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"Active Feedback" Fitbit-Based Physical Activity and Sleep Hygiene Intervention for Memory Assessment Service (MAS) Patients with Cognitive Deficits: Feasibility, Acceptability, Sleep Quality, Stress, and Wellbeing Outcomes

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Abstract

Research Background: Compared to the general population, people experiencing age-related cognitive decline are more likely to have low levels of physical activity and sleep problems. Sufficient physical activity and quality sleep are protective factors against cognitive decline and poor health and can improve coping with stressors. The "Active Feedback" intervention comprises a wearable activity and sleep tracker (Fitbit), access to Fitbit software healthy lifestyle software apps; one session with Memory Assessment Service (MAS) staff providing physical activity and sleep hygiene advice and two further engagement, discussion, and feedback sessions. **Purpose/Aim:** This study investigates the acceptability and feasibility of Active Feedback and the effect on stress, mental wellbeing, and sleep quality, and the links between these factors. **Methods:** An open-label patient cohort design with no control group was used. Pre-intervention, 4-week and 8-week intervention assessments were performed using participant self-report measures: Perceived Stress Scale (PSS), Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS), and Sleep Conditioning Index (SCI). Twenty-five participants completed an eight-week three-session intervention (18 males and 7 females), with the age range of 66 - 84 years old, and average age of 73.8 years (SD = 5.09). Fifteen participants had a diagnosis of MCI, ten participants did not. **Results:** There were non-significant improvements in SCI scores from 21.0 (SD = 8.84) to 21.6 (SD = 6.20) at 8 weeks, PSS scores from 17.5 (SD = 5.89) to 17.0 (SD = 6.20)

at 8 weeks, and WEMWBS scores from 46.9 (SD = 9.23) to 48.8 (SD = 9.69) at 8 weeks. There were negative correlations between WEMWBS and PSS. **Conclusion:** Active Feedback intervention was found to be feasible and acceptable. Active Feedback could be enhanced to include motivational interviewing and goal setting.

Keywords

Fitbit, Tracker, MCI, Exercise, Insomnia, Physical Activity, Wearables, Sleep

1. Introduction

Mild Cognitive Impairment (MCI) is defined as a level of decline in cognitive functioning that does not meet severity of decline of a dementia diagnosis [1], but that has: 1) change in cognition recognised by the affected individual or observers; 2) objective impairment in one or more cognitive domains; and 3) independence in functional activities [2]. MCI can be diagnosed with a clinical interview and objective and standardised cognitive assessment, and when deficits are not attributable to another medical or psychological condition (Swan *et al.*, 2021) [3]. The prevalence of MCI for people aged 65 years and over is up to 20% [4] [5]. In age-related cognitive decline, there is a close relationship between wellbeing and physical, mental, emotional, and cognitive health [6]. In addition, sedentary behaviour is related to cognitive decline in older individuals [7]. People who are physically active and get sufficient sleep are less likely to develop dementia, and effectively engaging in physical activities can be preventative of later disability [8] [9]. People with age-related cognitive decline who are physically active and get sufficient sleep can enhance their quality of life [8] [9].

Age-related cognitive decline can result in reduced physical activity levels [9]. Having levels of physical activity that are lower than those recommended is detrimental to physical and mental health [10]. A lack of physical exercise can be linked to more depressive symptoms, lower wellbeing, greater hopelessness, lower quality of life, and 25 physical health diseases (for example, cardiovascular disease [CVD], stroke, hypertension, osteoarthritis, diabetes, and chronic obstructive pulmonary disease [COPD]) [11].

Physical activity is associated with better late-life cognition, and aerobic exercise can reduce cognitive impairment [9]. The UK Chief Medical Officers "Physical Activity" report states that even minimal level of exercise generates health benefits [12]. Engaging in physical activity can reduce the risk of cognitive decline, MCI, Alzheimer's disease, and vascular dementia; and can improve cognitive outcomes in older adults [13] [14]. Physical activity can improve cognition, functioning, and mood, reduce behavioural problems in MCI [13] [15]-[18], and reduce risk of dementia diagnosis in people with MCI [19] [20].

Healthy lifestyles are emphasised in NHS Long-Term Plan [21] [22], and are

known to improve wellbeing, cognition, functioning, and mood, and reduce behavioural problems in early stages of dementia [13] [15]-[18]. It is recommended that interventions to maintain healthy lifestyles are used in age-related cognitive decline to reduce risk of mood problems and further cognitive decline [23]. To be effective, exercise and physical activity-focused healthy lifestyle interventions need an individualised approach to enable people with experience of cognitive decline to derive benefits [24].

The risk of depressive symptoms can be reduced by engaging in more physical activity and less sedentary behaviour [25]. Physical activity is beneficial in reducing the risk of depression by increasing levels of neurotransmitters, distracting from stressful stimuli, reducing anxiety, and improving self-efficacy and self-esteem [26]. Hence, physical exercise can help older adults engage in cognitive and social activities preventing depression and cognitive decline [27].

