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The Experience and Impact of a Fitbit-Based Physical Activity and Sleep Hygiene Intervention for Older Adults Experiencing Cognitive Decline

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Abstract

Objectives: This study aimed to understand the experience and impact of a physical activity and sleep wrist-worn tracker (Fitbit)-based healthy lifestyle intervention for older patients attending a memory assessment service, who are experiencing cognitive impairment but do not receive a dementia diagnosis. **Methods:** A qualitative design was employed. Semi-structured interviews were conducted with a purposeful sample of thirteen participants recruited from a memory assessment service. Thematic analysis, that was data driven and inductive, was undertaken to analyse the data. **Results:** Two global themes were developed. "*Understanding exercise and sleep as part of my lifestyle*" was made up of themes representing how participants viewed exercise and sleep as part of their lifestyles in terms of acknowledging the positive impacts and the barriers to exercise and sleep. The second global theme "*Understanding my experience of the healthy lifestyle intervention*" was made up of themes that identified the positive impact of the intervention regarding improving health and wellbeing, enabling validation of proactive behaviours and motivation to engage in healthy lifestyle behaviours, so promoting positive behaviour change. **Conclusion:** Patients experiencing age-related cognitive impairment, applied and benefited from a healthy lifestyle Fitbit-based intervention to facilitate and promote physical activity, better sleep hygiene and healthy lifestyles.

Keywords

Cognitive Impairment, Healthy Lifestyle Intervention, Fitbit, Health and Wellbeing, Behaviour Change

1. Introduction

Age is a major factor in cognitive decline [1]. Around 15% of individuals aged 65 - 84 years develop cognitive dysfunction, including memory impairment; this increases to 40% for those aged 85 years or older [2]. Mild cognitive impairment (MCI) is a classification of cognitive impairment not reaching a diagnosis of dementia [3]. The UK prevalence of MCI for those 65+ years, is 6% to 20% [4] [5]. MCI is associated with impaired quality of life and work productivity and increases the risk of later dementia diagnosis [6] [7], with annual progression rates of MCI to dementia estimated as ranging from 10% to 15% [8] [9]. Many other people experience age-related cognitive impairment, which while impacting on their functioning, would not meet an assessment of MCI or dementia [10].

Guidance recommends the implementation of health promoting interventions for older people to reduce cognitive decline, risk of dementia diagnosis and promote quality of life and wellbeing [11]. Participation in meaningful physical exercise and activities promotes healthy physical functioning and mental wellbeing in the elderly [12]. Improvements in emotional, psychological, social wellbeing, and cognitive functioning are associated with regular physical activity [13]. Physical activity/exercise has a positive effect on improved cognitive function in older adults without dementia [14], and physical activity and exercise improves cognitive and noncognitive (e.g., quality of life, disability, and physical function) outcomes in people with MCI [15]. Physical activity also attenuates the risk for dementia associated with aging in older adults with MCI [16]. A meta-analysis concluded that physical activity has a positive effect on cognition for those experiencing dementia or MCI, and that there is a need to include physical activity as part of the treatment plan for those experiencing cognitive impairments [17]. This had led to the development of several healthy lifestyle interventions e.g., Prevention of Dementia by Intensive Vascular Care (PreDiva), Finnish Geriatric Interventions Study to Prevent Cognitive Impairment and Disability (FINGER) and the Multidomain Alzheimer Preventive Trial (MAPT) [18].

Apart from the lack of physical activity, poor sleep quality is negatively associated with subjective wellbeing in older adults [19]. Good quality and sufficient sleep contribute to primary and secondary prevention of metabolic conditions such as obesity, diabetes, hypertension and coronary heart disease [20]. Effective sleep has significant positive effects on composite mental health: reducing depression, anxiety, rumination, stress, and psychotic symptoms; there is a dose response showing that greater improvements in sleep quality leads to greater improvements in mental health [21]. Sleep promotes the consolidation of memory (declarative, procedural and emotional memories) [22], and sleep deprivation impairs memory,

verbal fluency and response inhibition [23]. Poor sleep quality is associated with increased risk of cognitive decline [24]. Neuropsychiatric symptoms including sleep problems have high prevalence in MCI and dementia [25]. Therefore, sleep problems should be identified and treated to preserve cognition [26].

