Mindfulness-Based Interventions on Executive Function in non-clinical Adults: A Systematic Review and Meta-Analysis; 2) Exploring Representation of People of Global Ethnic Majority in the Memory Service: A Retrospective Analysis of 7-Years of Referral Data; 3) Exploring the Impact of Intensive Care Shifts on Nurses' Executive Function: An Observational Study.]

Volume 1

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Doctorate in Clinical Psychology

University of Bath

Department of Psychology

May 2024

Declaration of any previous submission of the work

The material presented here for examination for the award of a higher degree by research has not been incorporated into a submission for another degree.

Candidate's signature… [redacted] ……………………

Declaration of authorship

I am the author of this portfolio, and the work described therein was carried out by myself personally except for the following:

1) The concept for my literature review was developed between myself and my research supervisor, Rachel Paskell. Elise Arnold, Research Apprentice, acted as a second reviewer and supported with screening and selection of relevant papers and with data extraction.

2) My Service-Related Project was developed between myself, my field supervisor, Laura Meader, and my research supervisor, Rachel Paskell. I developed the final questions to explore and conducted the analysis. Interpretation of results was supported by supervisors, team members of the service, and an expert by experience.

3) The initial idea for my Main Research Project came from Mike Osborn, Consultant Clinical Psychologist. I developed the final questions to explore and gaining relevant ethical approval. Support for the analysis plan was provided by Rachael Bedford and Ashley Vanstone.

Feedback on drafts of reports was provided by supervisors listed on the cover sheet for each paper. I am responsible for the final thesis submitted here.

Candidate's signature… [redacted] ……………………

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Reflective Narrative: 2,879

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Abstracts

Literature Review

Objectives: The aim of this systematic review and meta-analysis was to explore effects of mindfulness-based interventions on executive functions (EF) in studies including ≥2 non-self-report measures of EF. ≥2 non-self-report measures are included, given that EF comprises of both unity and diversity between and within component processes.

Methods: Systematic searches were conducted on four databases (PsycINFO (APA PsychNET), CINAHL (EBSCO), Embase, and Medline (PubMed)) and grey literature searches via ProQuest Dissertations. Included studies were randomised-controlled trials comparing mindfulness-based interventions to active or inactive controls and outcomes with ≥2 non-self-report measures of EF, in non-clinical adult samples.

Results: Fifteen studies were identified that met inclusion criteria. Risk of bias, as assessed using the Cochrane Collaboration's revised tool for assessing risk of bias in randomised controlled trial's (RoB-2; Sterne et al., 2019), varied from 'some concerns' (k = 12) to 'high' (k = 3). Twelve studies were included in quantitative analysis. Mindfulness-based interventions were found to significantly improve inhibitory control, working memory, and overall EF, but not cognitive flexibility. However, magnitudes of effect were negligible, other than a small effect for inhibitory control (g = 0.26) and heterogeneity estimates between studies may be unreliable.

Conclusions: Findings suggest specific as opposed to general effects of mindfulness-based interventions on EF. Conclusions support previous reviews that included only one measure of EF. Current results allow more reliable comparisons between EF measures and subcomponents, given the inclusion of a meta-analysis. Further studies including active controls and follow-ups are needed.

Keywords: Mindfulness-Based Interventions, Mindfulness, Executive Function

Service-Related Project

Objectives: The current project aimed to explore ethnic inequalities in referrals to one United Kingdom memory service.
Methods: A retrospective clinical audit design explored routinely collected data for the 5,860 referrals received by the service from and including 2015 to 2021. Estimates of ethnic diversity were obtained from the 2011 and 2021 censuses.
Results: The proportion of referrals from people of global ethnic majority was lower than expected compared to their white counterparts. This proportion evened when referrals were compared to the ethnic diversity in just those aged 65 and over, the highest-risk age group for dementia (Prince et al., 2015). Fifteen percent of referrals had missing ethnicity data which may obscure findings.
Discussion: In line with UK-wide trends, ethnic inequalities exist in referrals, including age and access proportions. However, within the highest-risk age group for dementia, less evidence of ethnic inequalities in referrals was observed.

Keywords: Dementia, Ethnic Inequalities, Ethnicity

Main Research Project

Background: High stress and poor sleep negatively affect executive function (EF) and are prevalent among intensive care unit (ICU) nurses. Reductions in EF could impact patient safety and nurse wellbeing. This study examined changes in EF between the start and end of ICU nursing day shifts and predictors of post-shift EF performance.

Method: Data from 19 ICU nurses were collected at the start and end of day shifts for each component of EF (working memory, inhibition, and cognitive flexibility). Self-report measures of sleep quality and perceived stress were included to predict post-shift EF performance.

Results: Despite not meeting recruitment targets ($N = 34$), full datasets were obtained for 19 of 21 recruited participants. No statistically significant pre-post shift differences in EF performance were observed, but some reliable changes were found in inhibition ($n = 2$) and cognitive flexibility ($n = 4$). Pre-shift EF was the strongest predictor of post-shift EF. Perceived stress also predicted post-shift inhibition performance.

Conclusion: ICU nurses generally perform well on EF measures despite some reported stress and sleep difficulties. However, high stress may predict lower performance in certain EF aspects at shift end. Future studies with larger samples are warranted to further explore these preliminary findings.

Keywords: Executive Function, Intensive Care, Critical Care, Nurses, Stress

Literature Review

The Effects of Mindfulness-Based Interventions on Executive Function in non-clinical Adults: A Systematic Review and Meta-Analysis

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May 2024

Primary Supervisor: Dr Rachel Paskell, Senior Lecturer, University of Bath

Secondary Supervisors: Dr Rachael Bedford, Senior Lecturer/Associate Professor, University of Bath

Word Count: 7,669

The target journal for my Literature Review was 'Mindfulness' (word limit not specified; 45-page maximum). This journal was chosen as a peer reviewed journal with international reach, focussing on papers seeking to advance understandings in mindfulness, including outcomes of treatment interventions. The journal welcomes submissions from diverse perspectives including psychological and cognitive perspectives. Guidance on journal formatting requirements is here: https://link.springer.com/journal/12671/submission-guidelines.

Introduction

Executive functions (EF) are top-down, effortful mental processes that support reasoning, problem-solving and planning (Collins & Koechlin, 2012). EFs are critical across the breadth of human experience including mental health (Barch, 2005), physical health (Crescioni et al., 2011; Miller et al., 2011), quality of life (Brown & Landgraf, 2010), job success (Bailey, 2007), and marital harmony (Eakin et al., 2004). Reviews of the literature suggest EF models may vary by age (e.g., preschool children = one/two-factor; school-age children = three-factor; older adult = two/three-factor; Karr et al., 2018) as EF is still developing in younger people (Lenroot & Giedd, 2006), and adults in later life may experience cognitive decline (Blazer et al., 2015). In adults, a three-factor model consisting of updating/working memory, inhibition, and shifting/cognitive flexibility is generally most accepted (Miyake et al., 2000).

Working memory consists of perceiving, processing and storing, and retrieving information (Baddeley & Hitch, 1974). Working memory is thought to comprise of a central executive to guide executive attention and manage capacity, a phonological loop responsible for retaining auditory information, a visuospatial sketchpad responsible for retaining visual information, and an episodic buffer to support integration of information (Baddeley, 2000). Working memory differs from short-term memory, which allows information to be stored temporarily, by allowing the manipulation of stored information for reasoning and decision-making.

Inhibition involves the ability to consciously control automatic thoughts, feelings, or behaviours to select more appropriate responses consistent with one's goals (Munakata et al., 2011). Evidence suggests that response inhibition, the ability to supress prepotent motor responses, and attentional inhibition, the ability to inhibit interference from distracting stimuli, refer to independent constructs under the umbrella of inhibitory control (Tiego et al., 2018).

Lastly, cognitive flexibility refers to the ability to quickly switch between tasks (task shifting) or mental states (set shifting). Evidence suggests there may be two forms of cognitive flexibility. Spontaneous flexibility refers to the automatic flow of ideas and answers, including generation of diverse and creative solutions through engaging effective search strategies (e.g., verbal fluency tasks). In contrast reactive flexibility refers to ability to adapt behaviour and thinking in response to environmental cues (Eslinger & Grattan, 1993).

Evidence from both latent variable analysis (Miyake et al., 2000) and neuroimaging (Smolker et al., 2015) suggest whilst there is significant overlap between component processes of EF, that they are also separable. Factor analyses indicate whilst there are strong relationships between latent factors of EF, the model fit is lower if one or more latent factor is excluded from the model, suggesting factors are also separable (Miyake et al., 2000). Neuroimaging studies suggest whilst the prefrontal cortex supports EF, at a finer anatomical level, performance on tasks can be distinguished. Smolker et al. (2015) found that working memory was associated with dorsolateral prefrontal cortex grey matter volume whereas cognitive flexibility was associated with ventrolateral prefrontal cortex grey matter volume. Indeed, the Miyake and Friedman (2012) model refer to this as unity (tapping into a common underlying ability) and diversity (distinct cognitive processes).

Stress has been shown to impair EF performance (Diamond, 2013). Stress occurs frequently in daily life and can impact health, academic achievement, and career success (Shields et al., 2016). Certain populations are at greater risk of stress including those who are caregivers (Oken et al., 2010), from lower socioeconomic backgrounds (Sibinga et al., 2013), or in certain occupations, such as healthcare (Baglioni et al., 2018; Imo, 2017). There is some evidence to suggest that healthcare shifts negative effect EF performance (Esmaily et al., 2021). Given the importance of EF on the human experience, understanding interventions to improve it are paramount.

A recent large-scale review of typically developing and aging populations identified 179 different studies exploring intervention types to improve EF (Diamond & Ling, 2019). Of the 13 interventions identified, mindfulness-based interventions had the strongest evidence. Indeed, every study involving mindful movement included found clear or suggestive evidence of the benefit for EF (Diamond & Ling, 2019) and at least half of studies involving sedentary mindfulness found evidence for the benefit of EF. However, benefit in the review was defined as “more EF improvement or better EF post-test performance than control group on ≥ 50% of measures” (Diamond & Ling, 2019, p. 6) and was reported as a frequency as opposed to overall size of effect.

Mindfulness is the awareness that arises from paying attention in a particular way; on purpose, in the present moment and non-judgmentally (Kabat-

Zinn, 1994, p. 4). Mindfulness-based interventions are those that include mindfulness meditation as a core component, and an element of home meditation practice, to allow between-session development and implementation of skills (Parsons et al., 2017). Mindfulness-Based Cognitive Therapy (MBCT; Segal et al., 2002) would be considered a mindfulness-based intervention, whereas, Acceptance and Commitment Therapy (ACT; Hayes et al., 1999), which emphasizes the attitudinal stance, rather than formal practice itself, would not.

One hypothesis explaining why mindfulness-based interventions improve EF is that interventions to ameliorate stress indirectly benefit EF. Indeed, a study exploring effects of yoga on EF identified attenuating stress as a mediating factor in the relationship between yoga and EF (Gothe et al., 2016). Additionally, a more direct mechanism posits that mindfulness-based interventions improve EF by training participants to attend to the present moment through repeated inhibition of internal and external stimuli and shifting back to present moment awareness (Baer & Krietemeyer, 2006). This more direct mechanism suggests specific, as opposed to general, effects of mindfulness-based interventions on EF. Indeed, a review exploring the effects of mindfulness-based interventions on latent factors of EF, found that mindfulness-based interventions consistently benefited inhibition, with more variable benefits for working memory and flexibility (Gallant, 2016).

Considering EFs consist of three core, higher-order processes (Miyake et al., 2000), studies including only one measure may be biased. In a study exploring effects of mindfulness-based stress reduction (MBSR) on EF, MacCoon et al. (2014) found no benefit of MBSR on EF, however, used a measure of sustained attention as the only outcome. Given EF comprises of related, but separable latent components, it is possible another latent factor of EF may show improvements from MBSR, altering conclusions drawn.

To determine whether mindfulness-based interventions produce effects on EFs across all constituent processes (general), or on individual component process (specific), Gallant (2016) analysed results for each of three-factor latent components separately (Miyake et al., 2000). Results demonstrated specific as opposed to general benefits of mindfulness-based interventions on EF. Indeed, mindfulness-based interventions were shown to consistently benefit inhibition, with more variable benefits identified on working memory and cognitive flexibility (Gallant, 2016). This suggests the importance of studies exploring both general and specific effects of mindfulness-based interventions on EF by including more than one measure of EF. Whilst Gallant (2016) has begun to explore the effects of mindfulness-based interventions on EF, a meta-analytic approach would strengthen conclusions.

Current Study

Evidence from existing reviews suggest that mindfulness-based interventions may improve EFs (Chiesa et al., 2011; Diamond & Ling, 2019; Gallant, 2016; Whitfield et al., 2022), with consistent benefits on inhibition, and variable benefits for working memory and cognitive flexibility (Gallant, 2016). The aim of the current review is to strengthen current findings by including a meta-analysis within the design and examine effects of mindfulness-based interventions on component processes of EF in studies where ≥2 non-self-report measures are included, given that EF comprises of both unity and diversity between and within component processes. This could include measures within the same component process as it is likely that different measures will measure both unique and constituent cognitive processes (for example, measures of inhibition could represent distinct motor or response inhibition). Additionally, given popularity of study and/or publishing, additional papers may have been published, warranting systematic exploration.

Methods

Protocol and Registration

The review was registered with PROSPERO in November, 2022 [CRD42022375023], in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations (Moher et al., 2009).

Inclusion Criteria

Population

Participants in eligible studies were from community samples and aged 18 – 65 years. This age range was selected because EF is still developing in younger people (Lenroot & Giedd, 2006), and adults in later life may experience cognitive decline (Blazer et al., 2015). Studies were not specifically exploring known diseases and medical conditions.

Intervention

Interventions were mindfulness-based interventions of more than one session with pre- post-intervention assessments. Eligible interventions included mindfulness meditation as a core component and an element of home practice within treatment. Interventions that combined mindfulness with other therapeutic modalities including MBCT (Segal et al., 2002), were included. Interventions that emphasized the attitudinal stance of mindfulness rather than formal practice, including ACT (Hayes et al., 1999) were excluded.

Comparison

Eligible studies used a randomised controlled trial (RCT) design comparing mindfulness-based interventions to passive and/or active controls. Quasi-RCT's were included (e.g., group randomisation).

Outcome

Studies with ≥2 non-self-report measure of EF were included to allow component cognitive processes to be explored within the same participant groups. The ≥2 non-self-report measure of EF measures could encompass a single latent component of EF or multiple given that EFs show both unity and diversity (Miyake & Friedman, 2012).

There were no restrictions regarding publication period. Eligible studies were in English language.

Strategy Search

The databases PsycINFO (APA PsychNET), CINAHL (EBSCO), Embase, and Medline (PubMed), were systematically searched. Grey literature searches were conducted with ProQuest Dissertations. Reference lists from included papers were screened. The initial search was conducted on the 6th of April 2023. A final search was conducted on 12th February 2024 to ensure recently published papers were included. Search terms were grouped into "mindfulness-based intervention" and "executive function." Search terms were applied to title, abstract and keywords. See appendix A for search strings.

Study Selection and Data Extraction

Covidence was used to manage duplication, title and abstract, and full text reviews. One reviewer (TSJ) screened title and abstracts to remove articles that clearly met exclusion criteria. A 10% sample of title and abstracts were screened by a second reviewer (EA) to ascertain agreement. Two reviewers (TSJ & EA) applied inclusion and exclusion criteria to full texts to select eligible articles. Disagreements were recorded and discussed. One reviewer (TSJ) extracted the following data from each paper, which was checked by a second reviewer (EA): 1) participant characteristics (number, age, sex, gender, ethnicity); 2) intervention features (type of intervention, duration, home practice, timing of assessment, control); 3) cognitive tasks; and 4) outcomes. Lead authors were contacted in cases of missing data.

Analysis

Whilst the pre-specified analysis plan indicated that greater than five papers with the same outcome measure were required to complete a meta-analysis (PROSPERO [CRD42022375023]), it was decided to amend this to not specify the need for the same outcome measure.

Meta-Analysis

As outlined in the pre-specified analysis plan, four random-effects models were tested: 1) examine effect of mindfulness-based interventions on overall executive function; 2) examine effect of mindfulness-based interventions working memory; 3) examine effect of mindfulness-based interventions on cognitive inhibition; and 4) examine effect of mindfulness-based interventions on cognitive flexibility. Statistical analyses were constructed using the statistical software package JASP (Grasman, 2017).

The measure of effect size was the standardised mean difference, corrected for small sample sizes (Morris, 2008). Scores on tests where lower scores indicate better performance were multiplied by negative one to ensure all scores followed the same format, whereby higher scores represented better performance. For each outcome, pre-post intervention mean differences were calculated for each group, as well as the differences between these change scores. This score was divided by the pooled pre-test standard deviation, and adjusted using approximate correction factor *J,* to give Hedge's *g* (Morris, 2008). The pre-post intervention correlation for each outcome is required to calculate *g.* None of the papers in the review provided this value. Therefore, a value of $r = 0.50$ was chosen as this is typically used in cases where the pre-post intervention correlation is unknown and was used for all effect size calculations. The SMD was calculated for each individual outcome variable.

For meta-analyses, where studies used more than one measure within the same subcomponent of EF, effect sized were combined to ascertain one effect size for that subcomponent (Borenstein et al., 2021). For studies with both active and inactive control groups, only the effect size from the active control group were included in the main analyses, given this constitutes a more rigorous comparison. A random-effect model was applied as this assumes heterogeneity between studies, even if a test for heterogeneity does not show a significant result. I-squared, ranging from 0-100%, measures the degree of inconsistency across studies in a meta-analysis. Visual inspection and I-squared was used to assess for study heterogeneity (Higgins et al., 2003). I-squared values of 25%, 50%, and 75% represent low, moderate, and high heterogeneity respectively (Higgins et al., 2003). Publication bias was investigated through visual inspection of funnel plots.

Risk of Bias

Two reviewers (TSJ & EA) assessed risk of bias on included papers using the Cochrane Collaboration's revised tool for assessing risk of bias in RCT's (RoB-2; Sterne et al., 2019). Disagreements were recorded and discussed. RoB-2 provides a framework for considering risk of bias in a single estimate of an effect reported from RCT's by focussing on: 1) randomisation process; 2) deviations from intended interventions; 3) missing outcome data; 4) measurement of outcome; and 5) selection of reported result. For each domain, a level of risk is identified ('Yes' or 'Probably yes'; 'No' or 'Probably no'; 'No information'). Methodological quality of studies is based on overall risk of bias and assessed as either 'low, 'some concerns', or 'high' risk. Of note whilst the prespecified analysis plan stipulated use of ROB version one (Higgins et al., 2011), it was decided to amend this to use version two to reflect current recommendations and understandings of how causes of bias can influence study results (Sterne et al., 2019),

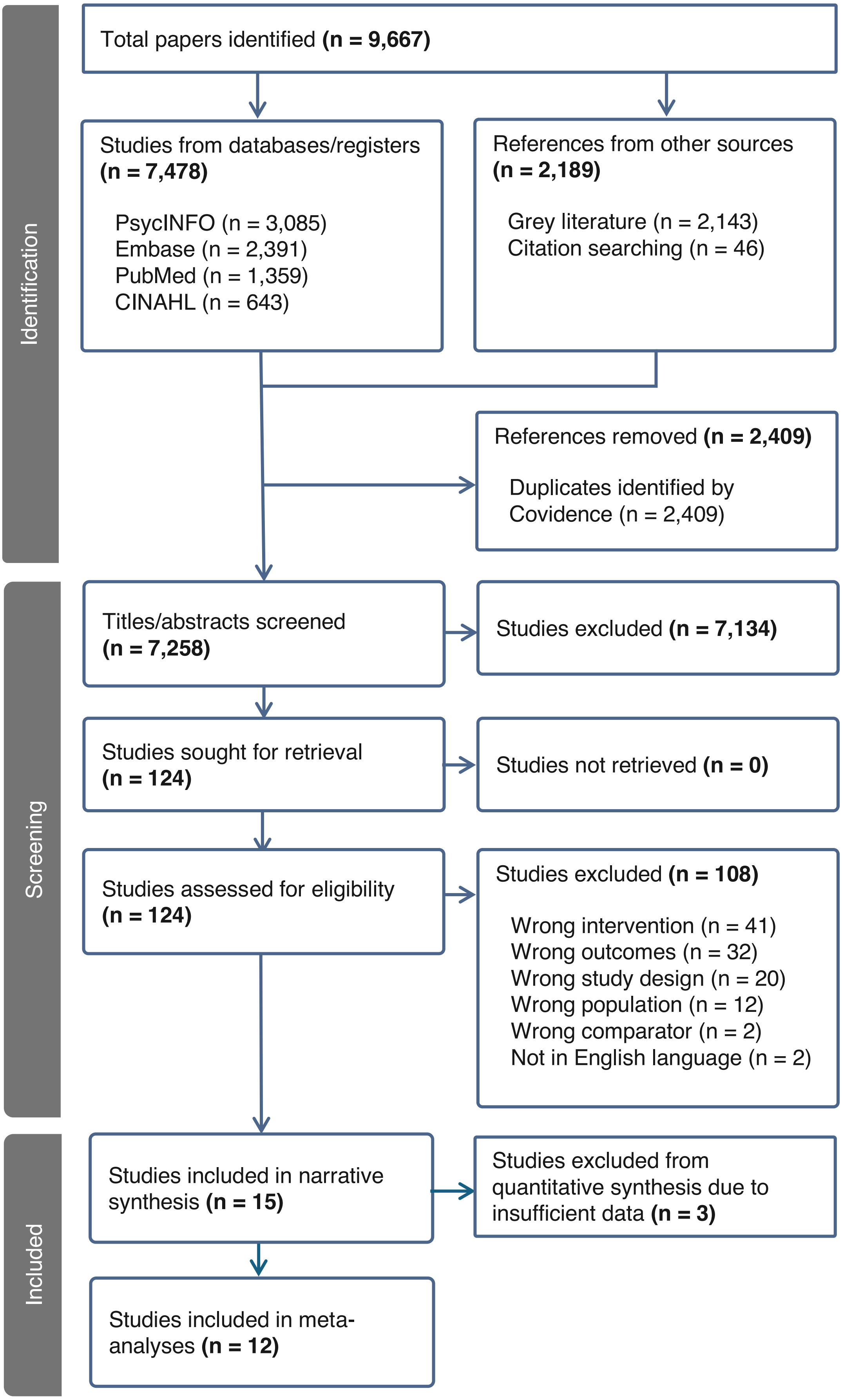
Results

Study Selection

The search across five databases (including grey literature and screen of reference lists) yielded 9,667 title-abstracts. After duplicates were removed, 7,258 title-abstracts remained which were screened by one reviewer (TSJ). A ~10% sample of title-abstracts (705) were read by a second reviewer (EA), with 100% agreement on inclusion/exclusion to full-text review. Full-text reviews were conducted by two authors (TSJ & EA) on 123 papers. During full-text review, 108 papers were excluded. Some studies were excluded as whilst they included participants within the eligible age range, data were not stratified, meaning specific effects could not be elicited for the population of study (Oken, 2016; Oken et al., 2010; Ron-Grajales et al., 2021). Fifteen papers were included in the final narrative review (see Figure 1 for PRISMA flowchart). Due to insufficient data, three studies were excluded from the meta-analysis (Dumontheil et al., 2022; Jensen et al., 2012; Semple, 2010). Three studies were excluded from the meta-analysis at the data extraction stage as they provided insufficient data, but all these studies supplied sufficient details to be included in a narrative synthesis. Five studies were included in the meta-analysis.