Sleep problems are common in older adults (approximately 50% prevalence) and are associated with poor quality of life, increased suicide risk, cognitive impairment, depression, and ability to function effectively [26] [28]. Sleep loss can increase impulsive reactions to negative stimuli, resulting in increased failure to inhibit negative and faster responses that are maladaptive [29]. Quality sleep and wellbeing are positively correlated [30], poor sleep negatively affects the quality of interpersonal relationships that are important to wellbeing [31]. Poor sleep quality is a risk factor for MCI and Alzheimer's disease [13]. There is a lack of effective psychosocial interventions for older adults that enhance sleep quality; drug therapy for insomnia is not effective for many people and has negative side effects [32].

Moderate to high levels of stress is a common problem experienced by people with age-related cognitive decline [33]. Neurodegeneration may lead to increased vulnerability to stressors [9]. If a person's stress threshold is reached, they can feel overwhelmed and they may no longer be able to function effectively [34]. Stress can lead to decline in short-term memory, reduced problem-solving, poor emotional control, reduced communication, inability to fully express needs, increase in anxiety, and behavioural issues [34]. Supporting a person with age-related cognitive decline to develop coping strategies (which can include improving sleep quality and physical activity) can reduce personal stress [35]. Depression, health, wellbeing, sleep, stress, and physical activity are interlinked [36] [37]. Healthy levels of night-time sleep positively impact the secretion of cortisol, which may reduce the risk of stress and mental illness [38] [39].

The UK Government stated that data generated by smart devices worn by individuals enable personalised health interventions allowing people to "be co-creators of their own health" [40]. A Fitbit accurately records physical activity, and sleep detection is 95% accurate [41]. Actively incorporating and applying the functions of a Fitbit can significantly increase physical activity, self-awareness, motivation, and goal setting, healthier lifestyles, sleep, and reduce body weight [42]-[45].

To seek to improve sleep quality, physical activity, and wellbeing of community-based patients, the study team has developed a physical activity and sleep hygiene intervention which has been implemented and evaluated over a period of five years in various patient populations. In our previous work, we found that the intervention improved participants' physical activity, sleep quality, motivation, self-awareness, functioning, wellbeing, healthy lifestyles, and quality of life, and reduced anxiety and depression levels [46]-[53].

This present study investigates acceptability and feasibility: whether Active Feedback can be offered in a Memory Assessment Service (MAS) and whether patients of a MAS are willing to take part in the intervention. The study investigated the impact of this intervention in a population experiencing age-related cognitive decline, it addresses the question: "What is acceptability and feasibility of Active Feedback and the effect on stress, mental wellbeing, and sleep quality, and what are the links between these factors?"

2. Methods

2.1. Design

Open-label patient cohort design with no control group was used.

2.2. Ethical Approval

Approval was granted by the review panel of the NHS Trust (Ideas Forum: reference IFACTIVE1). All participants provided informed consent. The study was delivered in accordance with the Declaration of Helsinki.

2.3. Participants

The sample was recruited from people referred to a MAS service within the United Kingdom's (UK) National Health Service (NHS) who were not given a dementia diagnosis. Participants were included if they were aged 18 or over, had the mental capacity to consent, provided informed consent, and had the ability to understand verbal English. Exclusion criteria were a medical reason meaning they could not wear a watch on their wrist.

2.4. Setting

The intervention was implemented whilst participants were under the care of the MAS. The MAS provides assessment, diagnosis, support, and treatment for people who are experiencing cognitive decline, referral is usually from the patient's GP (NHS, 2020) [54]. All areas of the UK have MAS services.

2.5. Intervention

An eight-week intervention which incorporated the provision of a free to keep Fitbit (specific model: Fitbit Charge 5) (which provides data on steps, heart rate sleep quality, and cardio fitness score), access to Fitbit software healthy lifestyle software apps, sleep hygiene and physical activity information sheets and verbal

advice, and two follow-up engagement, feedback, and discussion sessions with a MAS Assistant Psychologist (AP) at approximately four and eighth weeks. Fitbit software healthy lifestyle software apps include meditation, wellness report, "Eating Well" recipes, sleep profiles, and work out routines.

2.6. Procedure and Measures

The project was undertaken from June 2022 to February 2024. Patients were selected if they met inclusion/exclusion criteria and they were then provided with information about Active Feedback intervention and evaluation in a Participant Information Sheet (PIS). Informed consent was sought and required to take part. Patients could withdraw consent or stop engagement at any point without the need to provide a reason. Following informed consent, and at the two follow-upsat data collection points participants completed the three self-report questionnaires, as listed below:

- Sleep quality/insomnia: Sleep Condition Indicator (SCI) [55].
- Wellbeing: Warwick-Edinburgh Mental Wellbeing Scale-14 (WEMWBS) [56].
- Stress: Perceived Stress Scale (PSS) [57].