Regular physical activity and sleep are important factors to restore physical and mental health [27]. In recent years, wearable activity trackers have been found to encourage healthy physical activities and reduce barriers to engage in exercise [28], promote behaviour changes including healthy lifestyle self-management and goal setting [29], and increased physical activity [30]. Wearable activity trackers are associated with improved physiological outcomes (e.g., reduced BMI and blood pressure) and can improve mental health and wellbeing through increases in physical activity [31]. Furthermore, wearable trackers can improve sleep quality and effective sleep duration, as they provide access to a range of data about sleep and give insight into individuals' sleep health enabling people to employ strategies to improve sleep quality where possible [32]. The mechanisms of wearable trackers include providing quantified feedback [33], or what we describe as "Active Feedback", where activity trackers provide live data relating to activity and sleep, whilst indicating whether the individual is meeting their goals or not. Wearable activity trackers as part of a health service provided healthy lifestyle intervention can improve mental health, sleep quality, quality of life, levels of physical activity and wellbeing [34]. Although wearable activity trackers have been studied widely in adult populations, this is not the case in relation to older adults, especially those with MCI.

The aim of this current study is to understand the experience and impact of a physical activity and sleep wrist-worn tracker-based healthy lifestyle intervention (Active Feedback) for older patients attending a memory assessment service (who do not receive a dementia diagnosis). Specifically, the research looks to understand how a healthy lifestyle intervention could impact and benefit this group of people, examining what works well, and what does not work well.

2. Methods

2.1. Design

A qualitative approach was taken, employing semi-structured interviews. Interview questions were informed by research literature on studies exploring the experience of using an activity and sleep tracker in older adults [35] [36]. Questions were developed to explore: use of a Fitbit in the patients' lives; experience and perceptions of the intervention; any changes made; and impact due to the intervention. Open questions were utilised to encourage participants to talk about their experiences.

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. Medical Records

Following informed consent, demographic information (gender, ethnicity, date of birth) was extracted from clinical records containing routinely collected data.

2.4. Setting and Participants

Participants were recruited from individuals attending a memory assessment service, but who did not receive a dementia diagnosis (although they might be given a MCI diagnosis), and who the service determine require a six-month follow-up appointment due to identified risk of cognitive decline. Inclusion criteria were patients: 60 years or over; attending the memory assessment service but had not received a dementia diagnosis; offered a six-month follow-up appointment; and have capacity to consent. Exclusion criteria was having a medical reason that they cannot wear a watch-like device on their wrist.

Twenty participants were recruited and of those 13 were interviewed. Of the 13 participants, 3 (27.1%) were female and 10 (76.9%) were male. All identified as White British. The age range of the participants was 66 - 81 years (M = 72.62, SD = 4.39). For 6 (46.2%) of the participants, no diagnosis had been given, 7 (53.8%) had been diagnosed with MCI.

2.5. Intervention

Participants took part in a physical activity and sleep tracker-based healthy lifestyle intervention (Active Feedback). The intervention comprised participants being given a wearable fitness tracker (Fitbit Charge 5) (and shown by the research assistant how to use and access Fitbit software applications), sleep hygiene advice sheets (information on what individuals can do to help them have a good night's sleep) and physical activity advice sheets (tips about and links for engaging in physical activity). At approximately 4 weeks, participants engaged with staff to discuss their use of the tools and their physical activity and sleep.

2.6. Procedure

All interviews were completed one-to-one via the telephone. Interview lengths ranged from 26.28 to 54.15 minutes (M = 34.36, SD = 7.09). All interviews were recorded and transcribed verbatim, anonymised, and then all recordings securely deleted. NVivo 16 software was used to support the analysis of the interview data.

2.7. Data Analysis

Thematic analysis (TA) [37] was used to analyse the data. The TA was data driven and inductive (to explore understanding, perspectives and meanings of the participants in relation to their experience of the healthy lifestyle interven-

tion) and the themes were developed on the semantic level to capture explicitly expressed meaning [37]. The data were analysed following steps as proposed by Braun and Clarke [37] [38] which comprise: familiarisation with the data; generating initial codes; searching for themes; reviewing the themes assessing for consistency; defining and naming themes; and writing up a coherent account of the data. Two researchers independently coded the data into initial themes, and these codes were collated and developed into overarching themes. A third researcher examined the themes, and through discussions, debate and agreement refined and developed a thematic picture from the interview data. Verbatim quotes were reported to promote verifiability [39]. To promote credibility and confirmability of the research, and to make sure that the findings were the experiences of those interviewed, strategies for ensuring trustworthiness, advocated by Shenton [40] were followed.