Figure 1

PRISMA Flowchart



Study Characteristics

Characteristics of included studies are summarised in Table 2. The 15 papers represented 1,319 participants. Samples varied from 17 to 359 participants (median = 61.5). Publication years ranged from 2010 to 2022, with 9 (60%) published since 2019, suggesting more recent interest. Eight studies were conducted in the United States of America (53%), two in Taiwan, and one in each of: Denmark, Israel, New Zealand, Singapore, and United Kingdom. Study length varied from 10-days to 18-weeks (median = 6-weeks). Fourteen studies used pre-post intervention designs (93%). One study collected additional measures at mid-point (Basso et al., 2019). Three studies (20%) included follow-up, two were one-month post-intervention (Jha, Zanesco, Denkova, Morrison, et al., 2020; Keng et al., 2022) and one followed-up one year post baseline (Lebares et al., 2019).

Participant Characteristics

Characteristics of participants are summarised in Table 2. Four studies reported participants' biological sex (27%) of which 60% of participants were female and 40% were male. Three studies reported participants gender (20%) of which 85% of participants identified as female and 15% as male. Eight studies (53%) reported binary proportions of 'male' and 'female' but did not clarify whether this represented sex or gender No studies reported both sex and gender as recommended in the Sex and Gender Equity in Research (SAGER) guidelines (Heidari et al., 2016).

Five (33%) studies reported ethnicity (Flook et al., 2013; Keng et al., 2022; Lebares et al., 2019; Saldana, 2022; Semple, 2010). Across studies 45% of participants were 'Asian', 4% were 'black', 9% were 'Hispanic', 35% were 'white', and 8% were 'other'. Reporting of ethnicity varies by country making it difficult to reliably compare. This includes choice of higher order ethnicity categories reported, such as 'Hispanic or Latino' included in the USA census, but not the UK census (Office for National Statistics, 2022b; United States Census Bureau, 2021).

Seven (47%) studies described participants as 'adults'. Three (20%) described participants as 'military'. In one study (7%) participants were described as each of: military spouses, teachers, surgery residents, healthcare workers, and students. Nine (60%) excluded participants with current or prior mindfulness experience.

Intervention Features

Characteristics of interventions are summarised in Table 2. Five studies (33%) reported using ‘mindfulness meditation’ or ‘mindfulness therapy’. Three (13%) reported using ‘mindfulness-based stress reduction (MBSR)’ or modified-MBSR. Three (20%) used mobile-based applications including Headspace, ‘Journey Meditation’, and ‘mobile-based resonant frequency breathing training’. Two (13%) reported using ‘mindfulness-based attention training’. One study (7%) reported testing ‘body-mind axial awareness’, and ‘mindfulness-based mind fitness training’. Eight studies (53%) reported active control groups, including progressive muscle relaxation (Semple, 2010) and non-mindfulness stress reduction (Jensen et al., 2012). Seven studies (47%) reported waitlist controls. Three studies (20%) reported ‘no-treatment control’ groups. Three papers (20%) included active and passive control groups. Interventions varied in number of formal sessions offered, from a single session followed by home practice offered in two studies (13%) to one study which offered 18 instructor-led sessions. Two studies offered no formal sessions with the intervention following a mobile application. Four studies (27%) included an intensive ‘retreat’ within the treatment protocol.

Cognitive Tasks

Coding of cognitive tests included in the review are included in Table 1. Characteristics of cognitive tasks are summarised in Table 2. Eight studies (53%) included two measures of EF, four studies (27%) included three measures, two studies (13%) included four measures, and one study (7%) included five measures. For inhibition, four studies (27%) used a Stroop task. Four (27%) used a Sustained Attention to Response Task (SART). Each of the following was used in one study (7%): Continuous Performance Task, Digit Symbol Substitution, Dual Attention to Response Task, D2 Test of Attention, Rapid Visual Information Processing Task, Affective Go/No-Go, Digit Vigilance Task, Flanker Task, Attentional Control Task, Backwards Inhibition, and NIH Examiner Cognitive Control. For Working Memory, four studies (27%) used a Working Memory Delayed Recognition task with Affective Distractors (WMDA). Two studies (13%) used each Forwards Digit Span, Backwards Digit Span, and an n-Back Task. Each of the following was used in one study (7%): Spatial Working Memory, Operational Span, Digit Symbol Sequencing, and NIH Examiner Working Memory. For Cognitive Flexibility, two studies (13%) used a Letter Fluency Task. Each of the following was used in one study (7%): Wisconsin Card Sorting Task, Competitor Rule Suppression, an Attentional Switching, and oral Trail Making Test-B.

Table 1

Coding of Tasks by Component EF

Working Memory	Inhibition	Cognitive Flexibility
Working Memory Delayed Recognition task with Affective Distractors (WMDA)	Stroop	Letter Fluency
Forwards Digit Span	Sustained Attention to Response (SART)	Wisconsin Card Sorting Task
Backwards Digit Span	Continuous Performance Task	Competitor Rule Suppression
n-Back	Digit Symbol Substitution	Attentional Switching
Spatial Working Memory	Dual Attention to Response Task	Oral Trail Making Test-B
Operational Span	D2 Test of Attention	
Digit Symbol Sequencing	Rapid Visual Information Processing Task	
NIH Examiner Working Memory	Affective Go/No-Go	
	Digit Vigilance Task	
	Flanker Task	
	Attentional Control Task	
	Backwards Inhibition	
	NIH Examiner Cognitive Control	

Table 2

Randomised Controlled Trials Exploring the Effectiveness of Mindfulness-Based Interventions on ≥2 Measures of EF

Study	**Country**	**Intervention**	**Comparator**	**Participants**	**Age Years Range, (Mean, SD)**	**Sex/ Gender**	**Duration/ Intensity**	**EF Measures**	**Participants (n)**
Semple 2010	New Zealand	Mindfulness Meditation	Progressive Muscle Relaxation; WLC	Adults	23 - 56 (M = 40.20, SD = 8.90)	34 female; 12 male; unclear if sex or gender?	90-min training followed by 1 month of twice-daily home-practice	CPT; DSS; Stroop	Int = 19 WLC = 18, PMR = 16
Jensen 2011	Denmark	MBSR	Non-mindfulness-stress reduction; and WLC.	Adults	20 - 36	Only sex; 30 female; 18 male	8-week course, 2.5hr/week, plus 7hr intensive retreat	DART (white and grey); Stroop; D2	Int = 16 NMSR = 16, WLC = 16
Flook 2013	USA	Modified MBSR	WLC	Elementary school teachers	25 - 56 (M = 43.06, SD = 9.87)	16 female; 2 male; unclear if sex or gender?	8-week course, 2.5hr/week, plus 6 hr retreat	RVP; AGN	Int = 10 WLC = 8

Greenberg 2013	Israel	Mindfulness Meditation	WLC	Meditation-naïve adults	(*M* = 43.06, *SD* = 9.87)	Only gender; 48 female; 28 male	6-week course. 7x2hrs meetings plus half day retreat	Set switching – BI and CRS	Int = 38 WLC = 38
Ching 2015	Taiwan	Mindfulness Meditation	WLC	First year undergraduate students	18 - 19	Only sex; 172 female; 110 male	18 weekly 50-minute classes	Digit vigilance; spatial WM	Int = 204 WLC = 155
Teng 2016	Taiwan	Body-Mind Axial Awareness	Chan-Meditation; WLC	Community	19 - 50 (*M* = 37.82, *SD* = 9.69)	43 female; 8 male; unclear if sex or gender?	4-week/12hr training course, 8x90-min classes	OSPAN; Attentional switching; Stroop	MBAA = 15 Chan-Med = 16; WLC = 20,
Basso 2019	USA	Journey Meditation	Podcast Listening	Healthy adults	18 - 45	27 female; 15 male; unclear if sex or gender?	13-minutes daily for 8 weeks	n-back; WCST, Stroop; Flanker	Int = 20 Contr = 20
Lebares 2019	USA	Mindfulness-Based Stress Reduction	Active Control	First year surgery residents	(*M* = 28.00, *SD* = 2.31)	Only sex; 8 female; 13 male	8x2hr classes, home practice and a 2-3 hr retreat-hike	NIH- WM; Executive Composite; Cognitive Control; Fluency	MBSR = 12 Contr = 10

Zanesco 2019	USA	2-Week and 4-Week Mindfulness Therapy	NTC	Active-duty military males	(*M* = 33.14, *SD* = 5.62)	120 male; unclear if sex or gender?	8hr course; 4x2hrs twice weekly (2-week) or weekly (4-week)	SART; WMDA	2-week = 40, 4-week = 36 NTC = 44
Jha, Zanesco, Denkova, Morrison 2020	USA	MBAT and MBAT Expert Trainer	NTC	Active-duty military males	(*M* = 23.48, *SD* = 3.71)	180 male; unclear if sex or gender?	8hr course delivered 4x2hrs weekly	SART; WMDA	MBAT = 89 NTC = 46, Expert Trainer = 45
Jha, Zanesco, Denkova, Rooks 2020	USA	MMFT	Positive Emotional Resilience Training	Healthy Active-duty military males	(*M* = 24.68, *SD* = 3.90)	80 male; unclear if sex or gender?	16hr course of 9 sessions. 4x2hrs, 4x1hr, and 1x4hr	SART; WMDA	MMFT = 40 Contr = 40
Denkova 2021	USA	MBAT	NTC	Military spouses	(*M* = 33.97, *SD* = 8.29)	Only gender; 104 female; 2 male	4x2hr sessions over 4 weeks	SART; WMDA	MBAT = 48 NTC = 58
Saldana 2021	USA	mRFBT	WLC	Non-clinical, adults, elevated stress	(*M* = 21.10, *SD* = 2.90)	Only sex; 46 female; 24 male	Initial teaching followed by 2x daily practice 5 days/ week for 4 weeks	DSF; DSB; DSSeq; OTMT-B; Letter Fluency	mRFBT = 37 WLC = 33

Keng 2022	Singapore	Headspace App	Lumosity App	Healthcare workers	22 - 54 (*M* = 30.18, *SD* = 6.19)	Only gender; 72 female; 8 male	10-mins practice per day for 10-days	DSF; DSB	Int = 39 Contr = 40
Dumontheil 2022	UK	Mindfulness Therapy	Relaxation Training	Female adults	(*M* = 28.70, *SD* = 3.70)	17 female; unclear if sex or gender?	8x90min sessions over 10-weeks with 2-week break	Attentional control; emotional n-back	Int = 8 Contr = 9

Note. MBAT = Mindfulness-Based Attention Training; MMFT = Mindfulness-Based Mind Fitness Training; mRFBT = Mobile-Based Resonant Frequency Breathing Training; CPT = Continuous Performance Task; DSST = Digit Symbol Substitution Task; WCST = Wisconsin Cart Sorting Task; RVP = Rapid Visual Information Processing Task; AGN = Affective Go/No-Go task; BI = Backward Inhibition; CRS = Competitor Rule Suppression; OSPAN = Operational Span Task; SART = Sustained Attention to Response Task; WMDA = Working Memory Delayed Recognition task with Affective Distractors; OTMT-B = Oral Trail Making Task B; D-KEFS = Delis-Kaplan Executive Function System; ICV = intra-individual coefficient of variation; RT = Reaction Time; CPT-IP = Connor's Performance Task-Identical Pairs task; DART = Dual attention to response task; DSF = Digit Span Forwards; DSB = Digit Span Backwards; DSSeq = Digit Span Sequencing; WM = Working Memory; WLC = waitlist control; NTC = no treatment control; Int = intervention; Contr = control.

Risk of Bias

Methodological quality of studies varied, as assessed using RoB-2 (see Figures 2 and 3; Sterne et al., 2019). 'Randomisation process' bias varied from 'low' ($k = 7$; 47%), to 'some concerns' ($k = 7$; 47%), to 'high' ($k = 1$; 7%). Four studies (33%) did not report enough information regarding 'allocation concealment' to accurately assess bias (Ching et al., 2015; Jha, Zanesco, Denkova, Morrison, et al., 2020; Jha, Zanesco, Denkova, Rooks, et al., 2020; Teng & Lien, 2016). No studies found baseline differences between groups that suggest problems with the randomisation process. 'Deviations from intended interventions' varied from 'low' ($k = 14$; 93%), to 'high' ($k = 1$; 7%). One participant in Lebares et al. (2019) received the intervention and data analysed in a different group than randomised. 'Missing outcome data' bias varied from 'low' ($k = 14$; 93%), to 'high' ($k = 1$; 7%). Teng and Lien (2016) had evidence that missingness in the outcome may have depended on its true value. 'Measurement of outcome' bias was 'low' in all studies, as the method for measuring outcomes was appropriate and unlikely differed between groups. 'Selection of reported result' bias was mostly 'some concerns' ($k = 13$; 87%). Two studies (13%) included details of a pre-specified analysis plan, thus were rated 'low'. Overall risk of bias in 11 studies (80%) was 'some concern' and 'high' in three (20%).

Figure 2

Cochrane Risk of Bias Across the 15 Studies Included in the Review

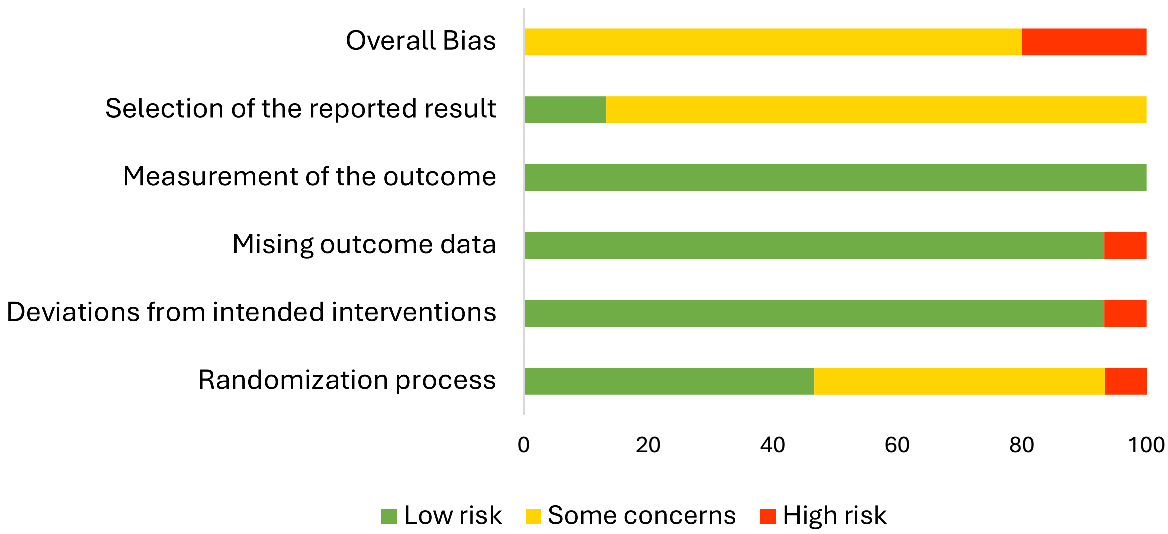


Figure 3

Cochrane Risk of Bias Summary for the 15 Studies Included in the Review

Study ID	D1	D2	D3	D4	D5	Overall
Semple (2010)	+	+	+	+	!	!
Jensen 2011	+	+	+	+	!	!
Flook (2013)	+	+	+	+	!	!
Greenberg (2013)	+	+	+	+	!	!
Ching (2015)	!	+	+	+	!	!
Teng (2016)	!	+	-	+	!	-
Basso (2019)	+	+	+	+	!	!
Lebares (2019)	+	-	+	+	+	-
Zanesco (2019)	!	+	+	+	!	!
Jha, Zanesco, Denkova, Morrison (2020)	!	+	+	+	!	!
Jha, Zanesco, Denkova, Rooks (2020)	!	+	+	+	!	!
Denkova (2021)	-	+	+	+	+	-
Keng (2022)	!	+	+	+	!	!
Saldana (2022)	!	+	+	+	!	!
Dumontheil (2023)	+	+	+	+	!	!

+ Low risk
! Some concerns
- High risk

D1 Randomisation process
D2 Deviations from intended interventions
D3 Missing outcome data
D4 Measurement of the outcome
D5 Selection of the reported result

Outcomes

Whilst three studies included quantitative analysis in their study designs, pre-post intervention means, standard deviations, nor effect sizes were recorded and so could not be included in quantitative analysis. Results for those studies will be summarised in a narrative synthesis.

Using an RCT design, Semple (2010) examined the effects of mindfulness meditation on EF using a progressive muscle relaxation active comparator and a waitlist control. Whilst Semple (2010) included three measures of inhibition, significant differences in performance were only observed for the continuous performance task (CPT) performance, but not Stroop or Digit Symbol Substitution task (DSS), with the mindfulness meditation group improving more than the progressive muscle relaxation and waitlist control groups. Findings suggested that brief 90-minute training session of mindfulness meditation, followed by one-month home practice, may improve some aspects of inhibitory control.

Whilst using an active control increases reliability in causal conclusions, Jensen et al. (2012) expanded upon this and explored the specificity of the mindfulness component of interventions on improvements in EF. Indeed, Jensen et al. (2012) compared mindfulness-based stress reduction (MBSR) to non-mindfulness-stress reduction and waitlist control. Results indicated no significant group differences on most measures, however, found significant improvement in error rate on the D2 task of attention in the MBSR group, suggesting a specific effect of the mindfulness component on performance on this measure. This suggests there may be something about the mindfulness component of the intervention, that is driving improvement in response inhibition. No improvements in performance were observed for measures of cognitive flexibility.

In their study, Dumontheil et al. (2022) examined the effects of mindfulness therapy on EF using an active relaxation group comparator. Again, the mindfulness-based intervention only produced effects on some, but not all, measures. Indeed, significant improvements were observed in reaction time, but not accuracy, on an attentional control task in the mindfulness therapy compared to relaxation group. This again suggests that response, but not attentional, inhibition may be improved through mindfulness-based interventions. Additionally, Dumontheil et al. (2022) found that mindfulness therapy did not result in improvements on a task of working memory (emotional n-back and backwards digit span), compared to active controls.

Whilst results suggests that some aspects of EF may be improved by mindfulness-based interventions, quantitative analysis of the standardised mean difference (SMD) will allow this to be explored further and consider the magnitude of effects observed. Twelve of the 15 eligible studies provided sufficient numerical data to be included in quantitative analysis and meta-analyses. SMD's are included in Table 3. Numerical data were not provided for all measures, therefore, reducing the reliability of findings in the current synthesis. For example, Basso et al. (2019) included four measures of EF in their study design, yet only numerically reported outcomes where significant differences between comparators were observed.

Working Memory. Across 10 studies SMD's were calculated for 20 outcomes of working memory (see Table 3). The magnitude of the SMD was small on nine outcomes and medium on two outcomes. For the remaining nine outcomes, the SMD was negligible in magnitude suggesting that any difference observed is unlikely meaningful in context. This suggests variable effects of mindfulness-based interventions on working memory as a component process of EF.

Zanesco et al. (2019) compared the same number of sessions and content of intervention delivered across two and four weeks. When sessions were more spaced out in the four-week intervention, the magnitude of effect was higher (g = 0.37), compared to when it was more condensed in the two-week intervention (g = 0.20). Length and timing of intervention may be important. Additionally, Jha, Zanesco, Denkova, Morrison, et al. (2020) compared the same intervention delivered by mindfulness experts and expert trained individuals familiar with the military context. Findings indicated a SMD of medium effect size between intervention and no treatment control comparator when delivered by military familiar trained instructors (g = 0.22), but effects in favour of control when delivered by a mindfulness expert (g = -0.31). Again, this suggests factors in delivery of interventions may influence outcome.

Only one study that explored outcomes of working memory compared active and inactive controls. Teng and Lien (2016) found that the body-mind axial awareness group performed better on tasks of working memory than active and inactive comparators. Indeed, a medium effect was observed for the waitlist control comparator (g = 0.56), yet only a small effect against the active, chan-meditation comparator (g = 0.46). Studies which only include an inactive control may inflate the magnitude of effects observed.

Whilst limitations in study designs may have inflated some effects, limitations in study designs may also have masked potential effects. Indeed, underpowered studies, such as Lebares et al. (2019), may not have sufficient power to detect all potential effects. Additionally, a high risk of bias was identified in Lebares et al. (2019), where a small effect was observed, and Denkova et al.

(2021), where no meaningful effects were observed, which further reduces reliability of findings.

Inhibitory Control. Across nine studies SMD's were calculated for 22 outcomes of inhibitory control (see Table 3). The magnitude of the SMD was small in eight outcomes, medium on three outcomes, and large on three outcomes. However, there are again discrepancies within studies, suggesting variability. In Greenberg et al. (2013) the SMD suggested a large effect in favour of mindfulness-based interventions on reaction time (g = 1.03), yet for errors, the SMD suggested a large effect in favour of controls (g = -1.23), similar to findings from Dumontheil et al. (2022). This suggests that even within measures, choice of reported outcome variable effect may affect conclusions drawn. For the remaining eight outcomes, the SMD was negligible in magnitude suggesting any differences observed are unlikely meaningful in context. This suggests variable effects of mindfulness-based interventions on inhibitory control as a component process of EF.

Zanesco et al. (2019) compared the same number of sessions and content of intervention delivered across two and four weeks. When sessions were more spaced out in the four-week intervention, the magnitude of effect on response inhibition accuracy was large in magnitude and higher (g = 0.89) than when it was more condensed in the two-week intervention, where the magnitude of effect was small and in favour of the no treatment control (g = -0.23). Therefore, length and timing of intervention may be important. Additionally, Jha, Zanesco, Denkova, Morrison, et al. (2020) compared the same intervention delivered by mindfulness experts and experts trained individuals familiar with the military context. Using the same measure as in Zanesco et al. (2019) findings indicated a SMD of medium effect size between intervention and no treatment control comparator when delivered by military familiar trained instructors (g = 0.64), but not when delivered by a mindfulness expert (g = -0.10). Again, this suggests that factors in the delivery of interventions may influence outcomes.