2.7. Methodology and Analysis

T-tests were conducted to determine whether there were statistically significant differences in PSS, WEMWBS, and SCI scores over the course of the 8 week intervention. Spearman's rho was used to calculate correlations.

2.8. Patient Data Obtained from Clinical Records

Following patient consent, NHS patient medical notes/records were reviewed to collate routinely collected data: DOB, sex, ethnicity, and Addenbrooke's Cognitive Examination III (ACE-III) [58] scores collected by MAS when referred to the service. ACE-III is a screening test that is composed of tests of attention, orientation, memory, language, visual perceptual and visuospatial skills that can differentiate patients with and without cognitive impairment, is sensitive to the early stages of dementia [59]. The data was linked by case.

3. Results

3.1. Descriptive Statistics and Scores on Measures

All participants were White British. Fourteen participants were males and ten were females. Mean age was 73.8 years (SD = 5.09), with an age range of 66 - 84 years. Fifteen participants had a diagnosis of MCI, ten participants had not met MCI diagnosis threshold. WEMWBS mean scores were lower than the general population norm for England (51, SD = 7.0) [56]. SCI scores were above cut off for insomnia diagnosis (16 or less) [60]. PSS scores indicate moderate stress (0 - 13 low stress, 14 - 26 moderate stress, 27 - 40 high stress) [61]. Mean ACE-III score of the participants at referral to the MAS was 85.1 (SD = 5.79), indicating

"inconclusive" dementia. The range of ACE-III score of the participants was 70 - 97 (see Table 1).

Table 1. Scoreson measures (n = 25) at baseline, four, and eight weeks.

	WEMWBS week 1	WEMWBS week 4	WEMWBS week 8	ACE III	SCI week 1	SCI week 4	SCI week 8	PSS week 1	PSS week 4	PSS week 8
M	46.9	48.5	48.8	85.1	21.0	22.4	21.6	17.5	15.5	17.0
SD	9.23	8.47	9.69	5.79	8.84	6.89	7.08	5.92	6.12	6.20
Min	26	23	24	7	0	6	7	8	3	6
Max	66	66	65	97	32	31	32	34	35	30

3.2. Preliminary Analysis

Assumptions of normality and homogeneity of variances was assessed for each scale. Shapiro-Wilk tests were conducted for each condition. Normality was met for all conditions ($p > 0.05$), indicating that the distribution of the differences was approximately normal. Levene's test was conducted to assess homogeneity of variances. The assumption of homogeneity of variances was met ($p > 0.05$), indicating that the variance of the differences between conditions was approximately equal.

3.3. WEMWBS

The paired sample t-test did not reveal any statistically significant differences in change in mean scores, $p > 0.05$. See Table 2.

Table 2. WEMWBS PAIRED samples t-test results.

		t	df	p
WEMWBS week 1	WEMWBS week 4	−0.535	21	0.598
WEMWBS week 1	WEMWBS week 8	−0.849	20	0.406
WEMWBS week 4	WEMWBS week 8	−0.769	20	0.451

3.4. SCI

The paired sample t-test did not reveal any statistically significant differences in change in mean scores, $p > 0.05$. See Table 3.

Table 3. SCI paired samples t-test results.

		t	df	p
SCI week 1	SCI week 4	0.316	21	0.755
SCI week 1	SCI week 8	0.448	19	0.659
SCI week 4	SCI week 8	0.643	19	0.528

3.5. PSS

The paired sample t-test did not reveal any statistically significant differences in change in mean scores, $p > 0.05$. See Table 4.

Table 4. PSS paired samples t-test results.

		t	df	p
PSS week 1	PSS week 4	1.525	23	0.141
PSS week 4	PSS week 8	−1.498	21	0.149
PSS week 1	PSS week 8	1.153	21	0.262

3.6. Correlations

Wellbeing (WEMWBS) was negatively correlated with Perceived Stress Scale (PSS) at <0.001. See Table 5.

4. Discussion

This study investigated the acceptability and feasibility of Active Feedback and impact on sleep quality, stress, and wellbeing. The study team found that MAS staff can deliver, and patients will choose to undertake Active Feedback, providing evidence for the acceptability and feasibility of the intervention. Whilst there were improvements in measures of stress, wellbeing, and sleep quality compared to baseline, these were not statistically significant.

Table 5. Correlations.