3. Results

Participants were initially asked some questions about their practical use of the watch and the different functions that they engaged with. This information was collected using basic content analysis, see **Table 1**.

Table 1. Practical use and functions of Fitbit participants engaged with.

Question	Yes *n* (%)	Exemplar quotes	No *n* (%)	Exemplar quotes
Did you have problems wearing the Fitbit?	1 (7.7)	P11: *The strap is causing all my skin to dry up underneath the strap. I have to keep moving it up my wrist.*	12 (92.3)	P1: *I found it perfectly comfortable. No issues at all.*
Did you wear it all the time?	13 (100)	P9: *All the time and apart from once a week it goes on charge for a couple of hours.*	0 (0)	
Did you have problems charging it?	0 (0)		13 (100)	P6: *I had no issues charging it.*
Did you use the following features:				
Steps?	9 (69.2)	P3: *Yes. Definitely I use that to measure how far I've gone and how many steps I've been taking.*	4 (37.8)	P4: *I didn't know how to do it anyway.*
Sleep tracking?	9 (69.2)	P10: *Yeah. It tells me how many hours I've slept and like the sort of sleep.*	4 (37.8)	P13: *I didn't I must admit I would have liked to but I didn't know how to set it up so easy.*
Sleep score?	6 (46.2)	P9: *The sleep score, is usually around sort of 65 to 70 and it says fair, I have had one poor one. I keep an eye on that.*	7 (53.8)	P11: *I don't know what that is.*
Calories burn?	5 (38.5)	P4: *I did look at the calorie burn that was the one thing that used to come up every day.*	8 (61.5)	P6: *No, I haven't quite got on to that yet.*
Guided breathing sessions?	1 (7.7)	P11: *I have done it once or twice, but it's remembering to do it.*	12 (92.3)	P10: *No... and I thought I should do, that would be good for me.*
Heart rate tracking?	9 (69.2)	P9: *Oh, heart rate I keep an eye... I take tablets to slow me heart down, because they reckon it was too high.*	4 (37.8)	P12: *I haven't. It's not part of what I've been looking at.*
Cardio fitness goal?	0 (0)		13 (100)	P11: *No, I don't. I don't know how to use it.*

Continued

Reminders to move?	7 (53.8)	P10: *I like an alarm, and I get up and move when it tells me to.*	6 (46.2)	P9: *No, I don't need reminding to move, I never stop.*
Goal-based exercise mode?	0 (0)		13 (100)	P3: *Not really, I am not the exercise person, I used to be many years ago.*
Personalised reminders?	1 (7.7)	P10: *Yeah, I do that.*	12 (92,3)	P13: *I would have liked to... I found that's a bit difficult, I was a bit bothered setting it up.*
Heart rate zones?	6 (46.2)	P11: *I do the heart rate. I am checking that it is within the parameters.*	7 (53.8)	P12: *No, because I am not allowed to do excessive exercise... I have not touched it.*