Similar to outcomes of working memory, only one study explored outcomes of inhibitory control compared active and inactive controls. Teng and Lien (2016) found that the body-mind axial awareness group performed better on tasks of inhibitory control than active and inactive comparators. However, when exploring magnitude of effects, the SMDs for both the active and inactive comparators were negligible, suggesting any difference observed is unlikely meaningful in context. Nonetheless, the magnitude of the effect for the chan-meditation, active, comparator, was marginally lower (*g* = 0.14) than for the waitlist control (*g* = 0.19).

Whilst limitations in study designs may have inflated some effects, limitations in study designs may again have masked potential effects. Lebares et al. (2019) presents an underpowered study which may have masked all potential effects. A high risk of bias was identified in Lebares et al. (2019) and Denkova et al. (2021) where small effects were observed, which reduces reliability of findings.

Cognitive Flexibility. Across four studies there were seven calculated effect sizes for outcomes of cognitive flexibility measures. One large effect was identified in favour of mindfulness-based interventions on cognitive flexibility. On three outcomes, the SMD was in favour of controls over the intervention condition, of which two were small in magnitude and one was large in magnitude. Additionally, for the remaining three outcomes, the SMD was negligible in magnitude suggesting any differences observed are unlikely meaningful in context. This suggests little effect for the benefit of mindfulness-based interventions on cognitive flexibility as a component process of EF.

Where a large effect in favour of mindfulness-based interventions on cognitive flexibility was observed, Greenberg et al. (2013) examined the effect of eight sessions of mindfulness therapy on a switching task, compared to a waitlist control. Whilst a large effect was observed in favour of mindfulness-based interventions on reaction time (*g* = 0.91), a large effect was also observed in favour of controls on errors (*g* = -1.10). This suggests that even within measures, choice of reported outcome variable effect may affect conclusions drawn.

Additionally, limitations in study designs may have masked potential effects. Indeed, Saldana (2022) is a non-peer reviewed, pilot, with the risk of bias assessment finding concerns regarding randomisation, deviations from intended intervention, and in selection of reported result, lowering confidence of results. Additionally, Lebares et al. (2019) presents an underpowered study which may have masked all potential effects.

Correlations of Outcomes with Home Practice. All studies (100%) included an element of home practice. Two studies (13%) reported no significant relationship between time spent in home practice and EF (Denkova et al., 2021; Dumontheil et al., 2022). However, one study (7%) found no significant relationships between time spent in home practice and inhibition, yet, found significant correlations with working memory (Zanesco et al., 2019).

Experience Outcomes. Two studies (12.5%; Denkova et al., 2021; Jha, Zanesco, Denkova, Morrison, et al., 2020) included participant experience measures. Denkova et al. (2021) found that most participants either ‘agreed’ or ‘strongly agreed’ that the trainer and training were effective. Jha, Zanesco, Denkova, Morrison, et al. (2020) compared ratings of trainer performance between the intervention delivered by ‘mindfulness experts’ and ‘US Army Master Resilience Trainer-Performance Experts’ (Train the Trainer) and found more positive experience ratings in the ‘Train the Trainer’ group compared to the ‘mindfulness expert’ group, which may have explained why effects of the intervention on inhibition were only found in the Train the Trainer group.

Table 3

Magnitude of Individual Effects within Included Studies

Paper	Measure	EF Component	SMD (Hedge's *g*)	SE of SMD
Flook 2013	*Modified MBSR vs Waitlist Control*			
	RVP	Inhibition	0.00	0.47
	AGN	Inhibition	0.23*	0.48
Greenberg 2013	*Mindful Meditation vs Waitlist Control*			
	BI RT	Inhibition	1.03***	0.24
	BI Error	Inhibition	-1.23***	0.25
	CRS RT	Flexibility	0.91***	0.24
	CRS Error	Flexibility	-1.10***	0.25
Ching 2015	*Mindful Meditation vs Waitlist Control*			
	Digit vigilance acc	Inhibition	0.22*	0.16
	Digit vigilance RT	Inhibition	0.31*	0.16
	WM acc	WM	0.10	0.16
	WM RT	WM	0.30*	0.16
Teng 2016	*Mind-Body Axial Awareness vs Chan Meditation*			
	OSPAN	WM	0.46*	0.36
	Attent Switch RT	Flexibility	-0.30*	0.36
	Stroop RT	Inhibition	0.14	0.36
	Mind-Body Axial Awareness vs Wait List Control			
	OSPAN	WM	0.56**	0.35
	Attent Switch RT	Flexibility	-0.07	0.34
	Stroop RT	Inhibition	0.19	0.34
Basso 2019	*Journey Meditation vs Podcast Listening*			
	n-back	WM	0.59**	0.32
	WCST	Flexibility	-	-
	Stroop	Inhibition	0.78**	0.33
	Flanker	Inhibition	-	-
Lebares 2019	*MBSR vs 'Active Control'*			
	Working Memory	WM	0.20*	0.46
	Cognitive Control	Inhibition	0.37*	0.46
	Fluency	Flexibility	-0.44*	0.46
	Executive Control	Overall EF	-0.06	0.46
Zanesco 2019	*4-Week Mindfulness Therapy vs No Treatment Control*			
	SART Acc	Inhibition	0.89***	0.24
	SART ICV	Inhibition	-0.31*	0.23
	WMDA	WM	0.37*	0.27
	2-Week Mindfulness Therapy vs No Treatment Control			
	SART Acc	Inhibition	-0.23*	0.23
	SART ICV	Inhibition	-0.17	0.23
	WMDA	WM	0.20*	0.25
Jha 2020a	*MBAT Expert Trainer vs No Treatment Control*			
	SART Acc	Inhibition	0.64**	0.23
	WMDA	WM	0.22*	0.20
	MBAT Mindfulness Expert vs No Treatment Control			
	SART Acc	Inhibition	0.10	0.26
	WMDA	WM	-0.31*	0.23
Jha 2020b	*MMFT vs Positive Emotional Resilience Training*			
	WMDA Acc	WM	0.51**	0.24
	SART Acc	Inhibition	0.50*	0.24

	SART ICV	Inhibition	-0.11	0.24
Denkova 2021	*MBAT vs No Treatment Control*			
	SART Acc	Inhibition	0.23*	0.21
	SART ICV	Inhibition	0.72**	0.22
	WMDA Acc	WM	0.12	0.21
	WMDA RT	WM	0.05	0.21
Saldana 2021	*mRFBT vs Waitlist Control*			
	DSF	WM	-0.01	0.24
	DSB	WM	-0.16	0.24
	Dsseq	WM	0.22*	0.24
	OTMT-B	Flexibility	0.15	0.24
	Fluency	Flexibility	0.07	0.24
Keng 2022	*Headspace App vs Luminosity App*			
	DSF	WM	0.20*	0.23
	DSB	WM	-0.06	0.23

Note. CPT = Continuous Performance Task; DSST = Digit Symbol Substitution Task; WCST = Wisconsin Cart Sorting Task; RVP = Rapid Visual Information Processing Task; AGN = Affective Go/No-Go task; BI = Backward Inhibition; CRS = Competitor Rule Suppression; OSPAN = Operational Span Task; SART = Sustained Attention to Response Task; WMDA = Working Memory Delayed Recognition task with Affective Distractors; OTMT-B = Oral Trail Making Task B; ICV = intra-individual coefficient of variation; RT = Reaction Time; CPT-IP = Connor's Performance Task-Identical Pairs task; DART = Dual attention to response task; DSF = Digit Span Forwards; DSB = Digit Span Backwards; DSSeq = Digit Span Sequencing; WM = Working Memory. * = small effect; ** = medium effect; *** = large effect.

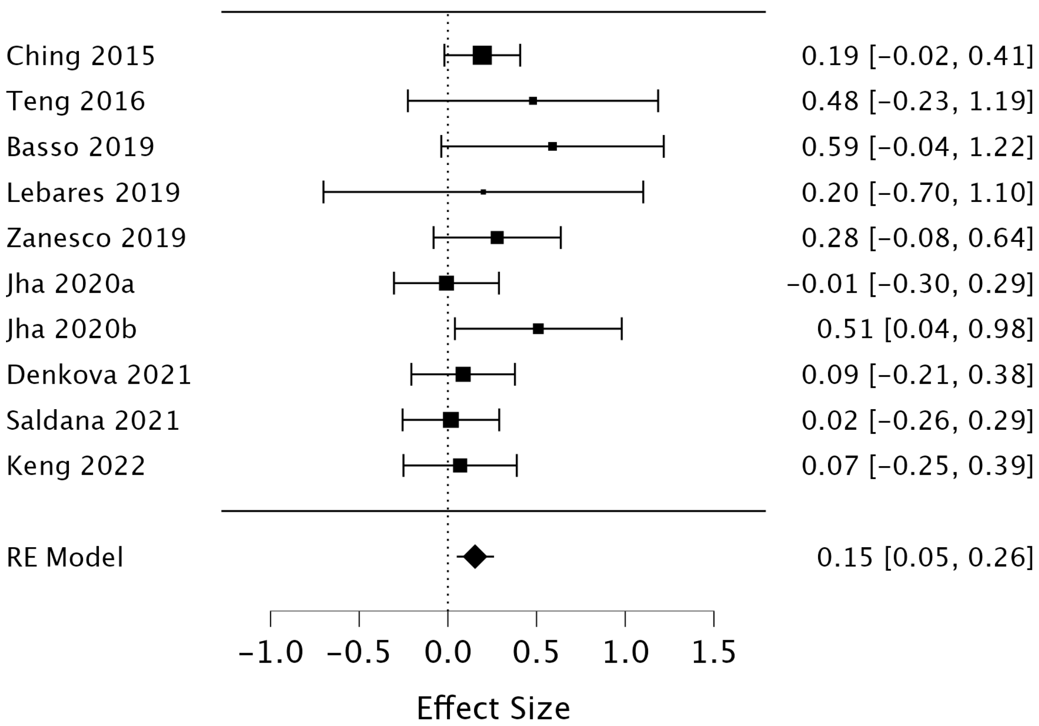
Meta-Analyses

Findings from individual studies suggested variable effects of mindfulness-based interventions on EF. Therefore, four meta-analyses were conducted to pool data and summarise overall effect sizes one for each working memory, inhibitory control, cognitive flexibility, and overall EF.

Working Memory. Ten studies examined the effects of mindfulness-based interventions on working memory. Meta-analysis of the random-effects model showed that mindfulness-based interventions improved working memory compared to controls, a statistically significant difference, Hedge's $g = 0.15$ [95% CI's = 0.046, 0.26, $p = .005$, $I^2 = 0.00\%$ [95% CI's = 0.00%, 74.94%], $\tau^2 = 0.00$ [95% CI's = 0.00, 0.095]. The summary of pooled data suggests an effect of negligible magnitude. Whilst the point estimates of heterogeneity in this model was low (Higgins et al., 2003) suggesting a high degree of consistency across studies, the confidence intervals were wide suggesting that the point estimate may be unreliable. See Forest Plot in Figure 4 for results of individual studies.

Figure 4

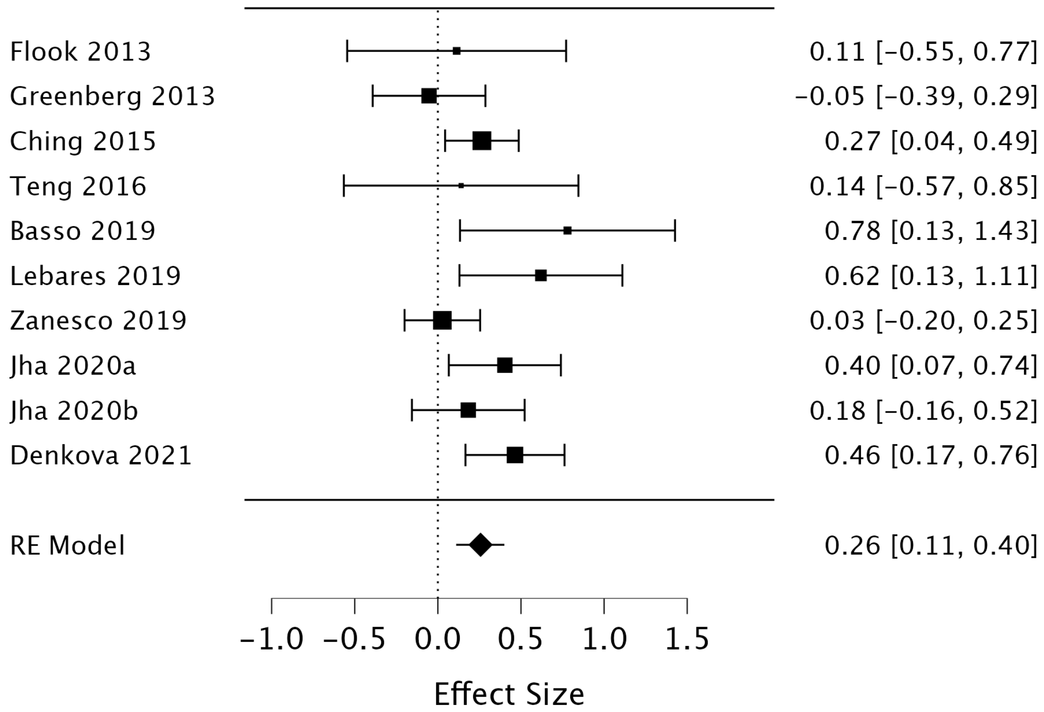
Meta-Analysis of Mindfulness-Based Interventions on Working Memory



Inhibitory Control. Ten studies examined the effects of mindfulness-based interventions on inhibition. Meta-analysis of the random-effects model showed that mindfulness-based interventions improved inhibition compared to controls, a statistically significant difference, Hedge's *g* = 0.26 [95% CI's = 0.11, 0.40], *p* <.001, I^2 = 38.66% [95% CI's = 0.00%, 84.80%], τ^2 = 0.020 [95% CI's = 0.00, 0.18]. The summary of pooled data suggests a small magnitude of effect. Whilst the point estimates of heterogeneity in this model was moderate (Higgins et al., 2003) suggesting a possible degree of inconsistency across studies, the confidence intervals were wide suggesting that the point estimate may be unreliable. See Forest Plot in Figure 5 for results of individual studies.

Figure 5

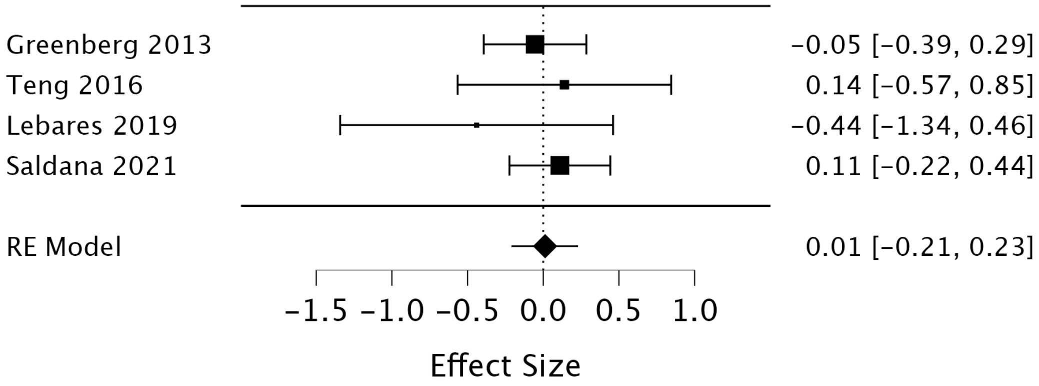
Meta-Analysis of Mindfulness-Based Interventions on Inhibition



Cognitive Flexibility. Four studies examined effects of mindfulness-based interventions on cognitive flexibility. Meta-analysis of the random-effects model showed that mindfulness-based interventions did not improve cognitive flexibility compared to controls, a non-statistically significant difference, Hedge's *g* = 0.012 [95% CI's = -0.21, 0.40], *p* = .91, I^2 = 0.00% [95% CI's = 0.00%, 93.60%], τ^2 = 0.00 [95% CI's = 0.00, 0.82]. The summary of pooled data suggests an effect of negligible magnitude. Whilst the point estimates of heterogeneity in this model was low (Higgins et al., 2003) suggesting a high degree of consistency across studies, the confidence intervals were wide suggesting that the point estimate may be unreliable. See Forest Plot in Figure 6 for results of individual studies.

Figure 6

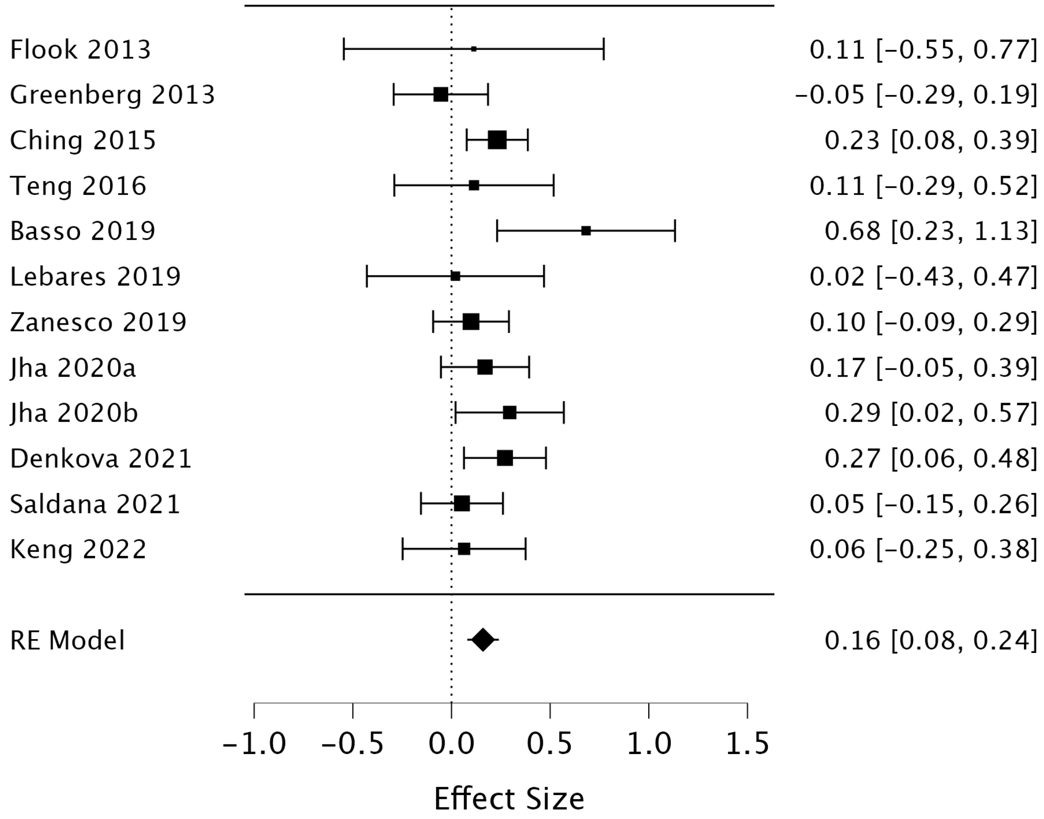
Meta-Analysis of Mindfulness-Based Interventions on Cognitive Flexibility



Overall EF. Twelve studies included numerical data that examined the effects of mindfulness-based interventions on EF. Meta-analysis of the random-effects model showed that mindfulness-based interventions improved EF compared to controls, a statistically significant difference, Hedge's g = 0.16 [95% CI's = 0.078, 0.24], $p < .001$, I^2 = 17.33% [95% = CI's 0.00%, 79.60%], τ^2 = 0.004 [95% CI's = 0.00, 0.065]. The summary of pooled data suggests an effect of negligible magnitude. Whilst the point estimates of heterogeneity in this model was low (Higgins et al., 2003) suggesting a high degree of consistency across studies, the confidence intervals were wide suggesting that the point estimate may be unreliable. See Forest Plot in Figure 7 for results of individual studies.

Figure 7

Meta-Analysis of Mindfulness-Based Interventions on Overall EF



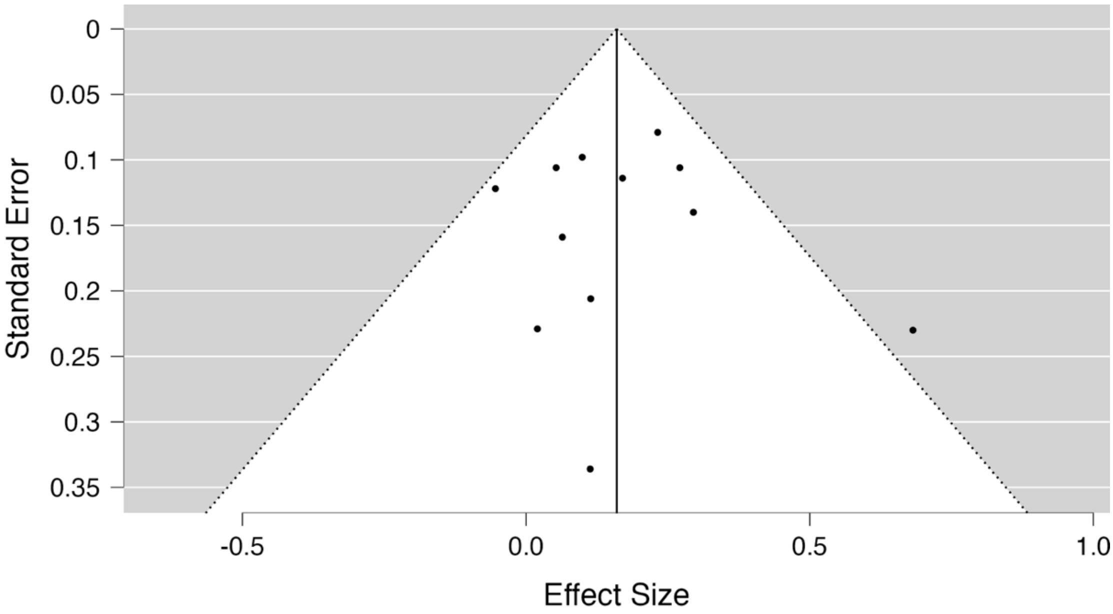
Publication Bias

A funnel plot was drawn to examine the possibility of publication bias (Figure 8). Visual inspection suggests no obvious asymmetry which may suggest that pooled results were influenced by publication bias. Basso et al. (2019) was identified as an outlier through visual inspection of a funnel plot (Figure 8). In the paper, numerical data were only available for outcomes where significant differences between conditions were identified, which may bias findings.

A sensitivity analysis was conducted by removing Basso et al. (2019) from the model. A meta-analysis of the random-effects model showed that mindfulness-based interventions improved overall EF compared to controls, a statistically significant difference, Hedge's g = 0.15 [95% CI's = 0.075, 0.22], $p < .001$, I^2 = 0.00% [95% = CI's 0.00%, 55.62%], τ^2 = 0.00 [95% CI's = 0.00, 0.020]. As removal of the paper had limited influence on the overall effect size (g = 0.16 when included, and g = 0.15 when excluded), it was retained in all analyses.