	WEM wk1	WEM wk4	WEM wk8	ACE III	SCI wk 1	SCI wk 4	SCI wk8	PSS wk 1	PSS wk 4	PSS wk 8
WEM wk1	-									
WEM wk4	0.74 <0.001*	-								
WEM wk8	0.55 0.0008	0.83 <0.001*	-							
ACE III	0.051 0.850	0.006 0.980	0.022 0.925	-						
SCI wk 1	0.601 0.001	0.626 0.002	0.449 0.041	0.186 0.364	-					
SCI wk 4	0.574 0.005	0.423 0.050	0.322 0.155	0.143 0.524	0.835 <0.001*	-				
SCI wk8	0.367 0.112	0.611 0.004	0.602 0.005	0.236 0.317	0.805 <0.001*	0.733 <0.001*	-			
PSS wk 1	−0.714 <0.001*	−0.776 <0.001*	−0.714 <0.001*	0.024 0.909	0.517 0.007	−0.429 0.046	−0.533 0.016	-		
PSS wk 4	0.547 0.006	−0.704 <0.001*	−0.633 0.002	0.016 0.941	−0.425 0.038	−0.444 0.039	−0.454 0.045	0.518 0.009	-	
PSS wk 8	−0.565 0.006	0.599 0.005	−0.749 <0.001*	−0.034 0.882	−0.430 0.046	−0.449 0.047	−0.581 0.007	0.692 <0.001*	0.763 <0.001*	-

Note: *denotes significant correlation at p <0.001.

The results did not support our previous work where we have found that the intervention significantly improved participants' wellbeing, mental health, and sleep quality [48] [49] [52]. The key differences in participant population were that this study's participants were older and experiencing more than normal age-related cognitive decline. It is assumed that factors related to this meant that patients did not experience statistically significant improvements seen previously. People experiencing more than normal age-related cognitive decline might be expected to decline in terms of stress, wellbeing, and sleep quality, we did not find this over the period of the study possibly indicating potential benefits of the Active Feedback intervention.

WEMWBS has a UK general population mean score of 51; scores in this study's population shows they were lower than this but higher than the cut-off point for a definition of experiencing low wellbeing [56]. Participants in this sample scored on average above cut off point for insomnia at the three times points [60], but many participants indicated they are experiencing sleep problems, a need which should be assessed and addressed in this population through appropriate assessment, advice, therapy, and medication. The PSS scores indicate this sample are experiencing moderate stress on average, rather than high or low stress levels [61], investigating and addressing needs related to stress and stressors in this population could improve coping and wellbeing, there was significant negative correlation found between stress and wellbeing.

In our most recent work [52], the intervention was expanded to include motivational interviewing and goal setting. Motivational interviewing and goal setting are effective tools in motivating people to engage in healthy lifestyle behaviours [62]. Interventions to enhance motivation for healthier lifestyles can help elicit long-term healthy lifestyle behaviour change [63]. Grounding healthy lifestyle intervention programmes in behaviour change theory can foster self-efficacy and increase the likelihood of intervention efficacy [64]. Further research could seek to deliver and assess the impact of this expanded intervention in the population which formed the basis of this current study. The study team are also investigating the delivery of this intervention by a qualified health coach, and this could be an option for delivery in a MAS.

Study limitations include the lack of control group and relatively small sample size. People who agreed to participate were self-selected; thus, it is possible more participants with better than average levels of cognitive functioning seen by MAS agreed to participate. The participants attended a MAS service in one county in the UK reducing generalisability; however, similar services are provided by all NHS providers.

5. Conclusion

There is a lack of healthy lifestyle interventions available in MAS, and Active Feedback has been found to be feasible and acceptable. A manualised version of the expanded intervention to include motivational interview and goal setting is now available to access free of charge via: https://www.nhft.nhs.uk/research/. This

expanded intervention could be made available to MAS patients, delivered by a qualified health coach and evaluation of outcomes undertaken.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Alzheimer's Society (2023) What Is Mild Cognitive Impairment (MCI)? https://www.alzheimers.org.uk/sites/default/files/2019-09/470lp-what-is-mild-cognitive-impairment-mci-190521.pdf

[2] Albert, M.S., DeKosky, S.T., Dickson, D., Dubois, B., Feldman, H.H., Fox, N.C., *et al.* (2013) The Diagnosis of Mild Cognitive Impairment Due to Alzheimer's Disease: Recommendations from the National Institute on Aging-Alzheimer's Association Workgroups on Diagnostic Guidelines for Alzheimer's Disease. *Focus*, **11**, 96-106. https://doi.org/10.1176/appi.focus.11.1.96

[3] Swan, L.B., Reichelt, K. and Clatworthy, L. (2021) A Conceptual History of Mild Cognitive Impairment (MCI) and Its Assessment—Part 3: Proposing a Single Criteria for MCI. *FPOP Bulletin*: *Psychology of Older People*, **1**, 14-17. https://doi.org/10.53841/bpsfpop.2021.1.155.14