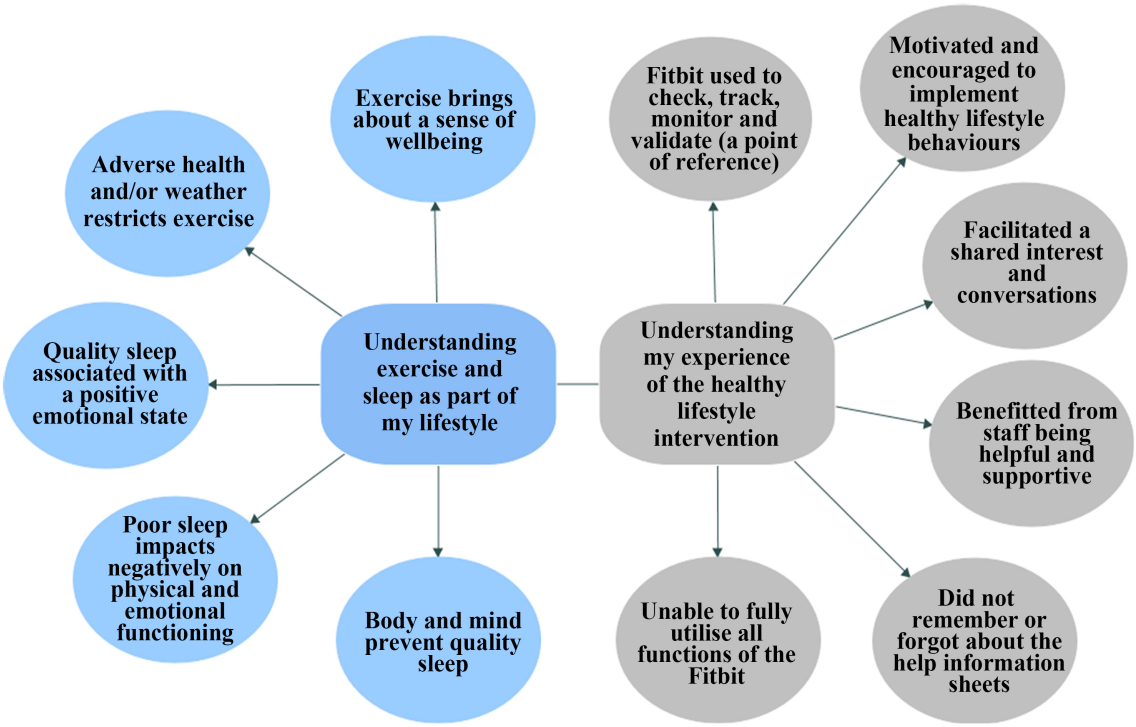

Figure 1. Two global themes and their associated themes that represent participants' experiences.

From the thematic analysis, a thematic map was developed that comprised two global themes, "*Understanding exercise and sleep as part of my lifestyle*" and "*Understanding my experience of the healthy lifestyle intervention*", made up of several interlinked themes. This is presented in **Figure 1**.

3.1. Understanding Exercise and Sleep as Part of My Lifestyle

This global theme describes participants' understanding of how exercise and sleep featured and impacted their current lifestyles; this comprised five themes that represented the different elements contributing to this understanding.

3.1.1. Exercise Brings About a Sense of Wellbeing

Participants experienced a positive impact following exercise. Exercise was associated with a sense of wellbeing for example having more energy, feeling better in the self and improvements in their mood:

*P*6: *Calmer, brighter, lighter... in general wellbeing... I feel better with the exercise... losing some of your memory is a grief. And that makes me very sad. Walking lifted that mood up.*

Several of the participants referred to the positive impact exercise had on their mental health:

*P*2: *Oh,* [*exercise is*] *excellent, really good and brilliant. I feel, worthwhile, and it makes me happy. That then has positive impact on my mental health. It makes me feel much better, and I can concentrate more if I am feeling like that.*

For some of the participants exercise (and being outdoors) had additional social and mental health benefits over the physical rewards experienced and brought about a sense of community for individuals:

*P*7: *I like being outdoors. I meet the dog walkers, and I've got people to talk to. It's quite a social thing... Exercise helps my mental health. Well a) it's social, b) you are getting out and about.*

Exercise was also found to promote good sleep, which is a known factor associated with facilitating good health (mental and physical) and wellbeing:

*P*9: *Good physical activity in the day, that perhaps can help me sleep, because of that, I then feel better generally... if you get tired enough to have a good sleep, you can sleep longer.*

3.1.2. Adverse Health and/or Weather Restricts Exercise

Although exercise was found to be beneficial, participants experienced barriers preventing them from exercising, and these comprised two different factors. The first was poor health and illness, which included medical conditions:

*P*13: *I can't walk very far. I've got a problem with this stoma. I have a hernia... I find it very difficult to walk very far. Consequently, I don't really do a lot of exercise*;

cardiac and respiratory issues:

*P*2: *I have had a stroke... but I have had a load of mini strokes and I have problems with my heart, and then my asthma*;

and joint problems:

*P*11: *I can't do as much as I want it all depends on, how my legs are... it's just, with my osteoarthritis in my ankles, knees and back, I mean, that restricts me a lot.*

The other factor was adverse or poor weather conditions which were found to act as a barrier to doing exercise. Participants agreed that if the weather was poor, it prevented them from exercising:

*P*7: *Most definitely the weather. We haven't had extremely warm weather where I can get out. I mean, I don't go out in the rain with the dog.*

3.1.3. Quality Sleep Associated with a Positive Emotional State

Participants recognised that good sleep was associated with positive emotional states and feelings; examples of this included feeling jollier, happier, calmer, and generally better in themselves:

*P*6: *I'm calmer and I'm more relaxed*.