Figure 8

Publication Bias of Included Studies (k = 12)



Discussion

The aim of the current review was to examine effects of mindfulness-based interventions on overall and component cognitive processes of EF in studies where ≥2 non-self-report measures of EF were included. Of the 15 studies that met inclusion criteria 12 had sufficient data to be explored within a meta-analysis. The remaining three papers did not publish sufficient numerical data to be included (Dumontheil et al., 2022; Jensen et al., 2012; Semple, 2010).

Given that models of EF indicate unity and diversity between component processes, separate analyses were conducted for overall EF and for each latent component of EF. Based upon the four separate models, the summary effect of pooled data significantly favoured mindfulness-based interventions over controls in the overall EF model, the working memory model, and the inhibitory control model. The summary effect of pooled data in the cognitive flexibility model did not significantly favour mindfulness-based interventions over controls.

When considering the magnitude of effect, negligible effect sizes were found in the overall EF model and the working memory model, suggesting that whilst the finding is unlikely to have occurred by chance, the difference observed is unlikely meaningful in context. However, there was evidence for a small effect in the inhibitory control model, suggesting that mindfulness-based interventions may improve inhibitory control to a modest, yet meaningful, degree.

This supports a theory of specific as opposed to general effects of mindfulness-based interventions on EF and is in line with findings from previous systematic reviews (Gallant, 2016). Given that mindfulness is thought to work by training participants to shift attention to present moment awareness through repeated inhibition of internal and external stimuli (Dunham et al., 2018), it is perhaps unsurprising that the most conclusive evidence was for inhibition.

In the inhibitory control model, the summary effect of pooled data significantly favoured mindfulness-based interventions over controls, and with a small effect (see Figure 5; $g = 0.26$). However, heterogeneity in the model was moderate (Higgins et al., 2003) suggesting there may be some degree of inconsistency across studies. Whilst not explored statistically, one explanation for the mixed effects on outcomes relates to the underlying mechanisms involved. Whilst (Semple, 2010) included three measures of attention, improvements were only found on one measure. The CPT which showed improvement, requires receptive awareness of quickly changing stimuli, whereas the Stroop and DSS, which did not improve, require inhibiting over-learned cognitive responses. Empirical evidence suggests that response inhibition and attentional inhibition are independent constructs (Tiego et al., 2018). It is possible that mindfulness-based interventions may only improve aspects of inhibition, further supporting evidence for specific as opposed to general effects of mindfulness-based interventions on EF.

In a review exploring the effects of acute stress on EF, Shields et al. (2016) found that acute stress negatively affects cognitive inhibition but enhances response inhibition. In response to an acute stressor the body reacts to handle the threat through activation of the fight-flight response, mediated primarily by the sympathetic-adrenal-medullary axis (Wetherell et al., 2006). Shields et al. (2016) found that stress contributes to a cognitive state of reactive and automatic processing, alongside enhancing executive motor control, which facilitates engagement with, or escape from, the stressor. During sympathetic-adrenal-medullary activation, instrumental behaviour is controlled by habitual stimulus–response processes at the expense of goal-directed performance (Schwabe & Wolf, 2009), which may explain nuanced effects of mindfulness-based interventions on inhibition, and supports the hypothesis that interventions to improve stress, including mindfulness-based interventions, may improve EF.

Nonetheless, Jensen et al. (2012) reported outcomes from a study exploring the specific effects of the mindfulness component of their intervention by comparing MBSR to non-mindfulness-stress reduction (NMSR) and waitlist control. The study found significant improvements on a task of inhibition only in the MBSR group. Physiological and self-report reductions of stress in both the MBSR and NMSR groups, but not waitlist control group. Additionally, self-reported mindfulness was only increased in the MBSR group. This suggests there may be something specific in the mindfulness component of the intervention that is driving improvement over and above stress reduction.

Considering working memory, whilst findings from individual studies appeared variable, the summary effect of pooled data did not significantly favoured mindfulness-based interventions over controls (see Figure 4; $g = 0.15$). However, there is increasing evidence that attentional processes factor in supporting working memory function (Gazzaley & Nobre, 2012). Working memory concerns ability to selectively maintain and manipulate goal-related information in the short-term, whilst inhibiting irrelevant information (Jha et al., 2019). Mindfulness-based interventions may improve working memory performance by improving sustained attention.

In the current review, of studies that included measures of working memory and response inhibition, none found improvements in working memory without also finding improvements in response inhibition, suggesting a hierarchical mechanism may be involved. Additionally, one study (7%) reported no significant relationships between time spent in home practice and inhibition, however, found significant correlations with working memory (Zanesco et al., 2019). This suggests there may be a dose-response effect of mindfulness on some measures and may explain why variable effects were found for working memory. Only including studies with ≥2 measures of EF increases reliability when drawing such conclusions and adds towards developing a model of the effect of mindfulness-based interventions on EF.

The summary effect of pooled data in the cognitive flexibility model did not significantly favour mindfulness-based interventions over controls ($g = 0.012$; see Figure 6), which is surprising, given that mindfulness works by training participants to shift attention (Dunham et al., 2018). Only one study observed a large effect in of mindfulness-based interventions on cognitive flexibility (Greenberg et al., 2013).

However, whilst a large effect was observed in favour of mindfulness-based interventions on reaction time (g = 0.91), a large effect was also observed in favour of controls on errors (g = -1.10). This suggests that even within measures, choice of reported outcome variable effect may affect conclusions drawn and should be considered in future study designs, particularly when pooling effects, as potential overall patterns may be masked. However, results support other reviews which did not find effects of mindfulness-based interventions on cognitive flexibility (Gallant, 2016).

Whilst the proposed mechanisms may explain some of the variance in the effect of mindfulness-based interventions in improving inhibition and working memory, methodological heterogeneity may also compound findings. Type of practice, duration, and intensity may influence outcome. The current review found studies with longer interventions were more likely to show improvements. Zanesco et al. (2019) only found improvements on inhibition and working memory when the same intervention of the same number of sessions was delivered over four weeks, but not two weeks.

Limitations of Evidence

The designs and format of interventions used across the included studies were heterogeneous. Studies differed in intervention type, length, and structure, as well as method of delivery (e.g., mobile-app, individual practice, formal training). Studies differed in number, type, and distribution of measures across component processes of EF. Several studies included a waitlist or no control comparator group, impeding ability to draw causal conclusions. Lastly, variable quality of studies reduces reliability. This included bias introduced from the randomisation process and lack of pre-specified analysis plans.

Limitations of Review Process

Only 10% of papers were reviewed by both reviewers at the initial stage. Whilst there was 100% agreement, some papers may have been wrongly excluded. Some were excluded because, although they recruited participants within the eligible age range, they failed to stratify data by age, meaning specific effects for the study population could not be identified. The review may be biased by not including all available evidence, including those published in languages other than English. Additionally, whilst 15 papers were eligible for inclusion, access to quantitative data was not available for three papers, meaning they were not included in the meta-analysis, which may bias findings. Whilst the review made some attempt at separating measures into latent variables of EF, as there is significant overlap, tests are unlikely specific in measuring single component processes (Miyake & Friedman, 2012). Whilst all studies included ≥2 measures of EF, some only explored one component process of EF.

Future Research

The evidence-base would benefit from more well-designed empirical studies, including active controls, more frequent measurements and follow-ups, and pre-specified analysis plans. This may include exploring what elements of mindfulness-based interventions are related to outcome. For example Jensen et al. (2012) explored which components of mindfulness-based interventions may be beneficial and Zanesco et al. (2019) answered questions on timing and length of intervention on outcome. Future research could consider exploring mechanisms of effects of mindfulness-based interventions on EF. For example, why only certain aspects of inhibition improve.

Conclusion

Results suggest specific as opposed to general effects of mindfulness-based interventions on EF when explored in studies of the same participants. Findings suggest more conclusive evidence for effects of mindfulness-based interventions on inhibition, with more variable effects on working memory, and little evidence on cognitive flexibility. However, given methodological limitations and potential biases within studies, results should be interpreted cautiously.

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Service-Related Project

Exploring Representation of People of Global Ethnic Majority in the Memory Service: A Retrospective Analysis of 7-Years of Referral Data.

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May 2024

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Word Count: 5,033

The target journal for my Service-Related Project was the 'Journal of Aging and Health' (Word limit not specified; 30-page maximum). This journal was chosen as it is a peer-reviewed interdisciplinary forum, focussing on a range of topics relevant to the intersection of aging and health, including dementia. Guidance on journal formatting requirements is here: https://journals.sagepub.com/author-instructions/JAH.

Introduction

Dementia is a progressive neurological condition characterised by impairments in memory, thinking, and behaviour, which has a negative impact on function (World Health Organisation, n.d.). National Institute for Health and Care Excellence (NICE) guidelines for dementia recommend that "providers should design services to be accessible to as many people living with dementia as possible, including… people from black, Asian and minority ethnic groups" (NICE, 2018, p. 45). In the UK, it is estimated there are 885,000 people living with dementia (Wittenberg et al., 2019) with over 25,000 people from global ethnic majority groups (All-Party Parliamentary Group on Dementia, 2013).

A recent survey of 5,014 people found that whilst respondents were generally negative of collective terminology (e.g. Black and Minority Ethnicity, BAME), when used in contexts such as research into ethnic inequalities, people were least unhappy with the term 'global ethnic majority' (NHS Race and Health Observatory, 2021). The term People of Global Ethnic Majority (PoGM) challenges the normativity of a white majority, where in a global context these groups represent approximately 80% of the population. Additionally, it provides a more universally inclusive term, allowing peoples identity to be framed independent of 'whiteness' (Campbell-Stephens, 2021).

By 2051 the number of PoGM with dementia is expected to increase by seven-fold, compared to two-fold across the UK as a whole (All-Party Parliamentary Group on Dementia, 2013). Despite this estimated increase in prevalence, research suggests that PoGM in the UK are less likely to receive a diagnosis of dementia when compared to those from a white ethnic background (Pham et al., 2018). Other research suggests that PoGM are both younger at referral, and were diagnosed with dementia an average of 4.5 years younger than their white counterparts (Tuerk & Sauer, 2015). Studies highlight service level differences in representation of PoGM in referrals. One study across London found comparable representation of people from white and non-white ethnic backgrounds in their referrals (Cook et al., 2019), yet, in Leicestershire, where ethnic diversity is roughly comparable to London, a different study found a significant underrepresentation of PoGM in referrals (Subramaniam et al., 2020). Together, evidence indicates ethnic inequalities in access to some services based on locality and indicates a need for services to work with local stakeholders to investigate access for PoGM to memory services.

Reducing inequalities in health is not only a moral imperative but is enshrined in legislation. Recording of ethnicity in secondary care NHS services has been mandatory in England since 1995 (DH/Health and Social Care Information Centre/NHS Employers, 2005). The Race Relations (Amendment) Act (2000) stipulates that public authorities have a duty to promote race equality, including by monitoring the impact of policies and services and take action to address any disparities (UK Public General Acts, 2000). The Equality Act 2010 extended anti-discrimination legislation to cover nine protected characteristics, including race (UK Public General Acts, 2010). Additionally, to reduce health inequalities in England, the Health and Social Care Act (2012) introduced specific legal duties for a range of health bodies (UK Public General Acts, 2012). It is therefore a legislative requirement to monitor ethnicity of patients to identify those at greatest risk of illness and ensure race discrimination is not taking place.

A recent national audit of UK NHS memory services found that ethnicity was not recorded in 6% of the 3,978 sample (Cook et al., 2020). Indeed, Cook et al. (2019) reported the mean percentage of referrals with missing data in their London study was 8.9 (range 0 – 22%), whilst in their Leicestershire study Subramaniam et al. (2020) report that missing data for ethnicity was 9.6% and an additional 'not known' at 6.4%. Poor recording of ethnicity may bias findings and obscure the extent of ethnic inequities reported. This includes the increased miscoding of 'not known', 'not stated' or 'other' as an ethnicity code, which has been found to disproportionally affect PoGM (Scobie et al., 2021). Accurate ethnicity coding is essential in understanding and improving ethnic inequalities.

Evidence has suggested there may be ethnic inequalities in referrals to memory services in the UK NHS, including differences in recording of ethnic data within services, ages of people at referral, and rates of referral, for people from white and global ethnic majority groups. To improve ethnic inequalities in services it is important to first understand the needs of the local population demographic.

Aim

The current project aimed to understand representation of PoGM in referrals to the Swindon Memory Service. Findings will support future quality improvement projects to continue reducing ethnic inequalities in NHS memory services. The project had three service evaluation questions:

1) Do all referrals to the service have ethnicity recorded?
2) Are there differences in average age at referral between PoGM and people from white ethnic backgrounds?
3) Is ethnic diversity in referrals representative of local population estimates of ethnic diversity?

Methods

Service Context

The Swindon Memory Service is a specialist NHS service for those requiring a memory assessment in the Swindon area of Wiltshire. Most referrals are to assess for dementia. Whilst referrals are accepted from all ages, most are for people aged 65 and over, the demographic at greatest risk for dementia (Prince et al., 2015). The Office for National Statistics (ONS) 2021 census estimated the population of Swindon was 233,411, with 37,100 people aged over 65 (ONS, 2022d). In Swindon, it was estimated that 81.5% of people identify as white, similar to the national estimate of 81.7% (ONS, 2022a).

Service Consultation

Subjective feedback from the service's multidisciplinary team suggested they believe PoGM are underrepresented in referrals they receive given local area demographics and requested support to better understand this. This project is in line with the wider Trust's quality improvement agenda focussing on equality, diversity, and inclusivity.

Ethical Approval

Using the Health Research Authority decision tool I (TSJ) found that the project did not constitute as research, and therefore did not require NHS ethical approval. The project was registered and granted approval by the local NHS Trust Quality Team (Appendix B). This involved submitting a project plan which helped finalise the design and ensure good clinical practice and governance. Support was provided by an assigned Quality Improvement Facilitator. It was agreed that findings would be presented to the Quality Improvement team to ensure quality, minimise risk, and disseminate findings across the Trust.

Design

The study was a retrospective cohort study formed from routinely collected clinical and administrative data.

Procedure

Referrals to the Swindon NHS Memory Service, by ethnicity, for the years between and including 2015 to 2021, were obtained by an NHS Trust Quality Team Facilitator on 27th April 2022. Recent evidence suggests that the COVID-19 pandemic disproportionately affected people from minoritised ethnic groups in the UK in relation to differential exposure, vulnerability, health consequences, social consequences, effectiveness of pandemic control measures, and adverse consequences of control measures (Katikireddi et al., 2021). The years between and including 2015 to 2021 were chosen in the current sample as they represent the five-years preceding the COVID-19 pandemic (2015 – 2019) and the full years since (2020 & 2021). A 5-year period is recommended when exploring trends (Withers & Nadarajah, 2015).

All referrals between this period were requested as each referral represented a distinct case. No other inclusion/exclusion criteria were given. Data were provided in table format which included the name of the person referred, date of referral, ethnic group identified with, age, date of birth, and biological sex. Data were extracted from the Trust's informatics system from electronic patient records in RiO, and as such are deemed reliable. Data were cleaned prior to analysis by removing patient's name, date of birth and date of referral, as only ethnic group, age, and year referred were required.

Population Estimates of Ethnic Diversity. The ONS census, conducted every 10-years, is the gold-standard for ethnicity recording in England and Wales (ONS, 2011). A population estimate of ethnicity can be obtained by local authority (e.g., Swindon) and age (e.g., over 65). Census data is mandatory to complete, with the 2021 census achieving a 97% response rate (ONS, 2022c). However, as data are only published every 10-years, this estimate does not accurately reflect ethnic diversity in any given year. The current study used census data for Swindon for both all age groups and just for those aged 65 and over for the 2011 and 2021 censuses, as the current sample falls within the two periods (ONS, 2011; 2023).

Research suggests ethnicity codes used by the NHS are outdated compared to the ONS (Scobie et al., 2021). Whilst the ONS and NHS use the same high-level categories (Asian, black, mixed, white, and other), the way each ethnic group is mapped onto aggregate groups differs. For example, 'Chinese' is mapped onto 'other' by the NHS and 'Asian' by the ONS. Additionally, the ONS use codes not included by the NHS, including classification for 'Gypsy, Roma, and Traveller', making it difficult to know how this population have been identified in NHS datasets. NHS ethnicity codes were mapped onto ONS aggregate groups for analysis (appendix C). Ethnic groups are listed alphabetically, in line with the UK government's guidelines on writing about ethnicity (GOV.UK, n.d.).

Analysis

Data were analysed using SPSS version 28. All referrals were included to maximise power. To explore whether all referrals had ethnicity recorded the percentage of referrals with and without ethnicity recorded per year was compared. A 10% sample of referrals with the ethnicity code 'Not Stated (Not Recorded)' were selected to explore potential reasons for use of this category, with the aim of finding ways to help the service improve this. A 10% sample was chosen as this was deemed sufficient to identify patterns. Cases were randomly selected using the 'Rand()' function of Microsoft Excel (Microsoft Support, ND). Cases with missing ethnicity data were excluded from subsequent analysis.

To explore differences in age at referral, the frequency of referrals for those aged under 65, were compared with those aged 65 and over for each ethnic group. Additionally, median age was compared between groups. Groups were collapsed from high-level ethnicity categories to 'white' and 'PoGM' ('Asian', 'black', 'mixed' & 'other') to allow comparison with previous research that used similar categories (Tuerk & Sauer, 2015). As age is likely to be negatively skewed in this population, the median was chosen as a measure of central tendency due to it being less affected by outliers than the mean (von Hippel, 2005). A non-parametric test was used to account for large variations in group size and for age being not normally distributed (assessed visually by inspection of Q-Q plots and statistically by Shapiro-Wilk's test ($p < .05$)).

To explore representativeness of ethnic diversity in referrals, proportions of those referred were descriptively compared with the proportion expected to be referred for each ethnicity, based upon each population estimate of ethnic diversity taken from the 2011 and 2021 ONS census (ONS, 2011, 2023). Chi-square goodness-of-fit tests with a pre-specified cut-off of 0.05 were run to explore this statistically. The 5% significance level was chosen to balance the risk of type I and type II errors (Cohen, 1982). Cohen's *w* was calculated as a measure of effect size to explore the magnitude of difference between observed and expected frequencies by ethnicity, with $w = 0.10$, $w = 0.30$, and $w = 0.50$ representing small, medium and large effect sizes respectively (Cohen, 1988). Given ethnicity categories are mutually exclusive, the assumption of independence of observations was satisfied. Ethnic group was collapsed to high-level ethnicity categories ('Asian', 'black', 'mixed', 'white', and 'other') to satisfy the assumption of five expected frequencies in each group of categorical variables. This assumption was still not satisfied in the 2021 census (aged 65 and over) reference data, and so a chi-square goodness-of-fit test was not conducted using this.

Self-Reflexivity and Patient and Public Involvement

Whilst quantitative methodologies are often assumed as epistemologically more objective than other approaches, it is recognised that decisions in research design, analysis and interpretation are vulnerable to researcher biases resulting in subjectivity. Myself (TSJ), and supervisors (RP & LM), are aged under 65 and identify as white. We recognise that our assumptions, beliefs, and biases may influenced the study process and have taken care to engage in self-reflexivity throughout the process and sought guidance from experts by experience when interpreting and disseminating findings.

The expert by experience identified as someone from a British Global Ethnic Majority, an unpaid carer for a parent with dementia and has previously worked in a formal capacity for a UK third-sector dementia service. The expert by experience read the report and discussed with the lead author regarding the written report, interpretation, and dissemination. This included discussion around collective terminology, findings, and how they linked to their personal experience of memory assessment services as a PoGM.

Findings

Aim 1 – Do All Referrals to the Service have Ethnicity Recorded?

Research suggests that 6% of referrals to UK NHS memory services have missing ethnicity data (Cook et al., 2020). Of the 5,860 referrals in the current sample, 15% were missing ethnicity data ($n = 876$). Ethnicity was 'not requested' for 867 referrals and 9 'refused' to provide data. Figure 1 displays annual referral numbers from and including 2015 to 2021. For the full years between 2015 and 2019 the proportion of referrals without recorded ethnicity data remained roughly stable (12 – 15%), until an increase in 2020 (25%) and 2021 (33%).

As the proportion of referrals without recorded ethnicity data is higher in the year 2021, 20 cases from this year (10%) where ethnicity was 'not requested' were randomly selected to explore reasons for this increase through visual inspection of patient electronic records in RiO. In total, 19 had not had contact with the service (seven were discharged before being seen; six were waiting to be seen; five died before being seen; and one referral was opened in error). In only one case in the sample where ethnicity was not recorded was the client seen by the service. This suggests that whilst 15% of referrals have missing ethnicity data overall, once seen within the service, ethnicity may be recorded in more cases. Due to 2021 wait times ranging between four and seven-months it is likely many of the 2021 referrals had not been seen by time of data retrieval, which may explain greater proportion of missing data in this year.

Figure 1

Comparing Annual Referrals with and without Recorded Ethnicity Data between 2015 – 2021

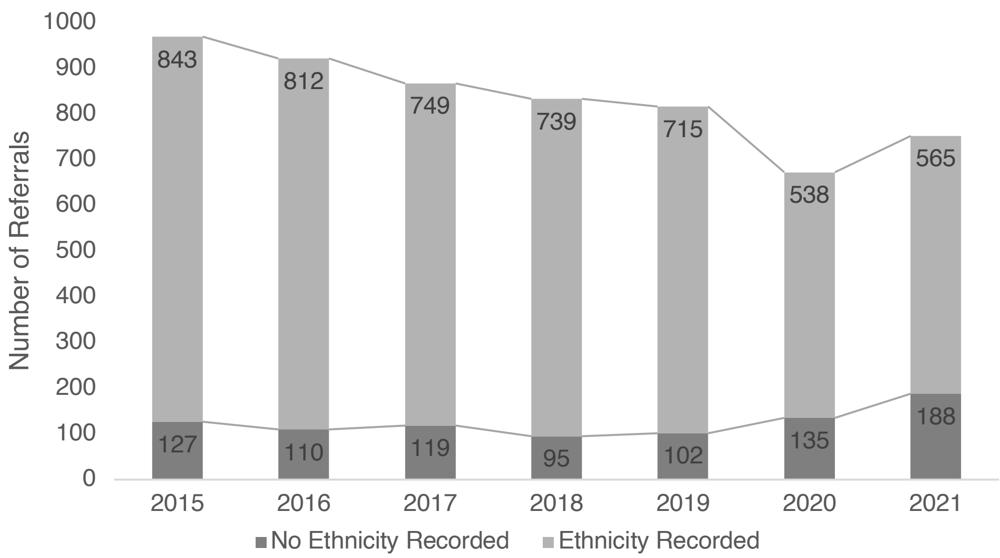

Table 1 displays demographic data for the 4,984 cases with ethnicity data. In the sample, 120 identified as 'Asian', 45 as 'black', 16 as 'mixed', 4,781 as 'white' and 22 as 'other'. The service received more referrals for females (*n* = 2,793) than males (*n* = 2,191). Of note, the system only collects data for 'biological sex' and not 'gender'. As such, data use binary 'male' and 'female' groups.