[4] Richardson, C., Stephan, B.C.M., Robinson, L., Brayne, C. and Matthews, F.E. (2019) Two-Decade Change in Prevalence of Cognitive Impairment in the UK. *European Journal of Epidemiology*, **34**, 1085-1092. https://doi.org/10.1007/s10654-019-00554-x

[5] Alzheimer's Society (2022) Mild Cognitive Impairment (MCI). https://www.alzheimers.org.uk/about-dementia/types-dementia/mild-cognitive-impairment-mci

[6] (2021) Dementia Together. https://dementiatogether.online/

[7] Maasakkers, C.M., Claassen, J.A.H.R., Scarlett, S., Thijssen, D.H.J., Kenny, R.A., Feeney, J., *et al.* (2021) Is There a Bidirectional Association between Sedentary Behaviour and Cognitive Decline in Older Adults? Findings from the Irish Longitudinal Study on Ageing. *Preventive Medicine Reports*, **23**, Article ID: 101423. https://doi.org/10.1016/j.pmedr.2021.101423

[8] Alzheimer's Society (2020) The Dementia Guide: Living Well after Your Diagnosis. https://www.alzheimers.org.uk/sites/default/files/2020-03/the_dementia_guide_872.pdf

[9] Livingston, G., Huntley, J., Sommerlad, A., Ames, D., Ballard, C., Banerjee, S., *et al.* (2020) Dementia Prevention, Intervention, and Care: 2020 Report of the Lancet Commission. *The Lancet*, **396**, 413-446. https://doi.org/10.1016/s0140-6736(20)30367-6

[10] NHS (2023) Physical Activity Guidelines for Adults Aged 19 to 64. https://www.nhs.uk/live-well/exercise/exercise-guidelines/physical-activity-guidelines-for-adults-aged-19-to-64/

[11] Rhodes, R.E., Janssen, I., Bredin, S.S.D., Warburton, D.E.R. and Bauman, A. (2017) Physical Activity: Health Impact, Prevalence, Correlates and Interventions. *Psychology & Health*, **32**, 942-975. https://doi.org/10.1080/08870446.2017.1325486

[12] Department of Health and Social Care (2020) Physical Activity Guidelines: UK Chief Medical Officers' Report. https://www.gov.uk/government/publications/physical-activity-guidelines-uk-chief-medical-officers-report

[13] Gallaway, P., Miyake, H., Buchowski, M., Shimada, M., Yoshitake, Y., Kim, A., *et al.* (2017) Physical Activity: A Viable Way to Reduce the Risks of Mild Cognitive Impairment, Alzheimer's Disease, and Vascular Dementia in Older Adults. *Brain Sciences*, **7**, Article 22. https://doi.org/10.3390/brainsci7020022

[14] Solomon, A., Mangialasche, F., Richard, E., Andrieu, S., Bennett, D.A., Breteler, M., *et al.* (2014) Advances in the Prevention of Alzheimer's Disease and Dementia. *Journal of Internal Medicine*, **275**, 229-250. https://doi.org/10.1111/joim.12178

[15] Demurtas, J., Schoene, D., Torbahn, G., Marengoni, A., Grande, G., Zou, L., *et al.* (2020) Physical Activity and Exercise in Mild Cognitive Impairment and Dementia: An Umbrella Review of Intervention and Observational Studies. *Journal of the American Medical Directors Association*, **21**, 1415-1422.e6. https://doi.org/10.1016/j.jamda.2020.08.031

[16] Karssemeijer, E.G.A., Aaronson, J.A., Bossers, W.J., Smits, T., Olde Rikkert, M.G.M. and Kessels, R.P.C. (2017) Positive Effects of Combined Cognitive and Physical Exercise Training on Cognitive Function in Older Adults with Mild Cognitive Impairment or Dementia: A Meta-Analysis. *Ageing Research Reviews*, **40**, 75-83. https://doi.org/10.1016/j.arr.2017.09.003

[17] Law, C., Lam, F.M., Chung, R.C. and Pang, M.Y. (2020) Physical Exercise Attenuates Cognitive Decline and Reduces Behavioural Problems in People with Mild Cognitive Impairment and Dementia: A Systematic Review. *Journal of Physiotherapy*, **66**, 9-18. https://doi.org/10.1016/j.jphys.2019.11.014

[18] Venegas-Sanabria, L.C., Martínez-Vizcaino, V., Cavero-Redondo, I., Chavarro-Carvajal, D.A., Cano-Gutierrez, C.A. and Álvarez-Bueno, C. (2020) Effect of Physical Activity on Cognitive Domains in Dementia and Mild Cognitive Impairment: Overview of Systematic Reviews and Meta-Analyses. *Aging & Mental Health*, **25**, 1977-1985. https://doi.org/10.1080/13607863.2020.1839862