Table 1

Demographics for Referral Data for Memory Service, 2015 – 2021

Ethnic Group	*n (%)*	Female Sex, *n* (%)	Referrals Aged <65, *n* (%)	Referrals Aged ≥65, *n* (%)	Median Age, Years (Range)
Asian	120 (2.41)	52 (43.33)	17 (4.33)	103 (2.24)	78 (40 – 101)
Black	45 (0.90)	23 (51.11)	11 (2.80)	34 (0.74)	81 (35 – 97)
Mixed	16 (0.32)	4 (25.00)	3 (0.76)	13 (0.28)	80 (42 – 93)
White	4,781 (95.93)	2,699 (56.45)	359 (91.35)	4,422 (96.32)	84 (24 – 106)
Other	22 (0.44)	15 (68.18)	3 (0.76)	19 (0.41)	69.5 (54 – 92)
Total/Average	4,984 (100.00)	2,793 (56.04)	393 (100.00)	4,591.00 (100.00)	83 (24 – 106)

Table 2

Frequency of Actual versus Expected referrals from Population Estimates, by Ethnicity

Ethnic Group	Actual *n* (%)	Expected *n* (%)			
		2011 Census (All)	2021 Census (All)	2011 Census (≥65)	2021 Census (≥65)
Asian	120 (2.41)	318.47 (6.39)	580.22 (11.64)	103.98 (2.09)	83.29 (1.67)
Black	45 (0.90)	68.18 (1.37)	130.74 (2.62)	26.95 (0.54)	1.42 (0.03)
Mixed	16 (0.32)	100.70 (2.02)	138.69 (2.78)	19.00 (0.38)	0.00 (0.00)
White	4,781 (95.93)	4,477.44 (89.84)	4,060.08 (81.46)	4,827.68 (96.86)	4,890.74 (98.13)
Other	22 (0.44)	19.21 (0.39)	74.27 (1.49)	6.39 (0.13)	8.54 (0.17)

Aim 2 – Are there Differences in Average Age at Referral between PoGM and People from White Ethnic Backgrounds?

Previous research suggested that PoGM are younger at referral than their white counterparts (Tuerk & Sauer, 2015). Table 1 displays median age of the sample for each ethnic group. Descriptively, the oldest median age is for 'white' (*Mdn* = 84) and the youngest for 'other' (*Mdn* = 69.5). When collapsed to 'white' and 'PoGM' ('Asian', 'black', 'mixed' & 'other'), a Mann-Whitney U test found age at referral was statistically significantly younger in PoGM (*Mdn* = 78 years, n = 203), than people who identified as 'white' (*Mdn* = 84 years, n = 4,781; U = 341,003, $z = 7.19$, $p < .001$). Dementia is considered young-onset when symptoms develop before the age of 65 (Hendriks et al., 2021). The proportion of people in the sample referred to the service who identify as white is higher in those aged 65 and over (96.32%) than those aged under 65 (91.35%; Table 1), with a higher proportion of PoGM aged under 65 (8.65%) than aged 65 and above (3.68%).

Aim 3 – Is the Ethnic Diversity in Referrals Representative of Local Population Estimates of Ethnic Diversity?

Previous research suggested that there may be ethnic inequalities in referrals to UK memory services (Subramaniam et al., 2020). Three chi-square goodness-of-fit tests were run to statistically compare whether ethnic diversity in referrals to the Swindon Memory Service was similarly distributed as in population estimates for Swindon. Results indicate that ethnicity was not similarly distributed in referrals as in expected frequencies from the 2011 census (all ages), ($\chi^2(4)$ = 223.80, $p < .001$, Cohen's w = 7.48, minimum expected frequency 19.2), the 2011 census (aged 65 and above), ($\chi^2(4)$ = 53.62, $p < .001$, Cohen's w = 1.09, minimum expected frequency 6.4), nor the 2021 census (all ages), ($\chi^2(4)$ = 694.60, $p < .001$, Cohen's w = 17.45, minimum expected frequency 74.3). A chi-square goodness-of-fit test could not be run using expected frequencies from the 2021 census (aged 65 and above) due to violations of the test assumption of minimum five expected frequencies in each group of categorical variables. This suggests, with large effects, that the distribution of referrals is not as expected, given local population estimates of ethnicity, and there may be ethnic inequalities in referrals.

To explore directionality of effects, the percentages of actual and expected referrals were compared for each ethnic group. Table 2 displays a comparison of frequencies and proportions between actual and expected number of referrals using each population estimate of ethnic diversity for each ethnic group. The number of referrals for individuals who identified as white was higher than expected when compared the 2011 census (all ages) reference group (95.93% compared to 89.84%) and 2021 census (all ages) reference group (95.93% compared to 81.46%). The number of referrals for individuals who identified as white was lower than expected when compared to the 2011 census (aged 65 and above) reference group (95.93% compared to 96.86%) and 2021 census (aged 65 and above) reference group (95.93% compared to 98.13%). This suggests that whilst people who identify as Asian, black, or mixed ethnicity appear underrepresented in referrals when compared to expected proportions for people of all ages, when compared to expected proportions for those aged 65 and above, the most at-risk age demographic for dementia, PoGM were better represented.

Presentation to the Service

A presentation to the service included a summary of existing research, guidelines, findings from the current study, and recommendations for practice. Findings and recommendations were well received and prompted discussion regarding ethnic inequalities and service development. The service considered how they could ensure accurate ethnicity data was available at the point of triage, rather than assessment, for example, by rejecting referrals with missing ethnicity data. However, whilst rejecting referrals with missing data may improve rates, this would likely only further perpetuate inequalities, if individuals were delayed in accessing the service, given missing ethnicity data disproportionally affects PoGM (Scobie et al., 2021). There was discussion regarding how the service could ensure they were delivering culturally and ethnically sensitive assessments, and this was identified as a need for further training. Additionally, the service considered implications for practice including discussion around health inequalities in prescribing if people from certain demographics are not being referred or referred later in their condition.

Discussion

The current project aimed to understand representation of PoGM in the Swindon, NHS Memory Service. The first question explored whether all referrals to the service had recorded ethnicity data. Whilst previous research found, on average, 6% of referrals to memory services in the UK NHS have missing ethnicity data (Cook et al., 2020), results of the current project found this was 15%. Whilst a national average highlights a broader systemic issue in collection of ethnicity data and understanding ethnic inequalities, understanding patterns of missing data at a service level opens opportunities for targeted service improvements.

Further investigation of the current sample's data explored why missing data may be higher than the national average. This exploration suggested that missing data may be in cases where referrals were opened, but an assessment had not occurred. This indicates that the problem of missing data may lie early in the patient journey. Exploring reasons for missing data for every case would allow stronger conclusions to be drawn. For example, exploring trends of missing data across the whole sample, which was beyond the scope of the current project.

Missing ethnicity data at referral may impede clinicians' ability to prepare for ethnically and culturally sensitive assessments, leading to an ethnic inequity in service. Understanding this pattern at a service level suggests need for a process level change and guides the point at which service improvement initiatives should be directed, in this case, likely at the point of referral. A strength of the current project was not only exploring what the problem was but hypothesising reasons why, to aid continuing service improvement. Future projects should consider this within designs to ensure future recommendations are specific to the needs of the service to continue improving ethnic inequalities in dementia and broader health.

The second question explored whether there were differences in age at referral between PoGM and those from white ethnic backgrounds. Evidence from the current project was in line with evidence from other services which suggested that PoGM were younger at referral than those from white ethnic backgrounds (Tuerk & Sauer, 2015). Previous research has suggested that the prevalence of young-onset dementia is three times higher in PoGM than in those from white ethnic backgrounds (Knapp et al., 2007). Whilst results of the current project did not explore young-onset dementia specifically (symptoms present before the age of 65 (Hendriks et al., 2021)), the proportion of PoGM was higher in those aged under 65 than those aged 65 and above, which suggested a greater representation of PoGM referred in the young-onset age group compared to those who identify as white. Dementia diagnosed at different ages presents with its own unique challenges, including loss of self-identify and meaningful role (Greenwood & Smith, 2016). Understanding the intersection of age, ethnicity, and other demographic differences, particularly at a local level, should be an important consideration in the design, setup, and provision of memory services.

The final question explored ethnic diversity in referrals. Previous studies identified differences in representation of PoGM in referrals across regional UK memory services, suggesting a need for this to be explored at a local level (Cook et al., 2019; Subramaniam et al., 2020). Whilst the current project found some evidence of ethnic inequalities, there was less evidence in the aged 65 and above group. The current project is strengthened by including estimates of ethnic diversity in the age demographic most at risk of developing dementia (Prince et al., 2015) given that the greater proportion of people who identified as white in this age demographic may have skewed findings. Evidence at this local level adds to the wider systemic understandings of ethnic inequalities in UK memory services, and health more broadly and further highlights the need for local services to explore representation in referrals locally.

Whilst both the current and aforementioned projects (Subramaniam et al., 2020) have identified that an inequity may exist, they do not hypothesise why. For example, in a study of perceptions of memory problems in London black African and Caribbean British communities, authors identified a plethora of cultural barriers to help seeking including that 'forgetfulness' was considered a normal part of ageing (Berwald et al., 2016). Understanding cultural considerations appears pivotal in remaining sensitive to cultural differences when interpreting findings and considering future initiatives to improve ethnic inequalities in health. For example, it is possible that whilst individuals may not be being supported formally by health services, they may still be receiving support through other channels in their community. Future projects would benefit from extending research designs to begin hypothesising why ethnic inequalities may exist within localities to begin addressing identified ethnic inequalities.

Clinical Implications

Findings raise implications for practice in the current service and memory assessment services more broadly. Ethnic inequalities in access may prevent PoGM from early access to support and treatment and may have longer term impacts on care. This may be particularly important for those who present to services under 65, as here, potential evidence of ethnic inequalities in access were observed. NICE guidelines (NICE, 2018) recommend acetylcholinesterase inhibitors in the pharmacological management of mild to moderate Alzheimer's Disease. Individuals not referred until later in their condition may miss early treatment and potential improvement and retention of cognitive function (Tuerk & Sauer, 2015). Missing ethnicity data at referral impedes clinicians' ability to prepare for ethnically and culturally sensitive assessments. Access to ethnicity data allows early consideration of ethnic differences in risk factors of dementia, for example, recognising PoGM may present younger than their white counterparts.

Research Implications

Findings raise implications for research. Missing ethnicity data results in incomplete datasets, thus reducing reliability of findings and subsequent recommendations. It is therefore difficult to truly evaluate effectiveness of assessment tools or interventions if we are unable to accurately conclude for whom they are effective. Additionally, incomplete datasets result in an incomplete picture of the local population demographics. This has implications in the identification of research needs and subsequent research designs. As previous evidence has suggested that missing data disproportionally affects PoGM (Scobie et al., 2021), certain demographics of people may be missed from study. Failing to accurately identify research needs further perpetuates ethnic inequalities in health.

Recommendations

Several recommendations have been made for the current service, memory assessment services more broadly, and for future research in this area.

The Current Service

1. The service would benefit in exploring ways to improve ethnicity data from referrers. It is possible information is available but is not being pulled from the national SPINE by local patient record systems. Referrers may benefit from clear guidelines on providing ethnicity data with training provided to ensure it is completed accurately. If data are still missing at point of referral, the service should contact the referrer to gather this information prior to first contact.
2. Practitioners should be aware that PoGM may present younger and hold ethnic differences in risk factors in mind when conducting assessments.
3. Ethnic diversity in referrals should continue to be monitored to ensure any ethnic inequalities in the service are identified and improved. The

Royal College of Psychiatrists (RC Psych) Memory Services National Accreditation Programme (MSNAP) guidelines recommend that services review data about the people who use it at least annually and take action to address any inequalities of access where identified (RC Psych, 2022). Ethnicity data in referrals should continue to be compared to the most relevant and up to date local census data.

4. The current service would benefit from exploring ethnic diversity in diagnosis to further support clinicians in understanding ethnic differences in risk relevant to the local demographic.
5. Exploring reasons for missing data for every case would strengthen the rationale for targeted service improvements.

UK Memory Assessment Services

1. All services should explore rates of and reasons for any missing ethnicity data to find ways to improve ethnicity data recording and allow greatest level of targeted service improvements.
2. All services should begin to and continue to monitor ethnic diversity in the referrals they receive in relation to local population estimates of ethnic diversity, for example, using local census data.
3. Future projects should consider exploring community outreach initiatives. Indeed, the Bristol BME Dementia Research Group conducted a project exploring dementia experiences and needs of PoGM locally (Cheston et al., 2017). Similar research in local regions would allow the development of culturally sensitive, targeted initiatives.

Future Research

1. Considering the intersection of age and ethnicity in dementia, research should focus on ensuring cognitive tests used in memory assessment are appropriately normed, given increase in ethnic diversity and needs of those presenting to services.
2. The intersection of other facets of identity in the relationship between ethnicity and referral rate including age, sex, gender, and aspects of sociocultural background should be considered.
3. Integrate findings from local services and explore the wider systemic problem of ethnic inequalities in dementia assessment across the UK to ensure equitable access in treatment for all ethnic groups.

4. Lastly, future projects would benefit from extending research designs to begin hypothesising why ethnic inequalities may exist within localities to begin addressing identified ethnic inequalities.

Limitations

Caution is emphasized in interpretation of results. The term PoGM encompasses a heterogenous group both within and between ethnic groups. Whilst ethnicity may play a role in influencing referrals, this is only one factor and individual difference must remain paramount. Outdated ethnicity categories offered by the UK NHS may impede reliability when making comparisons to population estimates of ethnicity. Additional limitations arise from use of census data. Census data only accurately reflect ethnic diversity at point of data collection. Census data does not have a 100% response rate, reducing the reliability as a reference set. Whilst previous research has suggested there is a higher prevalence of dementia in people from British African-Caribbean compared to white British communities (Adelman et al., 2009), results of the current project assume the risk of developing dementia is the same for all ethnic groups. Therefore, epidemiological data may provide a more accurate reference dataset than census data where health conditions, such as dementia, may not be equally distributed amongst ethnic groups. Additionally, other unmeasured variables may better inform this area of study. For example, services may benefit from recording sociocultural background data including family structure, living situation, religious background, and language which may influence a person's drive for help-seeking within the NHS context. Lastly, 15% of referrals had missing ethnicity data. Evidence suggests ethnic data recording problems disproportionately affect PoGM which further affects reliability of analysis of ethnic differences (Scobie et al., 2021).

Conclusion

To improve ethnic inequalities in services it is important to first understand the needs of the local population demographic. The current project aimed to understand representation of PoGM in the Swindon Memory Service. In line with other evidence across the UK, results found there may be ethnic differences in referrals to the NHS Swindon Memory Service, however, in the age demographic most at risk of developing dementia (Prince et al., 2015) results found less evidence of ethnic inequalities.

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Main Research Project

Exploring the Impact of Intensive Care Shifts on Nurses' Executive Function: An Observational Study

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Word Count: 7,232

The target journal for my Main Research Project was 'Applied Cognitive Psychology' (word count limit: 8,500). This journal was chosen as a peer-reviewed journal focussing specifically on the application of cognitive psychology to real-world issues. Guidance on journal formatting requirements is here: https://onlinelibrary.wiley.com/page/journal/10990720/homepage/forauthors.html.

Background

Intensive care units (ICUs) are hospital wards for people who are seriously ill and require intensive treatment and/or close monitoring. This includes use of equipment to monitor vital health parameters, including breathing, heart rate, and feeding (National Health Service (NHS), 2019). ICUs are staffed by multi-disciplinary teams of which nursing comprises the largest single profession. Guidelines for provision of intensive care services require a minimum registered nurse-to-patient ratio of 1:1 to deliver direct care (Intensive Care Society, 2019).

Executive Functioning in Healthcare Settings

Effective patient care requires higher-order cognitive functions, including executive functions (EF) to synthesise information and make quick inferences regarding course of action (Lundgrén-Laine et al., 2011). EFs are top-down, effortful mental processes that support reasoning, problem-solving and planning (Collins & Koechlin, 2012). Whilst systematic reviews suggest models vary by age (e.g., preschool children = one/two-factor; older adult = two/three-factor; Karr et al., 2018), a three-factor model consisting of updating/working memory, inhibition, and shifting/cognitive flexibility is generally most accepted in adults (Miyake et al., 2000). EF models suggest factors show correlation with one another and tap into a common underlying ability (unity), but also separability (diversity) suggesting distinct cognitive processes (Miyake & Friedman, 2012).

Working memory/updating encompasses the processes of perceiving information input, processing, storing, and retrieval through the act of remembering (Baddeley & Hitch, 1974). Whilst short-term memory allows information to be stored temporarily, working memory allows mental manipulation of information for reasoning and decision-making. Inhibitory control involves ability to consciously control automatic thoughts, feelings, or behaviours to select more appropriate goal-directed responses over automatic reactions (Munakata et al., 2011). Cognitive flexibility is characterised by capacity to adapt behaviour and thinking in response to environmental cues (Martin & Anderson, 1998).

Lack of sleep and stress independently impair EF performance (Diamond, 2013; Shields et al., 2016). The nature of shift-working negatively impacts sleep (Yu, 2019) and, over time, leads to circadian rhythm alterations (Leso et al., 2021). Additionally, studies have identified high levels of stress in UK healthcare workers (Gilleen et al., 2021). Whilst data presented represent shift work and healthcare workers more generally, little is known about ICU nurses specifically, who work in a unique environment with associated challenges.

National annual turnover of critical care nurses in England and Northern Ireland averages 10%, but was estimated as high as 42% in one unit (Cutler et al., 2021), with traumatic and stressful workplace experiences related to intention to leave (Khan et al., 2019). Despite high stress and poor sleep in ICU nurses (Bates et al., 2021; Yu et al., 2019), there is a dearth of research exploring the impact of this work on EF. Reductions in EF performance could have consequences in situations where tasks require quick and accurate responses (Niu et al., 2011), and may impact patient safety (Reason, 2000). In addition, ICU nurses are at risk of moral injury as a result of occupational decision making, including providing equal care for patients in the context of constrained or inadequate resources, and balancing personal physical and mental needs with those of patients (Greenberg et al., 2020). Reductions in EF performance may further constrain nurses' resources and increase personal needs.

Understanding change in EF performance across healthcare shifts is important for both patient safety and staff wellbeing. Whilst few studies have been conducted, there is some evidence that decline in EF performance may occur across shifts (Esmaily et al., 2021; James et al., 2021; Niu et al., 2013; Rollinson et al., 2003; Zion & Shochat, 2018).

Working Memory

Similar impacts of healthcare shifts on working memory performance have been identified across different healthcare professionals and settings. In an underpowered study of 12 emergency care physicians in the United States of America (USA), significant pre-post night shift reductions in visuospatial working memory performance were found, as assessed by the Delayed Recognition Span Test (Rollinson et al., 2003). This difference represented an 18.5% decrease in test performance (mean difference −2.2; 95% confidence interval −3.1 to −1.3).

Shift type appears to mediate this effect. Pre-post shift reductions were found in 35 nurses in different hospital wards in Iran, for morning (07:30 – 14:00), evening (14:00 – 19:30), and night shifts (19:30 – 07:30), assessed using the Digit Span Test (Esmaily et al., 2021). However, Esmaily et al. (2021) found that reduction in working memory performance was most prominent for the night, compared to day or evening shifts. Indeed, large effects were observed for the nightshift (*d* = 1.07; large effect), compared to small effects for morning (*d* = 0.43) and evening shifts (*d* = 0.49). Whilst previous research has suggested one night of sleep deprivation can affect EF (Skurvydas et al., 2020) differences in shift length, rather than shift type, may have impacted findings in Esmaily et al. (2021).

Fluctuations in performance across shifts have also been observed. Indeed, in a study of 92 nurses in Israel, working memory function lower during the middle compared to end of the night shift as assessed using the Digit Symbol Substitution Task (DSST; Zion & Shochat, 2018). Small effects were observed, after both the first (*d* = 0.48) and second (*d* = 0.24) consecutive night shifts. Mediating factors, such as tiredness, may explain fluctuations, with a significant association between sleepiness, as measured by the Karolinska Sleepiness Scale, and DSST performance ($F(1,248) = 6.27$, $p < 0.05$). Taken together, evidence suggests that working memory may decline from the start to end of healthcare shifts and may also fluctuate within the shift. However, given that stress impairs working memory performance (Shields et al., 2016), studies are yet to explore associations between stress and working memory in healthcare populations, including ICU nurses.

Inhibitory Control

Research suggests inhibitory control also declines over the course of a healthcare shift. Esmaily et al. (2021) found significant pre-post shift reductions in inhibitory control performance in 35 nurses working night shifts across hospital wards in Iran, assessed using a Stroop Colour-Word Interference Task (Stroop, 1935). This was with a large effect for the nightshift (*d* = 2.36) and a small effect for the evening shift (*d* = 0.36). However, similar effects were not observed for the day shift. Rollinson et al. (2003) found no significant pre-post day shift differences in attention in 12 emergency care physicians in the USA, assessed using a Continuous Performance Task. However, the pilot study was underpowered which may have reduced ability to detect all potential effects. Together, evidence suggests mediating factors in evening or night shifts may lead to decline in inhibition.

A cumulative effect has also been documented with greater declines in inhibitory control performance after consecutive shifts. A study of 94 nurse participants in the USA, identified more lapses of attention in participants after three (fatigued), compared to one (rested), consecutive shift (James et al., 2021).

The relationship between sleep and EF may explain reductions in inhibitory control performance only during the night shift or after consecutive shifts. However, given that stress impairs inhibitory control performance (Shields et al., 2016), studies are yet to explore associations between stress and inhibition in healthcare populations, including ICU nurses.

Cognitive Flexibility

The impact of healthcare shifts on cognitive flexibility has received relatively less attention, with available evidence not suggesting changes in cognitive flexibility performance. A small sample study of 13 Emergency Care Physicians in the USA working day and night shifts, found no changes in cognitive flexibility for either the day or night shift (Machi et al., 2012), as assessed using the Trail Making Test (Reitan, 1955). Nonetheless, data are from one small study making it difficult to infer strong conclusions.

Aim

There is currently limited conclusive empirical understanding of the potential impact of healthcare shifts on EF performance, particularly in the context of ICU nursing, which presents a unique working environment and associated challenges. Where research has been conducted, methodological heterogeneity impedes ability to infer strong conclusions through variations in assessment, participant demographics, and absence of each EF subcomponent. Notably, whilst studies conducted in diverse settings with distinct healthcare systems offer important cross-cultural insights, there poses the challenge of generalisation. Additionally, despite high stress and poor sleep in this population (Bates et al., 2021; Yu et al., 2019), there is, to our knowledge, no studies exploring how these relate to all subcomponents of EF performance in healthcare settings.

The current study aimed to explore EF in nurses at the beginning and end of ICU day shifts. One shift type was chosen to increase statistical power and assess feasibility of the method as part of a pilot trial. A measure for each working memory, inhibition, and cognitive flexibility was included to allow changes across each component variable of EF to be explored. Whilst changes in EF may more be more likely to be observed during the nightshift, it is nonetheless no less important to understand EF in the dayshift population too. An exploratory approach was taken given mixed available evidence; thus, testable hypotheses are not indicated. The following research questions were explored: 1) Is there change in nurses EF between the start and end of an ICU day shift?; 2) What factors are associated with EF performance at the end of a shift?; and 3) How feasible is it to recruit this population using the current study design in the UK NHS?

Methods

Epistemological Position

The study is grounded in principles of post-positivism, emphasising the role of data, evidence, and rational consideration in knowledge formation. Post-positivism is built on the premise that 1) research on human behaviour cannot be entirely accurate, but can generalise probable outcomes; and 2) all observations are imperfect and fallible (Creswell & Creswell, 2023). Creswell and Creswell (2023) characterise the post-positivistic worldview as involving 1) quantitative methods with an intervention or treatment; 2) testing theory through specification of a focused hypotheses; 3) utilisation of pre- and post-test measurement methods; and 4) collection of data to either support or refute hypotheses.

Design

A within-subjects, repeated-measures design explored the impact of an ICU day shift on EF in nurses. The independent variable was timepoint within shift (pre–post). Dependent variables were measures of EF subcomponents: working memory, inhibition, and cognitive flexibility. Sleep quality and perceived stress were included as independent variables to explore factors associated with post-shift EF performance.

Participants, Inclusion/Exclusion

Eligible participants were nurses working 12-hour-long day shifts in one ICU in a major acute care hospital in the Southwest of the UK. Eligible participants were required to have normal or corrected-to-normal vision, including seeing colour, a requirement for one of the dependent variables (Dimensional Change Card Sort). Whilst current depression or sleep disorder could affect EF and confound results, the within-subjects design accounted for this variance, and was therefore not an exclusion criterion.

Sample-Size

An a priori power analysis was conducted using G*Power (Faul et al., 2007) to determine minimum sample size to test change in EF performance pre-post ICU shifts. Previous studies exploring effects of healthcare shifts on EF have not reported effect sizes and so a medium effect size was chosen. Results indicated the required sample size to achieve 80% power for detecting a medium effect, at a significance criterion of $\alpha = .05$, was $N = 34$ for a 2-tailed, paired-samples *t*-test.

Measures

Demographic Data

Demographic data were collected for participants' age, biological sex, gender, handedness, ethnicity, and number of consecutive shifts worked.

Sleep Quality

The Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989) is a 19-item self-report questionnaire designed to measure sleep quality and sleep disturbances over a one-month period. The questionnaire produces a global PSQI score, as well as component scores for "subjective sleep quality," "sleep latency," "sleep duration," "sleep efficiency," "sleep disturbance," "use of sleep medication," and "daytime dysfunction." PSQI global scores range from 0 – 21. Scores of > 5 yielded a diagnostic sensitivity of 89.6% and specificity of 86.5% (kappa = 0.75, $p < 0.001$) in distinguishing "good" and "poor" sleepers (Buysse et al., 1989). Validation studies have identified acceptable internal consistency for the seven component scores (Cronbach's alpha = 0.83), good test-retest reliability ($r = 0.85$), and good discriminant validity (Buysse et al., 1989). In the current sample, internal consistency (as measured by Cronbach's alpha) was questionable ($\alpha = 0.59$).

Perceived Stress

The Perceived Stress Scale (PSS; Cohen et al., 1983) is a 10-item self-report questionnaire designed to evaluate the degree to which an individual has perceived life as unpredictable, uncontrollable, and overloading over the previous month. Reponse categories range from 0 = "never" to 5 = "very often." A global PSS score is calculated by summing item scores after reverse-scoring items 4, 5, 7, and 8. Scores of 0 – 13, 14 – 26, and 27 – 40 represent low, moderate, and high perceived stress, respectively. Validation studies identified good internal consistency (Cronbach's alpha = 0.78; Cohen et al., 1983) and good test-retest reliability (intraclass correlation coefficient = 0.86; Reis et al., 2010). Whist unsatisfactory criterion validity has been demonstrated by weak to moderate associations with criterion questionnaires (Lee, 2012), it has been questioned whether these criteria were gold-standard for the PSS, or whether biomarkers of stress, such as cortisol, would be more appropriate (van Eck & Nicolson, 1994). In the current sample, internal consistency (as measured by Cronbach's alpha) was good (α = 0.81).

Executive Function

Cognitive measures were validated and standardised non-self-report measures of each component variable of EF: working memory, inhibitory control, and cognitive flexibility (Miyake et al., 2000). Measures were administered using the National Institute of Health Toolbox (HealthMeasures, 2022), and presented on the same iPad using standard, recommended instructions (Gershon et al., 2013).

Working Memory. The List Sorting Working Memory Test (LSWM) requires immediate recall and sequencing of stimuli. Images of food and animals are displayed on screen, one at a time, for two seconds, accompanied simultaneously by audio. Participants are required to mentally reorder and repeat back items in size order from smallest to biggest. In the first condition participants list items based upon one dimension (food or animals). In the second condition participants list items based upon two dimensions (food then animals). Strings begin at two-items in length and with each correct response increased by one-item to a maximum seven-item string. If participants were unable to successfully sequence the string, they were provided with a second trial of the same length. The test was discontinued after participants provided incorrect responses to two consecutive trials of the same length.

Scores range from 0 – 28 and are calculated based upon the total number of correct responses in both conditions. The test takes approximately seven minutes to administer and is validated for use in people aged 7 – 85. Test-retest reliability in adults has been reported as excellent (intraclass correlation coefficient (ICC) = 0.77; Weintraub et al., 2013).

Inhibition. The Flanker Inhibitory Control and Attention Test is a version of the Eriksen Flanker and derived from the Attention Network Test (Rueda et al., 2004). Participants are asked to focus on a central directional target (arrow) while inhibiting attention to similar stimuli flanking it. Sometimes stimuli point the same direction as "flankers" (congruent), and sometimes the opposite (incongruent).

Scores are based on an algorithm integrating accuracy (0 – 5 points) and reaction time (0 – 5 points). Flanker accuracy scores are computed by multiplying the correct number of responses by 0.125. Participants over the age of 8 automatically receive 20 correct responses, plus up to 20 correct responses from the 20 flanker trials (40 x 0.125 = 5 points). Flanker reaction time scores are calculated using median reaction time from correct trials of incongruent conditions. Reaction times only greater than or equal to 100ms and less than 3SDs away from participants individual means are used in the calculation.

Based upon data from validation studies, median reaction times used for score calculations are set between 500ms and 3,000ms, with participants median reaction times outside of this range truncated. A log (base 10) transformation is applied to account for a positively skewed reaction time distributions. Log values are algebraically rescaled from a log(500) – log(3,000) range, to a 0-5 range. If accuracy is less than or equal to 80%, the score is equal to the accuracy score. Scores where participants achieve accuracy greater than 80% combine reaction time and accuracy. Scores vary from 0 – 10. The test takes approximately 3 minutes to administer and is validated for use in people aged 3 – 85. Test-retest reliability in adults has been reported as excellent (ICC = 0.80; Weintraub et al., 2013).

Cognitive Flexibility. The Dimensional Change Card Sort Test (DCCS) is a measure of cognitive flexibility. Participants are presented with two target pictures that vary in shape and colour. Participants are required to match bivalent choice pictures (e.g., yellow balls and blue trucks) to target pictures, first according to one dimension (e.g. shape or colour), then after several trials, according to the other dimension. “Switch” trials are employed where the participant changes dimension matched.

Scores are based on an algorithm integrating accuracy (0 – 5 points) and reaction time (0 – 5 points) over 38 trials (inclusive of 8 “practice” trials). DCCS accuracy scores are computed by multiplying the correct number of responses by 0.125 (40 x 0.125 = 5 points). Participants over the age of 8 automatically receive 10 accuracy points towards the computed score calculation. DCCS reaction time scores are calculated using participants raw, non-dominant dimension (dimension cued less frequently during the mixed trials) median reaction time. Reaction times only greater than or equal to 100ms and less than 3SDs away from participants means are used in the calculation.

Based upon data from validation studies, median reaction times used for score calculations are set between 500ms and 3,000ms, with participants median reaction times outside of this range truncated. A log (base 10) transformation is applied to account for a positively skewed reaction time distributions. Log values are algebraically rescaled from a log(500) – log(3,000) range, to a 0 – 5 range. If accuracy is less than or equal to 80%, the score is equal to the accuracy score. Scores of participants who achieve an accuracy of greater than 80% combine both reaction time and accuracy. Scores vary from 0 – 10. The test takes approximately 4 minutes to administer and is validated for use in people aged 3 – 85. Test-retest reliability in adults has been reported as excellent (0.88; Weintraub et al., 2013).

Procedure

Ethical approval was granted by the UK NHS Health Research Authority (HRA; Appendix D). One researcher (TSJ) was involved in data collection. Recruitment days were prior planned with the nurse in charge to ensure sufficient staff should be available to cover essential ward activities. Information was advertised through emails, posters, and approaching nurses directly. Most participants were recruited after being approached at the start of shifts for participation. Some nurses contacted researchers to arrange a testing session.

Assessment procedures took place in a private and quiet, non-clinical, space on the ICU free from distractions and to allow standardisation. Written informed consent was provided by each participant. Participants could withdraw at any time, however, data already collected were retained. Data were collected within the first (pre-) and last (post-) hour of single shifts. A 1-hour time window around the start and end of shifts was chosen to avoid clashing with essential ward activities such as handover and patient safety checks. Data collection followed a standardised procedure for all participants (Table 1).

Table 1

Data Collection Procedure

Order	Pre-Shift	Post-Shift
1	Demographic data	List Sorting Working Memory
2	Pittsburgh Sleep Quality Index	Flanker
3	PHQ-2	Dimensional Change Card Sort
4	Perceived Stress Scale	
5	List Sorting Working Memory	
6	Flanker	
7	Dimensional Change Card Sort	

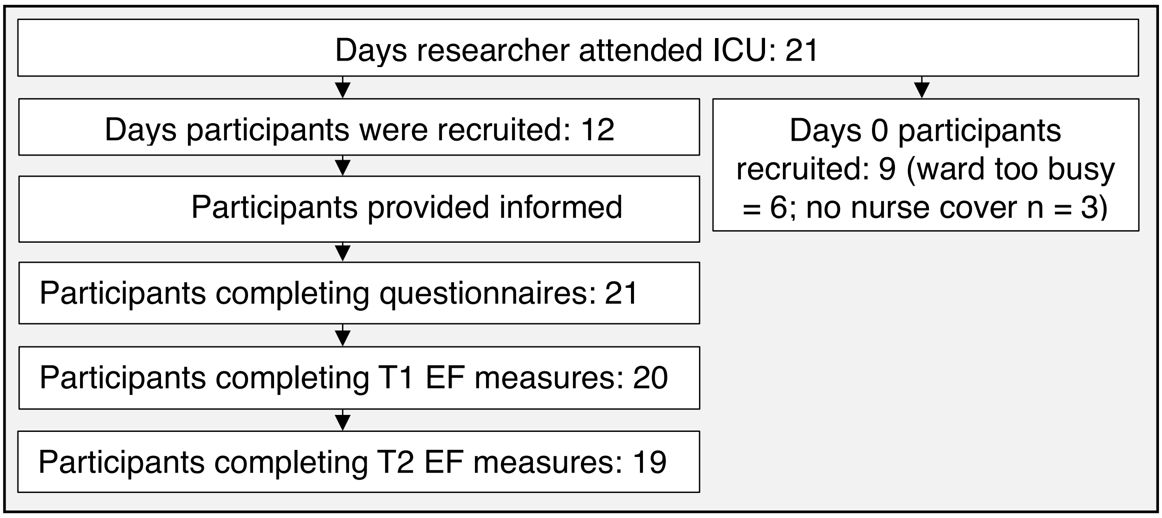
Recruitment

Figure 1 outlines recruitment flow. Over the eight-month study period (August 2023 – March 2024) one researcher attended the ICU to recruit on 21 days. At least one participant was recruited on 12 days. On the other nine days participants were not recruited due to staffing or general capacity of the unit. Twenty-one participants consented to participate. All 21 completed questionnaires. Twenty completed pre-shift cognitive testing and nineteen participants also completed post-shift cognitive testing. Where cognitive data were not obtained, no nurse cover was available to cover clinical activities. Analysis was completed for the 19 participants with full datasets (see Appendix F for descriptive statistics for the 21 recruited participants).

Based upon the current study design with one researcher collecting data at one unit and no additional nurse cover provided, a maximum of 2 participants could be recruited per day (range 0 – 2; median = 1). On average, it took 1.1 days attending the unit to recruit each participant. Therefore, to reach the minimum sample size (*N* = 34) researchers would need to recruit on 38 days.

Figure 1

Recruitment Flow Diagram



Statistical Analysis

Analyses were conducted using IBM SPSS version 29. Three paired samples *t*-tests were run each for the LSWM, Flanker, and DCCS, to determine whether EF significantly changed pre-post shift. Additionally, Reliable Change Indices (RCI; Morley & Dowzer, 2014) were calculated. The RCI has been proposed as a method to account for variability and practice effects, both common when administering brief retests of cognitive measures (Goldberg et al., 2015). The RCI determines whether magnitude of change is more than can be explained by measurement error. A change is deemed reliable when the change score from an individual participant exceeds the critical RCI value, which can be calculated using the Leeds Reliable Change Index (Moreley & Dowzer, 2014).

Seven outliers on difference scores of dependent variables were detected that were more than 1.5 box-lengths from edge of the box in a box plot. Inspection of values did not reveal them to be extreme and cases were retained in analysis. Additionally, difference scores between pre and post shift EF were not normally distributed, as assessed through visual inspection of Q-Q Plots.

Three multiple regression analyses were run, one for each LSWM, Flanker, and DCCS scores to explore any causal associations of post-shift EF with pre-shift EF, sleep quality and stress. A sensitivity analysis was conducted by removing sleep quality as a variable from the model, given the questionable internal consistency of the measure in the current sample (α = 0.59). Effects on conclusions were evaluated by comparing the difference in *p* values.

There was linearity as assessed by partial regression plots and a plot of studentised residuals against the predicted values. There were independences of residuals, as assessed by a Durbin-Watson statistics of 2.61, 1.90, and 2.02, for LSWM, Flanker, and DCCS models respectively. There was homoscedasticity, assessed through visual inspection of plots of studentised residuals versus unstandardised predicted values. There was no evidence of multicollinearity, assessed by tolerance values greater than 0.1. There were no studentised deleted residuals greater than ±3 standard deviations or values for Cook's distance above 1. There were leverage values greater than 0.2 for 8 participants, however, these were non-influential, and cases were retained. The assumption of normality was violated, assessed through visual inspection of Q-Q Plots.

Bootstrapped estimates of standard errors and bias-corrected and accelerated 95% confidence intervals (2,000 resamples) are reported to account for small sample size and violations of normality. Reported *p* values are 2-sided, and effects are considered statistically significant at $p < .05$. Bonferroni corrections for total number of tests were not applied as this is often considered too conservative where dependent variables are related (Nakagawa, 2004). Analyses were conducted using listwise deletion of missing data.

Results

Participants

Full datasets were obtained for 19 participants (hereby the sample). Table 2 displays demographics. All participants were substantive nurses working on the ICU. Most identified their gender and sex as female. All participants identified gender and biological sex the same. Additionally, the sample was biased to rested participants, with this being most participants (74%) first consecutive shift.

Descriptive Statistics

Descriptive data for sleep quality, stress and EF measures are displayed in Table 3. Raw scores are presented for the LSWM. Computed scores are presented for the Flanker and DCCS as overall scores are based upon an algorithm integrating raw accuracy and reaction time. Based upon established cut-off points (Buysse et al., 1989; Cohen et al., 1983) seven participants (37%) were identified as "poor" sleepers. Eleven participants (58%) were identified as having low stress, eight (42%) as having moderate stress, and no participants were identified as having high perceived stress.

Table 2

Participant Demographics (N = 19)

Demographic	Number (%)
Age, mean (SD), Range, years	33.00 (6.51), 25 – 52
Biological Sex	
Female	13 (68)
Male	6 (32)
Gender Identity	
Female	13 (68)
Male	6 (32)
Handedness	
Right	18 (95)
Left	1 (5)
Ethnicity	
White	14 (74)
Asian	4 (21)
Hispanic	1 (5)
Consecutive Shifts	
One	14 (74)
Two	2 (10.5)
Three	1 (5)
Four	2 (10.5)

Table 3

Descriptive Statistics and Bivariate Correlations Between Key Study Variables (N = 19)

Variable	Mean (SD)	1.	2.	3.	4.	5.	6.	7.	8.
1. LSWM – Pre	17.11 (2.28)	--							
2. LSWM – Post	17.58 (2.27)	0.80***	--						
3. Flanker – Pre	9.08 (0.89)	0.02	-0.33	--					
4. Flanker – Post	9.24 (0.56)	-0.04	-0.18	0.58**	--				
5. DCCS – Pre	9.17 (0.74)	-0.22	-0.36	0.72***	0.53*	--			
6. DCCS – Post	9.26 (0.70)	-0.18	-0.24	0.44	0.56*	0.74***	--		
7. Stress	12.53 (5.00)	0.20	0.16	-0.16	-0.57*	-0.46*	-0.53*	--	
8. Sleep	4.84 (2.99)	0.06	-0.11	0.39	0.39	0.06	0.12	-0.24	--

Note. LSWM = List Sorting Working Memory; DCCS = Dimensional Change Card Sort. Stress and sleep quality represent Perceived Stress Scale and Pittsburgh Sleep Quality Index scores, respectively. * $p < .05$. ** $p < .01$. *** $p < .001$.

Changes in EF

To address the first aim relating to pre-post shift EF changes three paired-samples *t*-tests were run (Table 4). There were no significant differences in pre-post scores for LSWM, Flanker, or DCCS. Table 4 also displays reliable changes indices for each measure of EF. Two participant's Flanker scores and three participant's DCCS scores reliably improved. One participant's DCCS score reliably deteriorated. Most participants demonstrate no reliable change.

Table 4

Results Comparing Pre- and Post-Shift EF Performance

						Reliable Change, *n* (%)		
	t **(df)**	***p***	d_z	***CI's***	**RCI**	**Impr.**	**No change**	**Det.**
LSWM	-1.45 (18)	.17	0.21	-1.05, 0.11	3.03	0 (0)	19 (100)	0 (0)
Flanker	-0.94 (18)	.36	0.22	-0.49, 0.14	1.10	2 (11)	17 (89)	0 (0)
DCCS	-0.76 (18)	.46	0.13	-0.31, 0.12	0.71	3 (16)	15 (79)	1 (5)

Note. LSWM = List Sorting Working Memory; DCCS = Dimensional Change Card Sort. CIs represent bootstrapped BCa 95% CI of the mean difference. Impr = improve; Det = deteriorate.

Causal Associations with Post-Shift EF

Correlation and multiple regression analyses were run to examine the relationship between key study variables and explore associations between post-shift EF and pre-shift EF, stress, and sleep quality. Correlations between study variables are presented in Table 3. Of note, there were positive correlations between pre- and post-shift scores within each outcome measure. Stress was negatively correlated with pre-shift Flanker and DCCS scores, and post-shift DCCS scores only. Sleep quality was not statistically significantly correlated with any other variable.

All regression models were statistically significant. Individual variables were examined and indicated that pre-shift EF scores were causally associated with post-shift EF in each of the LSWM, Flanker, and DCCS models. Participants with higher pre-shift scores had higher post-shift scores. Additionally, scores for perceived stress were significantly associated with post-shift Flanker scores after controlling for other independent variables, with a 1-point increase in perceived stress associated with a 0.52 decrease in Flanker score. Sleep quality did not contribute to any of the models. A sensitivity analysis was conducted by removing sleep quality as a variable from the model. All models remained statistically significant after removing sleep quality, suggesting its exclusion did not impact on the results; LSWM ($F(2, 16) = 14.52$, $p <.001$, $\Delta R^2 = 0.60$), Flanker ($F(2, 16) = 10.30$, $p <.001$, $\Delta R^2 = 0.50$), or DCCS models ($F(2, 16) = 11.76$, $p <.001$, $\Delta R^2 = 0.54$).

Table 5

Summary of Multiple Regression Analysis Predicting Post Shift EF (N = 19)

	LSWM			Flanker			DCCS		
Post Shift EF	$F(3, 15) = 10.19$, $p < .001$, $\Delta R^2 = 0.61$			$F(3, 15) = 6.64$, $p = .005$, $\Delta R^2 = 0.49$			$F(3, 15) = 7.38$, $p = .003$, $\Delta R^2 = 0.52$		
Model	*B*	*CI*	*p*	*B*	*CI*	*P*	*B*	*CI*	*p*
Constant	4.47	-2.40, 9.66	.17	7.16	1.37, 8.46	.004	4.09	-0.30, 6.81	.021
Pre-Shift	0.82	0.50, 1.17	.007	0.29	0.13, 0.85	.047	0.60	0.21, 1.12	.003
Stress	-0.18	-0.17, 0.13	.77	-0.52	-0.95, -0.001	.042	-0.31	-0.092, 0.041	.17
Sleep	-0.13	-0.37, 0.22	0.35	0.018	-0.52, 0.079	.53	0.008	-0.071, 0.095	.86

Note. LSWM = List Sorting Working Memory Test; DCCS = Dimensional Change Card Sort. Stress and sleep quality represent Perceived Stress Scale and Pittsburgh Sleep Quality Index scores, respectively. *B* = unstandardised regression coefficient; β = standardised regression coefficient; *SE B* = standard error of the coefficient; *CI* = confidence interval; ΔR^2 = adjusted coefficient of determination. Ninety-five % bias corrected and accelerated CIs are shown. CIs, SEs, and *p* values are based on 2,000 bootstrap samples.

Post-Hoc Power Calculations

Post-hoc power analyses were conducted as the minimum required sample size was not achieved through recruitment. At a significance criterion of $\alpha = .05$, the current sample size of 19 only achieved power of 54% to detect a medium effect, for a 2-tailed, paired-samples *t*-test. However, whilst post-hoc calculations were included, it is recognised that some research suggests that this type of analysis may be conceptually flawed and could be considered misleading (see Zhang et al., 2019).

Discussion

The current study aimed to explore change in EF from the start to end of 12-hour ICU nursing day shifts and consider factors causally associated with post-shift EF performance. Results indicated no significant pre-post shift differences for working memory, inhibition, or cognitive flexibility. Additionally, at an individual level, most participants demonstrated no reliable changes in performance on any measure. Findings suggested that nurses EF abilities are relatively unaffected after an ICU shift, and, despite some evidence of poor sleep and stress, still perform well.