[19] Feter, N., Dumith, S.C., Smith, E.C., da Cunha, L.L., Cassuriaga, J., Leite, J.S., *et al.* (2021) Physical Activity Attenuates the Risk for Dementia Associated with Aging in Older Adults with Mild Cognitive Impairment. Findings from a Population-Based Cohort Study. *Journal of Psychiatric Research*, **141**, 1-8. https://doi.org/10.1016/j.jpsychires.2021.06.034

[20] Kim, Y.J., Han, K., Baek, M.S., Cho, H., Lee, E.J. and Lyoo, C.H. (2020) Association between Physical Activity and Conversion from Mild Cognitive Impairment to Dementia. *Alzheimer's Research & Therapy*, **12**, Article No. 136. https://doi.org/10.1186/s13195-020-00707-1

[21] NHS (2019) NHS Long Term Plan. https://www.longtermplan.nhs.uk/online-version/

[22] NHS (2019) Long Term Plan Implementation Framework. https://www.longtermplan.nhs.uk/implementation-framework/

[23] Yates, J.A., Clare, L. and Woods, R.T. (2016) What Is the Relationship between Health, Mood, and Mild Cognitive Impairment? *Journal of Alzheimer's Disease*, **55**, 1183-1193. https://doi.org/10.3233/jad-160611

[24] van der Wardt, V., Hancox, J., Pollock, K., Logan, P., Vedhara, K. and Harwood, R.H. (2019) Physical Activity Engagement Strategies in People with Mild Cognitive Impairment or Dementia—A Focus Group Study. *Aging & Mental Health*, **24**, 1326-1333. https://doi.org/10.1080/13607863.2019.1590308

[25] Hallgren, M., Nguyen, T., Owen, N., Stubbs, B., Vancampfort, D., Lundin, A., *et al.* (2019) Cross-sectional and Prospective Relationships of Passive and Mentally Active Sedentary Behaviours and Physical Activity with Depression. *The British Journal of Psychiatry*, **217**, 413-419. https://doi.org/10.1192/bjp.2019.60

[26] Zhai, L., Zhang, H. and Zhang, D. (2015) Sleep Duration and Depression among Adults: A Meta-Analysis of Prospective Studies. *Depression and Anxiety*, **32**, 664-670. https://doi.org/10.1002/da.22386

[27] Robitaille, A., Muniz, G., Lindwall, M., Piccinin, A.M., Hoffman, L., Johansson, B., *et al.* (2014) Physical Activity and Cognitive Functioning in the Oldest Old: Within- and Between-Person Cognitive Activity and Psychosocial Mediators. *European Journal of Ageing*, **11**, 333-347. https://doi.org/10.1007/s10433-014-0314-z

[28] Neikrug, A.B. and Ancoli-Israel, S. (2009) Sleep Disorders in the Older Adult—A Mini-Review. *Gerontology*, **56**, 181-189. https://doi.org/10.1159/000236900

[29] Anderson, C. and Platten, C.R. (2011) Sleep Deprivation Lowers Inhibition and Enhances Impulsivity to Negative Stimuli. *Behavioural Brain Research*, **217**, 463-466. https://doi.org/10.1016/j.bbr.2010.09.020

[30] Chow, C.M. (2020) Sleep and Wellbeing, Now and in the Future. *International Journal of Environmental Research and Public Health*, **17**, Article 2883. https://doi.org/10.3390/ijerph17082883

[31] Gordon, A.M. and Chen, S. (2013) The Role of Sleep in Interpersonal Conflict: Do Sleepless Nights Mean Worse Fights? *Social Psychological and Personality Science*, **5**, 168-175. https://doi.org/10.1177/1948550613488952

[32] Krystal, A.D., Prather, A.A. and Ashbrook, L.H. (2019) The Assessment and Management of Insomnia: An Update. *World Psychiatry*, **18**, 337-352. https://doi.org/10.1002/wps.20674

[33] Levenson, R.W., Sturm, V.E. and Haase, C.M. (2014) Emotional and Behavioral Symptoms in Neurodegenerative Disease: A Model for Studying the Neural Bases of Psychopathology. *Annual Review of Clinical Psychology*, **10**, 581-606. https://doi.org/10.1146/annurev-clinpsy-032813-153653

[34] Kinnaird, L. and Taggart, M. (2018) Responding to Stress and Distress in Dementia, Alzheimer Scot-Land. https://www.alzscot.org/sites/default/files/2019-11/Understanding%20stress%20and%20distress%20in%20dementia.pdf

[35] Sharp, B.K. (2017) Stress as Experienced by People with Dementia: An Interpretative Phenomenological Analysis. *Dementia*, **18**, 1427-1445. https://doi.org/10.1177/1471301217713877

[36] Kaseva, K., Dobewall, H., Yang, X., Pulkki-Råback, L., Lipsanen, J., Hintsa, T., *et al.* (2019) Physical Activity, Sleep, and Symptoms of Depression in Adults—Testing for Mediation. *Medicine & Science in Sports & Exercise*, **51**, 1162-1168. https://doi.org/10.1249/mss.0000000000001896

[37] WHO (World Health Organization) (2020) Global Recommendations on Physical Activity for Health.

https://www.who.int/standards/classifications/classification-of-diseases

[38] Kumari, M., Badrick, E., Ferrie, J., Perski, A., Marmot, M. and Chandola, T. (2009) Self-reported Sleep Duration and Sleep Disturbance Are Independently Associated with Cortisol Secretion in the Whitehall II Study. *The Journal of Clinical Endocrinology & Metabolism*, **94**, 4801-4809. https://doi.org/10.1210/jc.2009-0555

[39] Meerlo, P., Sgoifo, A. and Suchecki, D. (2008) Restricted and Disrupted Sleep: Effects on Autonomic Function, Neuroendocrine Stress Systems and Stress Responsivity. *Sleep Medicine Reviews*, **12**, 197-210. https://doi.org/10.1016/j.smrv.2007.07.007

[40] Department of Health (2019) Advancing Our Health: Prevention in the 2020s London, Department of Health. https://www.gov.uk/government/consultations/advancing-our-health-prevention-in-the-2020s

[41] Beattie, Z., Oyang, Y., Statan, A., Ghoreyshi, A., Pantelopoulos, A., Russell, A., *et al.* (2017) Estimation of Sleep Stages in a Healthy Adult Population from Optical Plethysmography and Accelerometer Signals. *Physiological Measurement*, **38**, 1968-1979. https://doi.org/10.1088/1361-6579/aa9047

[42] Kooiman, T.J.M., de Groot, M., Hoogenberg, K., Krijnen, W.P., van der Schans, C.P. and Kooy, A. (2018) Self-Tracking of Physical Activity in People with Type 2 Diabetes. *CIN*: *Computers*, *Informatics*, *Nursing*, **36**, 340-349. https://doi.org/10.1097/cin.0000000000000443

[43] Naslund, J.A., Aschbrenner, K.A., Barre, L.K. and Bartels, S.J. (2015) Feasibility of Popular M-Health Technologies for Activity Tracking among Individuals with Serious Mental Illness. *Telemedicine and e-Health*, **21**, 213-216. https://doi.org/10.1089/tmj.2014.0105

[44] Ringeval, M., Wagner, G., Denford, J., Paré, G. and Kitsiou, S. (2020) Fitbit-Based Interventions for Healthy Lifestyle Outcomes: Systematic Review and Meta-Analysis. *Journal of Medical Internet Research*, **22**, e23954. https://doi.org/10.2196/23954

[45] Chum, J., Kim, M.S., Zielinski, L., Bhatt, M., Chung, D., Yeung, S., *et al.* (2017) Acceptability of the Fitbit in Behavioural Activation Therapy for Depression: A Qualitative Study. *Evidence Based Mental Health*, **20**, 128-133. https://doi.org/10.1136/eb-2017-102763

[46] Griffiths, C., Hina, F., Pollard, L., Jugon, S., Sam, M. and Kelbrick, M. (2021) A Qualitative Study of Early Intervention Psychosis (EIP) Service Patient's Experience of Sleep, Exercise, Sleep Hygiene Advice and Fitbit Wearable Activity and Sleep Tracker. *Open Journal of Psychiatry*, **11**, 91-106. https://doi.org/10.4236/ojpsych.2021.112009

[47] Griffiths, C., Walker, K. and Leathlean, C. (2022) Wearable Physical Activity and Sleep Tracker Based Healthy Lifestyle Intervention in Early Intervention Psychosis (EIP) Service: Patient Experiences. *Open Journal of Psychiatry*, **12**, 115-127. https://doi.org/10.4236/ojpsych.2022.121010

[48] Griffiths, C., Silva, K.d., Hina, F., Jugon, S., Willis, G., Yardley, S., *et al.* (2022) Effectiveness of a Fitbit Based Sleep and Physical Activity Intervention in an Early Intervention Psychosis (EIP) Service. *Open Journal of Psychiatry*, **12**, 188-202. https://doi.org/10.4236/ojpsych.2022.122015

[49] Griffiths, C., da Silva, K.M., Leathlean, C., Jiang, H., Ang, C.S. and Searle, R. (2022) Investigation of Physical Activity, Sleep, and Mental Health Recovery in Treatment Resistant Depression (TRD) Patients Receiving Repetitive Transcranial Magnetic

Stimulation (rTMS) Treatment. *Journal of Affective Disorders Reports*, **8**, Article ID: 100337. https://doi.org/10.1016/j.jadr.2022.100337

[50] Griffiths, C., Walker, K. and Leathlean, C. (2022) An Exploration of Patient Experience of Sleep, Physical Activity, and Exercise in Early Psychosis. *Psychosis*, **15**, 319-331. https://doi.org/10.1080/17522439.2022.2064907