When exploring causal associations of post-shift EF performance, pre-shift EF had the strongest casual association with post-shift working memory and cognitive flexibility, and a significant causal association with inhibition, with higher pre-shift scores associated with higher post-shift scores. However, when controlling for pre-shift performance and sleep quality, perceived stress had the strongest causal association with post-shift inhibitory control performance, suggesting perceived stress may be important factor in ICU nurse EF performance. Here, a one-point increase in perceived stress score was associated with a 0.52 [95% BCI CI's -0.95 – -0.001]. decrease in Flanker score, around a standard deviation decline.

Results of the current study partially support previous research on the impacts of healthcare shifts on EF performance. Indeed, previous research also did not find changes in inhibitory control or cognitive flexibility performance after healthcare dayshifts (Machi et al., 2012; Rollinson et al., 2003). Where pre-post shift effects on EF were identified, they were primarily for the nightshift (Esmaily et al., 2021; Niu et al., 2013; Zion & Shochat, 2018), suggesting factors such as tiredness, a known factor to impair EF (Diamond, 2013), is likely to be higher.

Where it may have been more likely for effects to have been seen on the night shift, due to the exploratory nature of the current study only one shift-type was included. It was considered important to also understand the pattern of EF performance in this population, whether decline was observed or not. Additionally, use of one shift type has allowed the method to be piloted in this setting which can be successfully applied to other shift types in future studies.

Whist findings related to inhibitory control and cognitive flexibility performance are supported by previous research, findings related to working memory performance are not. Where previous studies identified reductions in working memory performance after healthcare dayshifts (Esmaily et al., 2021) the current study did not find any changes. However, methodological heterogeneity may explain these differences. Rollinson et al. (2003) identified pre-post shift changes in visuospatial working memory performance, where the current study found no change in a verbal working memory task. Models of working memory suggest verbal and visuospatial working memory reflect unique neural networks (Baddeley, 2012), meaning change in these individual processes may not follow the same trajectory. Therefore, methodological heterogeneity is important to consider in neuropsychological research due to variations in testing methods.

Whilst heterogeneity may explain why EF change was not observed in the current study, potential effects may have been masked by study design. In their study Zion and Shochat (2018) found that working memory function was lower during the middle compared to end of night shifts, suggesting performance may fluctuate. Two-instance repeated measures designs may mask ability to identify all effects. However, increasing the number of datapoints over time would have further reduced statistical power, but should, nonetheless, be considered in future studies to further develop understandings of EF in this population.

Practice effects are characteristic of serial cognitive assessments (Goldberg et al., 2015). At brief test-retest intervals the greatest magnitude of practice effects occur between the first and second administration (Alexander et al., 2003). To reduce unwanted variance introduced by practice effects, Rollinson et al. (2003) included a pre-shift testing session, which may have increased reliability of findings. Including a reliable and standardised second baseline session may not always be feasible, particularly when research is conducted in busy clinical settings such as the ICU. In the absence of a second baseline, there is increasing research proposing the use of statistical methods to account for variability and practice effects (Calamia et al., 2012). However, there is currently no consensus on the choice of method to use and reliability of findings has been mixed (Maassen et al., 2009; Temkin et al., 1999). Indeed, the risk of making a Type I error may be greater than making a Type II error after using such methods. However, in the current study, consensus between different analytical methods increases reliability of findings. Indeed, findings from RCI calculation on individual participant datapoints, mean group significance testing, and bootstrapped confidence intervals all suggest no change in EF from start to end of ICU nursing shifts.

Because of the Covid-19 pandemic, stress within healthcare populations has received an increase in attention. In a recent study of healthcare workers in the UK, PSS scores during the Covid-19 lockdown were recorded, on average, in the ‘moderate’ stress range (Gilleen et al., 2021). Lower perceived stress in the current study is a surprising finding given reports of high stress within critical care nursing (Khan et al., 2019) meaning results may only be generalisable to lower stress populations. Additionally, a recent study of UK nurses found that 78% of the sample were above the cut-off for “poor” sleep (McDowall et al., 2017), compared to 37% in the current sample. Again, a surprising finding considering that nursing shifts negatively impact sleep (Yu, 2019). Lower stress and better sleep may partly explain why larger effects were not observed, as previous (Esmaily et al., 2021; Rollinson et al., 2003). However, it should be noted that these conclusions are based upon findings from cross-sectional data and should be interpreted cautiously. Whilst the measures reflect participants sleep and perceived over the previous month and cut-offs used in the current study were based upon validation studies of the measure (Buysse et al., 1989; McDowall et al., 2017), cross-sectional data are limited through inability to determine causality and may only represent factors at a single time point and may not be reflective of participants overall perceived stress and sleep quality.

Whilst no significant pre-post shift changes were identified, the uniqueness of the current study comes from exploring significant associations of post-shift EF performance. Unsurprisingly, given high test-retest of cognitive measures used (Weintraub et al., 2013) pre-shift EF performance was significantly associated with post-shift EF performance on tasks of working memory, inhibition, and cognitive flexibility, with higher pre-shift scores associated with higher post-shift scores. However, the strongest association with post-shift performance on a task of inhibition was perceived stress, with higher perceived stress significantly associated with lower post-shift inhibitory control performance. This finding suggests that stress may be an important factor in inhibitory control performance in this population and that nurses with higher levels of stress may not be performing at the same level as their less stressed peers. However, given the nature of the current design, conclusions regarding causality cannot be drawn.

Previous meta-analytical studies have demonstrated associations between stress and EF performance for each latent variable of EF (Shields et al., 2016), yet, in the current study, stress was not causally associated with performance on tests of working memory or cognitive flexibility. Stress in the current sample was skewed towards lower stress based upon cross sectional questionnaire data, with more than half of the sample self-reporting low-levels of current perceived stress over the previous month, based upon cut-offs of the measure (Cohen et al., 1983). The relationship between stress, working memory and cognitive flexibility may be stronger at higher levels of stress and therefore may explain why an effect was not observed in the current population. This may be an important factor to consider during extreme scenarios, such as the COVID-19 pandemic, where stress in healthcare workers was higher (Gilleen et al., 2021). It is possible that recruitment bias may have caused this skew as recruitment was not possible on busier shifts, where stress may have been higher. Consideration of reducing recruitment bias warrants consideration in future study designs. However, again, caution is advised in the interpretation of findings given limitations in the use of cross-sectional measures previously outlined.

Sleep quality has also been shown to impair EF performance (Diamond, 2013), however, this was not identified as a factor causally associated with post-shift EF performance in the current population. Similarly to stress, sleep quality in the current sample was skewed towards better sleep quality, with only 37% of the sample identified as “poor sleepers” based upon cut-offs from the measure (Buysse et al., 1989). It is possible that the relationship between sleep quality and EF may be stronger at poorer levels of sleep and therefore may not have been evident in the current sample. However, internal consistency of the PSQI (Buysse et al., 1989) which was used to measure sleep quality was identified as questionable within the current sample (α = 0.59), likely a product of small sample size and increased variability. Therefore, this may not have been a valid measure of sleep quality within the current sample and may explain why a relationship between sleep quality and EF was not observed.

Recruitment Challenges

The current study identified challenges in recruitment which led to a smaller sample size than targeted. Provision in the ICU requires a minimum nurse to patient ratio of 1:1 – 1:2 (Intensive Care Society, 2019; Royal College of Nursing, 2020). This meant appropriate cover was required to allow nurses to participate and ensure patient care was met. During busy shifts, this was often not available, meaning recruitment could not take place and this could not always be planned. This may have led to biases within the data as busier, more stressful shifts may have led to greater effects on EF, which were not captured. Additionally, two post-shift measures were not taken as it was not appropriate in some instances for nurse participants to handover patient care for the short participation period. Scores on both the PSS and the PSQI were higher in the total sample recruited than in the final sample included in analysis (see Appendix A) suggesting they may have been related to the outcome.

These factors should be considered when designing full-scale trials of similar designs, particularly when factoring recruitment strategy and timeline. However, the current study still achieved a 90% retention rate. Additionally, mitigating procedures were applied during analysis such as the use of bootstrapped resamples to account for a smaller sample size.

Clinical Implications

The project was developed after consideration of risk and patient safety by ICU psychologists. It was questioned whether nurses could stay cognisant when potentially stressed and tired. It had been hypothesised that reductions in EF abilities could impede nurse reaction time and decision-making abilities, which pose potential risk to healthcare provision. However, no significant differences were identified in the current study, suggesting EF may not decrease over the course of an ICU shift in nurses and that despite poor sleep and stress, nurses still perform well in cognitive tasks of EF.

Nonetheless, whist EF performance did not decrease over shifts, stress was causally associated with post-shift inhibitory control performance, with higher stress associated with lower inhibitory control. This suggests that nurses with higher levels of stress may not be performing at the same level as their less stressed peers. However, little is known about how these scores on cognitive testing may translate into nurses' clinical practice. Monitoring stress and taking measures to address this may be important not only for ICU nurse wellbeing, but also their cognitive function, and potential downstream implications for patient safety.

Strengths and Limitations

It is believed that this is the first study exploring the impacts of a healthcare shift on each latent component variable of EF. The current study achieved a diverse sample including age, gender, sex and ethnicity, representative of the overall diversity on the ICU. The use of standardised and validated computerised tests of EF increases reliability of results and reduces bias from human error. Data collected in naturalistic settings increases ecological validity of findings. Additionally, results of the study are strengthened using bootstrapped resamples and including both group and individual methods of exploring change.

Several limitations are also noted. Whilst representative, the small sample size may have led to the study being underpowered and increased the risk of type II errors. Reporting of bootstrapped confidence intervals and RCI's helped mitigate effects of the small sample size on conclusions. Recruitment bias may have led to the sample being skewed towards those on their first consecutive shift, and those with lower perceived stress and sleep difficulties, which may have masked potential effects. As a control group was not incorporated, conclusions regarding causality cannot be drawn. However, regardless of cause, change in EF over the course of a shift could impact nurses practice, and therefore is important to understand. Practice effects may have introduced unwanted variance into the study. Inclusion of a baseline session may have reduced any variance from practice effects. Inclusion of a control or another comparison group would have allowed further exploration of practice effects on outcomes. However, inclusion of RCI's helps mitigate against impact of practice effects on conclusions.

Whilst proficient English was an inclusion criterion non-native English speakers may have been disadvantaged in completing the list sorting working memory task. Additionally, reaction time tasks may be considered a western construct and affected by participants' cultural background. Lastly, data were collected within the first and last hours of shifts to ensure cover for essential ward activities. Therefore, pre-post time intervals varied from 10 – 12 hours which may reduce reliability of findings.

Future Research

Although no significant decline in EF was observed in the current study, further fully powered studies exploring effects of ICU shifts on EF in nurses are still warranted. A larger trial should focus on exploring the effect of night shifts and consecutive shifts on nurses EF given that previous research has highlighted that these factors may be more likely to be related to decline in EF performance in other healthcare settings (James et al., 2021; Niu et al., 2013). The current study demonstrates that the method of data collection is practical and achieves a particular recruitment rate which should be considered in future studies to obtain sufficient statistical power. However, embedded researchers within the unit trained in the method of data collection may improve recruitment rate to support achieving a sample size sufficient for statistical power.

Future studies would benefit from inclusion of a control and comparison group to allow inferences regarding causality to be established, as well as to better explore the magnitude of practice effects, which may have masked potential effects in the current study. This might include testing the same participants on a non-working day at the same time intervals or using matched-pair controls or nurses working on different hospital wards of similar shifts. Nonetheless, regardless of causality, any impact on EF over the course of a shift is still critical to understand and address.

Other research could explore ways to improve EF in this population, given the critical role of EFs in ICU nursing. For example, it is widely accepted that interventions to improve stress, such as mindfulness-based interventions, may improve EF. Indeed, the literature review presented in this thesis found evidence for the effect of mindfulness-based interventions on inhibition and working memory components of EF. Nonetheless, whilst individual interventions may increase staff wellbeing, it should be emphasised that this does not equate to welfare, and any interventions aimed at improving stress or EF in this population should be implemented alongside broader interventions within the systemic context.

Conclusion

Overall, results of the current study suggest that ICU nurses perform well despite stress and sleep difficulties, but that high stress may be causally associated with lower performance in some aspects of EF by the end of shifts. However, challenges in recruitment led to a smaller sample size than expected. Changes may have been masked by low statistical power as well as potential influences of practice effects. Future fully powered studies exploring the effects of both day and night ICU shifts on EF in nurses are warranted to test these preliminary findings, whilst considering recommendations outlined in this pilot.

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Zion, N., & Shochat, T. (2018). Cognitive functioning of female nurses during the night shift: The impact of age, clock time, time awake and subjective sleepiness. *Chronobiology international*, *35*(11), 1595-1607. https://doi.org/https://doi.org/10.1080/07420528.2018.1497642

Executive Summary

Whilst the three research papers in this portfolio differ, they share themes pertaining to the role of clinical psychology within the neuropsychology specialism. The collective aim was to consider the application of clinical psychology in broader aspects of clinical practice and consider contexts beyond the traditional neuropsychological focus of working with people with neurological conditions.

Literature Review

The first paper was a literature review exploring the effects of mindfulness-based interventions on executive functions in non-clinical adult samples. Executive functions refer to higher-order, top-down, effortful mental processes that support reasoning, problem-solving and planning. They consist of three core processes: working memory, inhibition, and cognitive flexibility. Mindfulness is thought to improve executive functions by training participants in attending to the present moment through repeated inhibition of internal and external stimuli and shifting back to present moment awareness. Other hypothesised mechanisms posit that mindfulness-based interventions improve executive functions by improving stress.

The current project identified 15 papers that met inclusion criteria and were assessed for quality using the Cochrane Collaboration's revised tool for assessing risk of bias in RCT's (RoB-2; Sterne et al., 2019). Twelve studies included numerical data that could be pooled and explored in meta-analyses. Between studies there was evidence that some mindfulness-based interventions may improve inhibition, working memory, and overall executive function, but that the largest effects were for inhibitory control. There was no evidence for mindfulness-based interventions improving cognitive flexibility. There was high heterogeneity in study designs, including differing interventions, comparator groups, length of study, and measures used to assess executive function. More intensive interventions appeared to improve working memory and inhibition. Findings of the review highlighted the need for further high-quality research exploring longer-term effects of mindfulness-based interventions on executive function and consider exploring the mechanisms of action for the effect of mindfulness-based interventions on executive functions.

Service-Related Project

The second paper explored retrospective referral data from a memory assessment service to see whether ethnic diversity in referrals was as expected.

Dementia is a progressive neurological condition characterised by impairments in memory, thinking and behaviour, which has a negative impact on a person's ability to function. Whilst there is currently no cure for dementia, accurate and timely diagnosis is vital to ensuring people and their carers receive the appropriate care to enable them to live well with dementia. There is evidence that people from global ethnic majority groups are underrepresented in referrals to UK memory services overall.

The aim of this project was to explore ethnic diversity in referrals to one service in the Southwest of the United Kingdom. This was done by comparing ethnic diversity in actual referrals received between and including the years 2015 and 2021, with expected number of referrals, calculated from population estimates of ethnic diversity for the locality, from the 2011 and 2021 censuses. Results suggested that people from white ethnic groups may be overrepresented in referrals and that people from non-white ethnic groups may be under referred. Ethnic diversity in the locality decreases in older generations, with the proportion of people who identify as white British increasing in older age groups. When considering only the population most at risk of developing dementia (aged 65 and over), ethnic diversity in referrals is closer to expected. However, 15% of referrals did not have ethnicity data recorded, which may obscure findings. A presentation of findings to the team led to a discussion pertaining to how the service could improve collection of ethnicity data alongside ensuring parity of access to the service regardless of ethnicity.

Main Research Project

The final paper in the portfolio was an empirical project exploring change in executive function from the start to end of a 12-hour nursing shift in intensive care, as well as exploring which factors predict executive function at the end of the shift. Executive functions are negatively and independently affected by poor sleep and stress. Both poor sleep and high stress have been reported in nurses, leaving executive functions in this population vulnerable to impact. Executive functioning in intensive care nurses is vital for synthesising information and making quick inferences regarding the course of action in patient care, and therefore understanding effects of healthcare shifts on cognitive performance in intensive care nurses is vital for both patient safety and staff wellbeing.

This project gathered data for 19 nurses from one intensive care unit and measured working memory, inhibition, and cognitive flexibility pre and post a 12-hour dayshift, alongside measures of current sleep behaviour and perceived stress. No significant changes were observed in working memory, inhibition, or cognitive flexibility performance between the start and end of a shift. Pre-shift scores were most strongly causally associated with post-shift scores for working memory and cognitive flexibility. However, stress was the strongest causal association for inhibitory control performance, and suggestive that nurses with higher levels of stress may face increased difficulty on tasks requiring them to set aside distracting information, compared to their less stressed peers.

Overall, results suggest that intensive care nurses perform well despite stress and sleep difficulties, but that stress may be an important factor in inhibitory control performance. However, challenges in recruitment led to a smaller sample size than expected. Further, more subtle changes may have been masked by low statistical power. Findings of the current study support the need for future fully powered studies to support between understanding the relationships between sleep, stress, and executive function in this population and consider how to best support nurses working in intensive care.

Acknowledgements

Firstly, I would like to thank the clients, families, and research participants I have had the privilege of working with during training. It has been a pleasure, and I thank you for everything I learnt along the way. Thanks go to Health Education England for funding my training and the privilege this opportunity has given me.

With kind regards to my research supervisor, Rachel Paskell, for her ongoing kindness, support, and encouragement throughout training. I particularly thank her for her support in reading drafts of papers, even whilst on maternity leave. I would also like to thank my other research supervisors Rachael Bedford and Ashley Vanstone for collaborating on my research and providing much needed guidance, knowledge, and supervision throughout. Additional thanks go to Mike Osborn for providing the initial idea for my main research project and for his ongoing commitment, passion, and support to the project. I would also like to thank Elise Arnold for her time and commitment as a second reviewer for my Literature Review, and who I could not have completed the project without.

Many thanks go to the staff at the RUH ICU for their time and commitment in allowing this project to take place, and for always making me feel welcome on the unit. It was a privilege witnessing the passion and skill that goes into the care you provide for your patients.

I would also like to thank the teams, clinical supervisors, and BABCP supervisors who have welcomed and supported me during my clinical placements. With thanks to my clinical supervisors Laura Meader, Rhiannon Bennett, Manuela Barona, Zoe Engeldew, Kate Allez, Leon Dysch, Fiona Laver, and Andy Champion who have helped me shape and develop my practice and support me to become the psychologist I want to be.

To my friends, family, and partner Tom for their patience, love and support through the highs and lows of the last few years and for being a constant reminder of life outside of training. I could not have done this without you.

Finally, I would like to thank my fellow trainees in cohort 2021 who I had the pleasure of sharing the past 3-years with. Particular thanks to Ellie, Hannah, and Holly, who may have started as colleagues, but have become lifelong friends in the process.

Research Appendices

Table of Appendices

Appendix A – Database Specific Search Strings

APA PsychNet

1. Keywords: Mindfulness OR Keywords: Meditation OR Keywords: MBSR OR Keywords:MBCT OR Keywords: “Mind-body therapies” OR Keywords: “Mindfulness-based” OR Keywords: “Mindful awareness” OR Keywords: “Mindful practice” OR Keywords: “Cognitive behavioural stress reduction” OR Abstract: Mindfulness OR Abstract: Meditation OR Abstract: MBSR ORAbstract: MBCT OR Abstract: “Mind-body therapies” OR Abstract: “Mindfulness-based” OR Abstract: “Mindful awareness” OR Abstract: “Mindful practice” OR Abstract: “Cognitive behavioural stress reduction”
2. Keywords: “Executive function*” OR Keywords: “Executive control*” OR Keywords: “Cognitive function*” OR Keywords: “Cognitive control*” OR Keywords: “Executive Network” OR Keywords: “Dysexecutive” OR Keywords: “Inhibit* control” OR Keywords: “Working memory” OR Keywords: “Cognitive flexibility” OR Keywords: “Cognitive dysfunction” OR Keywords: Inhibition OR Keywords: Attention OR Keywords: Cognition OR Keywords: Planning OR Keywords: “Verbal fluency” OR Keywords: Shifting OR Keywords: Switching OR Keywords: Neuropsychologic* OR Keywords: “Decision making” OR Keywords: Reward OR Abstract: “Executive function*” OR Abstract: “Executive control*” OR Abstract: “Cognitive function*” OR Abstract: “Cognitive control*” OR Abstract: “Executive Network” OR Abstract: “Dysexecutive” OR Abstract: “Inhibit* control” OR Abstract: “Working memory” OR Abstract: “Cognitive flexibility” OR Abstract: “Cognitive dysfunction” OR Abstract: Inhibition OR Abstract: Attention OR Abstract: Cognition OR Abstract: Planning OR Abstract: “Verbal fluency” OR Abstract: Shifting OR Abstract: Switching OR Abstract: Neuropsychologic* OR Abstract: “Decision making” OR Abstract: Reward
3. Age Group: Adulthood (18 yrs & older) OR Young Adulthood (18-29 yrs) OR Thirties (30-39 yrs) OR Middle Age (40-64 yrs)
4. ((((AgeGroupFilt: ("Adulthood (18 yrs & older)") OR AgeGroupFilt: ("Young Adulthood (18-29 yrs)") OR AgeGroupFilt: ("Thirties (30-39 yrs)") OR AgeGroupFilt: ("Middle Age (40-64 yrs)"))))) AND ((Keywords: (Mindfulness)) OR (Keywords: (Meditation)) OR (Keywords: (MBSR)) OR (Keywords: (MBCT)) OR (Keywords: ("Mind-body therapies")) OR (Keywords: ("Mindfulness-based")) OR (Keywords: ("Mindful awareness")) OR (Keywords: ("Mindful practice")) OR (Keywords: ("Cognitive behavioural stress reduction")) OR (abstract: (Mindfulness)) OR (abstract: (Meditation)) OR (abstract: (MBSR)) OR (abstract: (MBCT)) OR (abstract: ("Mind-body therapies")) OR (abstract: ("Mindfulness-based")) OR (abstract: ("Mindful awareness")) OR (abstract: ("Mindful practice")) OR (abstract: ("Cognitive behavioural stress reduction"))) AND ((Keywords: ("Executive function*")) OR (Keywords: ("Executive control*")) OR (Keywords: ("Cognitive function*")) OR (Keywords: ("Cognitive control*")) OR (Keywords: ("Executive Network")) OR (Keywords: ("Dysexecutive")) OR (Keywords: ("Inhibit* control")) OR (Keywords: ("Working memory")) OR (Keywords: ("Cognitive flexibility")) OR (Keywords: ("Cognitive dysfunction")) OR (Keywords: (Inhibition)) OR (Keywords: (Attention)) OR (Keywords: (Cognition)) OR (Keywords: (Planning)) OR (Keywords: ("Verbal fluency")) OR (Keywords: (Shifting)) OR (Keywords: (Switching)) OR (Keywords: (Neuropsychologic*)) OR (Keywords: ("Decision making")) OR (Keywords: (Reward)) OR (abstract: ("Executive function*")) OR (abstract: ("Executive control*")) OR (abstract: ("Cognitive function*")) OR (abstract: ("Cognitive control*")) OR (abstract: ("Executive Network")) OR (abstract: ("Dysexecutive")) OR (abstract: ("Inhibit* control")) OR (abstract: ("Working memory")) OR (abstract: ("Cognitive flexibility")) OR (abstract: ("Cognitive dysfunction")) OR (abstract: (Inhibition)) OR (abstract: (Attention)) OR (abstract: (Cognition)) OR (abstract: (Planning)) OR (abstract: ("Verbal fluency")) OR (abstract: (Shifting)) OR (abstract: (Switching)) OR (abstract: (Neuropsychologic*)) OR (abstract: ("Decision making")) OR (abstract: (Reward)))

CINAHL

S1. TI mindfulness OR TI meditation OR TI (mbsr or mindfulness-based stress reduction) OR TI (mbct or mindfulness based cognitive therapy) OR TI “Mind-body therapies” OR TI “Mindfulness-based” OR TI “Mindful awareness” OR TI “Mindful practice” OR TI “Cognitive behavioural stress reduction”

S2. AB mindfulness OR AB meditation OR AB (mbsr or mindfulness-based stress reduction) OR AB (mbct or mindfulness based cognitive therapy) OR AB “Mind-body therapies” OR AB “Mindfulness-based” OR AB “Mindful awareness” OR AB “Mindful practice” OR AB “Cognitive behavioural stress reduction”

S3. TI (executive function or executive dysfunction or executive functioning) OR TI “Executive control*” OR TI (cognitive function or cognitive functioning) OR TI “Cognitive control*” OR TI executive network OR TI “Dysexecutive” OR TI inhibition control OR TI (inhibitory control or inhibition) OR TI “Working memory” OR TI (cognitive flexibility or task switching or task- switching)

S4. AB (executive function or executive dysfunction or executive functioning) OR AB “Executive control*” OR AB (cognitive function or cognitive functioning) OR AB “Cognitive control*” OR AB executive network OR AB “Dysexecutive” OR AB inhibition control OR AB (inhibitory control or inhibition) OR AB “Working memory” OR AB (cognitive flexibility or task switching or task- switching)

S5. AB (cognitive dysfunction or cognitive impairment) OR AB inhibition OR AB attention OR AB (cognition or cognitive function or brain function or cognitive function or memory or brain) OR AB planning OR AB “Verbal fluency” OR AB shifting OR AB switching OR AB Neuropsychologic* OR AB (decision making or decision-making or decision making process or decision-making process) OR AB reward

S6. TI (cognitive dysfunction or cognitive impairment) OR TI inhibition OR TI attention OR TI (cognition or cognitive function or brain function or cognitive function or memory or brain) OR TI planning OR TI “Verbal fluency” OR TI shifting OR TI switching OR TI Neuropsychologic* OR TI (decision making or decision-making or decision making process or decision-making process) OR TI reward

S7. S1 OR S2

S8. S3 OR S4 OR S5 OR S6

S9. Limiters - Age Groups: Adult: 19-44 years, Middle Aged: 45-64 years Expanders - Apply equivalent subjects Search modes - Boolean/Phrase

S10. S7 AND S8 AND S9

Embase

#1 (mindfulness:ti,ab,kw OR meditation:ti,ab,kw OR ‘mindfulness-based stress reduction’:ti,.ab,kw OR 'mindfulness-based cognitive therapy':ti,ab,kw OR 'mind-body therapies':ti,ab,kw OR 'mindfulness- based':ti,ab,kw OR 'mindful awareness':ti,ab,kw OR 'mindful practice':ti,ab,kw OR 'cognitive behavioural stress reduction':ti,ab,kw) AND [embase]/lim

#2 ('executive function':ti,ab,kw OR 'executive control*':ti,ab,kw OR 'cognitive function*':ti,ab,kw OR 'cognitive control*':ti,ab,kw OR 'executive network':ti,ab,kw OR 'dysexecutive':ti,ab,kw OR 'inhibition control':ti,ab,kw OR 'inhibitory control':ti,ab,kw OR 'working memory':ti,ab,kw OR 'cognitive flexibility':ti,ab,kw OR 'cognitive defect':ti,ab,kw OR inhibition:ti,ab,kw OR attention:ti,ab,kw OR cognition:ti,ab,kw OR planning:ti,ab,kw OR 'verbal fluency':ti,ab,kw OR shifting:ti,ab,kw OR switching:ti,ab,kw OR neuropsychologic*:ti,ab,kw OR 'decision making':ti,ab,kw OR reward:ti,ab,kw) AND [embase]/lim

#3 #1 AND #2

Medline (PubMed)

1. ((((((((Mindfulness[Title/Abstract]) OR (Meditation[Title/Abstract])) OR (MBSR[Title/Abstract])) OR (MBCT[Title/Abstract])) OR ("Mind-body therapies"[Title/Abstract])) OR ("Mindfulness-based"[Title/Abstract])) OR ("Mindful awareness"[Title/Abstract])) OR ("Mindful practice"[Title/Abstract])) OR ("Cognitive behavioural stress reduction"[Title/Abstract])
2. (((((((((((((((((("Executive function*"[Title/Abstract]) OR ("Executive control*"[Title/Abstract])) OR ("Cognitive function*"[Title/Abstract])) OR ("Cognitive control*"[Title/Abstract])) OR ("Executive Network"[Title/Abstract])) OR ("Dysexecutive"[Title/Abstract])) OR ("Inhibition control"[Title/Abstract])) OR ("Working memory"[Title/Abstract])) OR ("Cognitive flexibility"[Title/Abstract])) OR ("Cognitive dysfunction"[Title/Abstract])) OR (Inhibition[Title/Abstract])) OR (Attention[Title/Abstract])) OR (Cognition[Title/Abstract])) OR (Planning[Title/Abstract])) OR ("Verbal fluency"[Title/Abstract])) OR (Shifting[Title/Abstract])) OR (Switching[Title/Abstract])) OR (Neuropsychologic*[Title/Abstract])) OR ("Decision making"[Title/Abstract])) OR (Reward[Title/Abstract])) OR ("Inhibitory control"[Title/Abstract])
3. ((((((((((((((((((("Executive function*"[Title/Abstract]) OR ("Executive control*"[Title/Abstract])) OR ("Cognitive function*"[Title/Abstract])) OR ("Cognitive control*"[Title/Abstract])) OR ("Executive Network"[Title/Abstract])) OR ("Dysexecutive"[Title/Abstract])) OR ("Inhibition control"[Title/Abstract])) OR ("Working memory"[Title/Abstract])) OR ("Cognitive flexibility"[Title/Abstract])) OR ("Cognitive dysfunction"[Title/Abstract])) OR (Inhibition[Title/Abstract])) OR (Attention[Title/Abstract])) OR (Cognition[Title/Abstract])) OR (Planning[Title/Abstract])) OR ("Verbal fluency"[Title/Abstract])) OR (Shifting[Title/Abstract])) OR (Switching[Title/Abstract])) OR (Neuropsychologic*[Title/Abstract])) OR ("Decision making"[Title/Abstract])) OR (Reward[Title/Abstract])) OR ("Inhibitory control"[Title/Abstract])) AND (((((((((Mindfulness[Title/Abstract]) OR (Meditation[Title/Abstract])) OR (MBSR[Title/Abstract])) OR (MBCT[Title/Abstract])) OR ("Mind-body therapies"[Title/Abstract])) OR ("Mindfulness-based"[Title/Abstract])) OR ("Mindful awareness"[Title/Abstract])) OR ("Mindful practice"[Title/Abstract])) OR ("Cognitive behavioural stress reduction"[Title/Abstract]))

ProQuest

S1. Searched for: (((title(Mindfulness) OR title(Meditation) OR title(MBSR) OR title(MBCT) OR title("Mind-body therapies") OR title("Mindfulness-based") OR title("Mindful awareness") OR title("Mindful practice") OR title("Cognitive behavioural stress reduction")) AND stype.exact("Dissertations & Theses")) OR ((summary(Mindfulness) OR summary(Meditation) OR summary(MBSR) OR summary(MBCT) OR summary("Mind-body therapies") OR summary("Mindfulness-based") OR summary("Mindful awareness") OR summary("Mindful practice") OR summary("Cognitive behavioural stress reduction")) AND stype.exact("Dissertations & Theses")))

S2. Searched for: (((summary(("executive function" OR "executive functioning" OR "executive functions")) OR summary(("executive control")) OR summary(("cognitive function" OR "cognitive functioning" OR "cognitive functions")) OR summary(("cognitive control")) OR summary("Executive Network") OR summary("Dysexecutive") OR summary("Inhibition control") OR summary("Inhibitory control") OR summary("Working memory")) AND stype.exact("Dissertations & Theses")) OR ((title(("executive function" OR "executive functioning" OR "executive functions")) OR title(("executive control")) OR title(("cognitive function" OR "cognitive functioning" OR "cognitive functions")) OR title(("cognitive control")) OR title("Executive Network") OR title("Dysexecutive") OR title("Inhibition control") OR title("Inhibitory control") OR title("Working memory")) AND stype.exact("Dissertations & Theses")) OR ((title("Cognitive flexibility") OR title("Cognitive dysfunction") OR title(Inhibition) OR title(Attention) OR title(Cognition) OR title(Planning) OR title("Verbal fluency") OR title(Shifting)) AND stype.exact("Dissertations & Theses")) OR ((summary("Cognitive flexibility") OR summary("Cognitive dysfunction") OR summary(Inhibition) OR summary(Attention) OR summary(Cognition) OR summary(Planning) OR summary("Verbal fluency") OR summary(Shifting)) AND stype.exact("Dissertations & Theses")) OR ((summary(Switching) OR summary(Neuropsychologic*) OR summary("Decision making") OR summary(Reward)) AND stype.exact("Dissertations & Theses")) OR ((title(Switching) OR title(Neuropsychologic*) OR title("Decision making") OR title(Reward)) AND stype.exact("Dissertations & Theses")))

S3. Searched for: (((title(Mindfulness) OR title(Meditation) OR title(MBSR) OR title(MBCT) OR title("Mind-body therapies") OR title("Mindfulness-based") OR title("Mindful awareness") OR title("Mindful practice") OR title("Cognitive behavioural stress reduction")) AND stype.exact("Dissertations & Theses")) OR ((summary(Mindfulness) OR summary(Meditation) OR summary(MBSR) OR summary(MBCT) OR summary("Mind-body therapies") OR summary("Mindfulness-based") OR summary("Mindful awareness") OR summary("Mindful practice") OR summary("Cognitive behavioural stress reduction")) AND stype.exact("Dissertations & Theses"))) AND (((summary(("executive function" OR "executive functioning" OR "executive functions")) OR summary(("executive control")) OR summary(("cognitive function" OR "cognitive functioning" OR "cognitive functions")) OR summary(("cognitive control")) OR summary("Executive Network") OR summary("Dysexecutive") OR summary("Inhibition control") OR summary("Inhibitory control") OR summary("Working memory")) AND stype.exact("Dissertations & Theses")) OR ((title(("executive function" OR "executive functioning" OR "executive functions")) OR title(("executive control")) OR title(("cognitive function" OR "cognitive functioning" OR "cognitive functions")) OR title(("cognitive control")) OR title("Executive Network") OR title("Dysexecutive") OR title("Inhibition control") OR title("Inhibitory control") OR title("Working memory")) AND stype.exact("Dissertations & Theses")) OR ((title("Cognitive flexibility") OR title("Cognitive dysfunction") OR title(Inhibition) OR title(Attention) OR title(Cognition) OR title(Planning) OR title("Verbal fluency") OR title(Shifting)) AND stype.exact("Dissertations & Theses")) OR ((summary("Cognitive flexibility") OR summary("Cognitive dysfunction") OR summary(Inhibition) OR summary(Attention) OR summary(Cognition) OR summary(Planning) OR summary("Verbal fluency") OR summary(Shifting)) AND stype.exact("Dissertations & Theses")) OR ((summary(Switching) OR summary(Neuropsychologic*) OR summary("Decision making") OR summary(Reward)) AND stype.exact("Dissertations & Theses")) OR ((title(Switching) OR title(Neuropsychologic*) OR title("Decision making") OR title(Reward)) AND stype.exact("Dissertations & Theses")))

Appendix B – AWP NHS Trust Quality Approval Letter

NHS
Avon and Wiltshire
Mental Health Partnership
NHS Trust

Tamara Smith-Jones

Carla Carter
Quality Improvement &
Clinical Audit Manager
AWP NHS Trust
Victoria Centre
53 Downs Way
Swindon SN3 6BW

T: 01793 327876
Or dial reception on:
01793 327800

Date: February 2022.

Dear Tamara Smith-Jones

Re: How are Ethnic Minorities represented in the Memory Service?

I am pleased to confirm approval of your Service Evaluation by AWP NHS Trust.

Please note that this approval has come from AWP's Quality Team and not AWP's Research and Development Team. However, we do expect a good level of governance will be achieved from the ethical scrutiny by your University as well as adherence to general ethical principles for the protection of patients. The specific ethical principles and patient protection laws to be followed are:

- **Consent** – It is important that potential participants are not coerced to take part in the project. They have the right to refuse to take part and to withdraw at any point and this is explained via an information sheet provided prior to any engagement or data gathering such as surveys or interviews. This information sheet will often lead to the signing of a consent form by participants agreeing to take part in your Project.

- **Anonymity** – Participants need to know whether their anonymity will be protected and if so how this will be carried out. This will also be documented within your participants' information sheet/consent form.

- **Data protection and privacy** – You need to consider how you are going to ensure that your data is stored safely and that participant privacy is protected. Again this should be stipulated within your participants' information sheet/consent form. You will need to adhere to the Data Protection Act (2018) and the General Data Protection Regulation (GDPR).

- **Information sharing and data transfer** – If you have securely transferred data between an AWP and University device, the data cannot then be analysed or transferred onto a personal device. This would not be secure and therefore considered a data breech. Using Citrix on a personal laptop is considered secure. You cannot email data to your personal email address.

Sharing findings - The importance of dissemination of all Service Evaluation or Quality Improvement work cannot be over emphasised. For this reason, the findings of all Projects have to be shared with the Quality Team so that we can make judgements regarding risk and champion and disseminate the results across the rest of the Trust, so that good practice can be shared and replication kept to a minimum. Reports may require approval by Locality Governance Groups if specific actions or improvements are required following your findings or particularly, if you wish to gain external publication, you will require AWP approval of your final report before doing so.

Draft copies of your report must be shared with your Facilitator so that presentation and approval at Governance Groups can be arranged. Once you have an approved final version of your report, please ensure you send a copy to your allocated Facilitator.

Jess Hillier (*jess.hillier@nhs.net*) has been assigned as your allocated AWP Quality Team Facilitator. Please contact this Facilitator if you have any queries or require further support or information during your project. They will email you at regular intervals for updates, so that progress of your project can be updated on our central project database, and fed into Trust committees. You will be assigned an AWP Project Reference Number by your Facilitator once we have confirmation that data collection has commenced and the project has actually started.

If you do need any further support or information, please contact your Facilitator or myself, quoting the title of your project.

Yours sincerely

[redacted]

Carla Carter
Quality Improvement and Clinical Audit Manager

Appendix C – Ethnicity Categories

ONS Ethnicity Categories	NHS Ethnic Categories
Asian	
Indian	Indian
Pakistani	Pakistani
Bangladeshi	Bangladeshi
Chinese	
Any other Asian background	Any other Asian background
Black	
Caribbean	Caribbean
African	African
Any other black, black British, or Caribbean background	Any other black, black British, or Caribbean background
Mixed	
White and black Caribbean	White and black Caribbean
White and black African	White and black African
White and Asian	White and Asian
Any other mixed or multiple ethnic background	Any other mixed or multiple ethnic background
White	
English, Welsh, Scottish, Northern Irish, or British	English, Welsh, Scottish, Northern Irish, or British
Irish	Irish
Gypsy or Irish traveller	
Roma	
Any other white background	Any other white background
Other	
Arab	Arab
	Chinese
Any other ethnic group	Any other ethnic group

Appendix D – HRA Approval

Ymchwil Iechyd a Gofal Cymru
Health and Care Research Wales

NHS Health Research Authority

Miss Tamara Smith Jones
Clinical Psychologist in Training
Somerset NHS Foundation Trust
Department of Psychology, 10 West University of Bath
Claverton Down
Bath
BA2 7AY

Email: approvals@hra.nhs.uk
HCRW.approvals@wales.nhs.uk

27 February 2023

Dear Miss Smith Jones

HRA and Health and Care Research Wales (HCRW) Approval Letter

Study title:	**The Impact of an Intensive Care Shift on Executive Function in Nurses**
IRAS project ID:	**318482**
Protocol number:	**N/A**
REC reference:	**23/HRA/0538**
Sponsor	**University of Bath**

I am pleased to confirm that **HRA and Health and Care Research Wales (HCRW) Approval** has been given for the above referenced study, on the basis described in the application form, protocol, supporting documentation and any clarifications received. You should not expect to receive anything further relating to this application.

Please now work with participating NHS organisations to confirm capacity and capability, in line with the instructions provided in the "Information to support study set up" section towards the end of this letter.

How should I work with participating NHS/HSC organisations in Northern Ireland and Scotland?

HRA and HCRW Approval does not apply to NHS/HSC organisations within Northern Ireland and Scotland.

If you indicated in your IRAS form that you do have participating organisations in either of these devolved administrations, the final document set and the study wide governance report (including this letter) have been sent to the coordinating centre of each participating nation. The relevant national coordinating function/s will contact you as appropriate.

Please see IRAS Help for information on working with NHS/HSC organisations in Northern Ireland and Scotland.

How should I work with participating non-NHS organisations?
HRA and HCRW Approval does not apply to non-NHS organisations. You should work with your non-NHS organisations to obtain local agreement in accordance with their procedures.

What are my notification responsibilities during the study?

The *"After HRA Approval – guidance for sponsors and investigators"* document on the HRA website gives detailed guidance on reporting expectations for studies with HRA and HCRW Approval, including:

- Registration of Research
- Notifying amendments
- Notifying the end of the study

The HRA website also provides guidance on these topics and is updated in the light of changes in reporting expectations or procedures.

Who should I contact for further information?
Please do not hesitate to contact me for assistance with this application. My contact details are below.

Your IRAS project ID is **318482**. Please quote this on all correspondence.

Yours sincerely,
Catherine Adams

Approvals Manager

Email: approvals@hra.nhs.uk

Appendix E – Questionnaires

IRAS ID: 318482

Participant Identification Number: _ _ _

Department of Psychology

UNIVERSITY OF BATH

Bath BA2 7AY · United Kingdom

Telephone +44 (0)1225 383843
Facsimile +44 (0)1225 386752
Email
psychology-enquiries@bath.ac.uk
www.bath.ac.uk/psychology

University of Bath
Department of Psychology
Tamara Smith Jones
Tsj23@bath.ac.uk

The Impact of an Intensive Care Shift on Executive Function in Nurses

Questionnaire Pack

Please complete the following pages of questionnaires.

DEMOGRAPHIC INFORMATION

1. What is your age (years): ________
2. What biological sex were you assigned at birth?: Male / Female / Prefer not to say
3. What is your gender identity?: ____________
4. Which hand do you write with: Left / Right / Ambidextrous (both)
5. Which ethnic group do you identify with: _____________
6. How many consecutive shifts have you worked, without a day off?: ________
7. What shift type are you currently working: ________________

Date Created: 26/08/22
Review Created: 23/06/23
Version Number: 2

Pittsburgh Sleep Quality Index (PSQI)

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? ___________________
2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night? __________
3. During the past month, what time have you usually gotten up in the morning? ___________________
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.) ___________________

5. During the past month, how often have you had trouble sleeping because you…	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
a. Cannot get to sleep within 30 minutes				
b. Wake up in the middle of the night or early morning				
c. Have to get up to use the bathroom				
d. Cannot breathe comfortably				
e. Cough or snore loudly				
f. Feel too cold				
g. Feel too hot				
h. Have bad dreams				
i. Have pain				
j. Other reason(s), please describe:				
6. During the past month, how often have you taken medicine to help you sleep (prescribed or “over the counter”)?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
	No problem at all	Only a very slight problem	Somewhat of a problem	A very big problem
8. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?				
	Very good	Fairly good	Fairly bad	Very bad
9. During the past month, how would you rate your sleep quality overall?				

	No bed partner or room mate	Partner/room mate in other room	Partner in same room but not same bed	Partner in same bed
10. Do you have a bed partner or room mate?				
	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
If you have a room mate or bed partner, ask him/her how often in the past month you have had:				
a. Loud snoring				
b. Long pauses between breaths while asleep				
c. Legs twitching or jerking while you sleep				
d. Episodes of disorientation or confusion during sleep				
e. Other restlessness while you sleep, please describe:				

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**

Please feel free to use the *Perceived Stress Scale* for your research. The PSS Manual is in the process of development, please let us know if you are interested in contributing.

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References

The PSS Scale is reprinted with permission of the American Sociological Association, from Cohen, S., Kamarck, T., and Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24,* 386-396.

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Appendix F – Demographic Data and Descriptive Statistics for Recruited Participants (*N* = 21)

Twenty-one nurses consented to participate in the study. The sample's mean age was 33.05 years (SD = 6.51), with a range of 23 – 52. Fifteen (71%) reported their biological sex as female and six (29%) as male. Fifteen (71%) identified their gender as female, six (19%) as male and none identified with any other gender. Nineteen participants (90%) were right-handed and two (10%) were left-handed. Most participants identified as white (*n* = 16; 76%), with 4 (19%) identifying as Asian, and one (5%) as Hispanic. Most participants (*n* = 15; 71%) were rested with this being their first consecutive shift. Three (14%) reported it was their second consecutive shift, one (5%) as their third consecutive shift, and two (10%) reported that it was their fourth consecutive shift.

Supplementary Table 1

Descriptive Statistics for Key Study Variables

Measure	*n*	Mean (SD)	Skewness (*z*)	Kurtosis (*z*)
PSQI (Global)	21	5.48 (3.56)	1.15	-0.02
PSS (Total)	21	13.62 (6.00)	1.45	-0.21
LSWM – Pre	20	17.35 (2.48)	-0.24	-0.77
LSWM – Post	19	17.58 (2.27)	-1.01	1.22
Flanker – Pre	20	9.13 (0.89)	-2.21	0.66
Flanker – Post	19	9.24 (0.56)	-0.65	-0.67
DCCS – Pre	20	9.11 (0.77)	-1.03	-1.15
DCCS – Post	19	9.26 (0.70)	-1.65	0.08