[51] Griffiths, C., Walker, K. and Jiang, H. (2023) Experience and Impact of the "Well-Track" Physical Activity and Sleep Tracker Based Healthy Lifestyle Intervention for Patients in an Early Intervention in Psychosis (EIP) Service. *Open Journal of Psychiatry*, **13**, 73-93. https://doi.org/10.4236/ojpsych.2023.132009

[52] Griffiths, C., da Silva, K., Jugon, S., Jiang, H., Rogers, R., Althorpe, T., *et al.* (2023) "Well-Track": Fitbit Based Physical Activity and Sleep Hygiene Intervention for Early Intervention in Psychosis (EIP) and At-Risk Mental State (ARMS) Service Patients. *Open Journal of Psychiatry*, **13**, 246-261. https://doi.org/10.4236/ojpsych.2023.134020

[53] Walker, K., Griffiths, C. and Willis, A. (2024) Patients' and Staff's Experiences of Well-Track Physical Activity and Sleep Quality Intervention in an Early Intervention in Psychosis (EIP) Service. *Advances in Mental Health*. https://doi.org/10.1080/18387357.2024.2302118

[54] NHS (2020) Memory Service Assessments: A New Way of Working. https://www.rcpsych.ac.uk/docs/default-source/improving-care/ccqi/national-clinical-audits/national-audit-of-dementia/round-5/amanda-thomsell-memory-assessment-services-oct-9th.pdf?sfvrsn=f7a48a77_2

[55] Espie, C.A., Kyle, S.D., Hames, P., Gardani, M., Fleming, L. and Cape, J. (2014) The Sleep Condition Indicator: A Clinical Screening Tool to Evaluate Insomnia Disorder. *BMJ Open*, **4**, e004183. https://doi.org/10.1136/bmjopen-2013-004183

[56] Tennant, R., Hiller, L., Fishwick, R., Platt, S., Joseph, S., Weich, S., *et al.* (2007) The Warwick-Edinburgh Mental Well-Being Scale (WEMWBS): Development and UK Validation. *Health and Quality of Life Outcomes*, **5**, Article No. 63. https://doi.org/10.1186/1477-7525-5-63

[57] Cohen, S., Kamarck, T. and Mermelstein, R. (1983) A Global Measure of Perceived Stress. *Journal of Health and Social Behavior*, **24**, 385-396. https://doi.org/10.2307/2136404

[58] Hodges, J.R. and Larner, A.J. (2017) Addenbrooke's Cognitive Examinations: ACE, ACE-R, ACE-III, ACEapp, and M-ACE. In: Larner, A.J., Ed., *Cognitive Screening Instruments*, Springer, 109-137. https://doi.org/10.1007/978-3-319-44775-9_6

[59] Bruno, D. and Schurmann Vignaga, S. (2019) Addenbrooke's Cognitive Examination III in the Diagnosis of Dementia: A Critical Review. *Neuropsychiatric Disease and Treatment*, **15**, 441-447. https://doi.org/10.2147/ndt.s151253

[60] Espie, C.A., Farias Machado, P., Carl, J.R., Kyle, S.D., Cape, J., Siriwardena, A.N., *et al.* (2017) The Sleep Condition Indicator: Reference Values Derived from a Sample of 200 000 Adults. *Journal of Sleep Research*, **27**, e12643. https://doi.org/10.1111/jsr.12643

[61] Cohen, S. and Williamson, G. (1988) Perceived Stress in a Probability Sample of the United States. In: Spacapan, S. and Oskamp, S., Eds., *The Social Psychology of Health: Claremont Symposium on Applied Social Psychology*, Sage, 31-67.

[62] Hardcastle, S.J., Hancox, J., Hattar, A., Maxwell-Smith, C., Thøgersen-Ntoumani, C. and Hagger, M.S. (2015) Motivating the Unmotivated: How Can Health Behavior Be Changed in Those Unwilling to Change? *Frontiers in Psychology*, **6**, Article 835. https://doi.org/10.3389/fpsyg.2015.00835

[63] McGrane, N., Galvin, R., Cusack, T. and Stokes, E. (2015) Addition of Motivational Interventions to Exercise and Traditional Physiotherapy: A Review and Meta-Analysis. *Physiotherapy*, **101**, 1-12. https://doi.org/10.1016/j.physio.2014.04.009

[64] Smith, J., Griffiths, L.A., Band, M., Hird-Smith, R., Williams, B., Bold, J., *et al.* (2020) Early Intervention in Psychosis: Effectiveness and Implementation of a Combined Exercise and Health Behavior Intervention within Routine Care. *Frontiers in Endocrinology*, **11**, Article 577691. https://doi.org/10.3389/fendo.2020.577691