*P*1: *After a good night's sleep, get up and you're a bit more jolly... if you have a very good rest, I think you can function better. I can cope better*.

The knock-on effect of having the ability to do activities following quality sleep, then promoted a feeling of happiness; this in turn lends itself to further positive impact on mood and mental health:

*P*2: *If I have a good night's sleep, I can do activity, if I do activity, it makes me happy, and I can settle myself calm, nice and calm. I get into a good pattern, I am sleeping well, I have energy and do more activities and I feel better in my mood and mental health*.

3.1.4. Poor Sleep Impacts Negatively on Physical and Emotional Functioning

This theme portrays how poor sleep is associated with a negative impact. There was a recognition that this can be a problem for some on their emotional functioning:

*P*9: *It is bound to affect it because you do get tired, and we all get irritable when we get tired. I'm more quick tempered because of perhaps not getting enough sleep*.

Poor sleep for some of the participants was perceived as impacting on mental health and the resultant impact of this:

*P*7: *Yeah, I think tiredness does affect my mental health. The lethargicness* [*sic*] *and not being able to get up have any get up and go*.

Others also suggested that poor sleep affected their thinking; one person commented that it impacts on their ability to think clearly (P13: *Well, you feel fuzzy in the head, a bit disorientated*), while the following participant felt it disrupted his concentration:

*P*1: *If I have a tough night, not sleeping, I'm not very good the next day at all. And I'm like, all over the place. I can't concentrate generally most of the day. I wouldn't be able to concentrate on anything at all*.

Poor sleep also resulted in a lack of energy and so negatively affected individual's physical functioning, which impacted on their ability to engage in any activities (which could then affect their mental health):

*P*2: *Tired, lack of energy. Struggle to do anything... really just sit in the chair and that's about it... I just feel as if I can't do anything... I just don't feel as if I want to do anything, me brain sort slows down a bit*.

3.1.5. Body and Mind Prevent Quality Sleep

This final theme relates to the barriers to sleep that were identified, with two contributors—the mind and the body. Both were found to prevent the individual's ability to sleep or to achieve good quality sleep. For the mind, this was when the "brain" and "thinking" were associated with preventing sleep. Examples of this include when there is too much going on in an individual's head, and finding that their thoughts kept them awake, as they were overthinking and ru-

minating:

*P*1: *Thinking about things all night long... things that turn around in your mind all night long. Unnecessary stuff, what's relevant to nothing really. It's just floating around in there and it keeps you awake*.

The body element of this theme comprises barriers such as physical pain experienced because of an aging body:

*P*7: *The arthritis really, now. The pain in my hands and my knee and sometimes the pain and it can keep me awake... pain is the worst to keep you awake*;

as well as ongoing medical illnesses and issues:

*P*2: *If I am struggling breathing... that can affect my sleep at times. I've had asthma for the last couple of months, waking up struggling to breath, and I could lay there with me eyes open for* 10, 15 *minutes, just staring*.

For some participants there was also the scenario that as they are getting older, due to their age and/or medication they are waking frequently during the night to use the toilet and so experiencing disrupted (and therefore poor quality) sleep:

*P*9: *Taking this tablet, and it is literally having to wake up go to the toilet... certainly, three times sometimes four*.

3.2. Understanding my Experience of the Healthy Lifestyle Intervention

This global theme comprises six associated themes and is about how the participants viewed their individual experience and understanding of the intervention. This all collates what participants identified as having impacted and benefitted them, what worked well, as well as what did not work so well, as part of their overall experience.

3.2.1. Fitbit Used to Check, Track, Monitor and Validate (a Point of Reference)

The Fitbit was a useful tool for the participants to observe what was happening, and to "*keep an eye on things*", in relation to both exercise and sleep. Several participants referred specifically to using it as a means of "checking":

*P*2: *I checked it every night, and looked at it every morning to see how my sleep was... it was useful because it could tell me, how much light sleep, repetitive eye movement, and waking up during the night, I didn't realise you did that*;

"tracking":

*P*1: *If you are thinking about your exercise, you can track that, track the exercise as well. Then then I can relate to that and then I can see what's going on*;

"monitoring":

*P*11: *I look and monitor how I have been doing on sleep. If I walk out anywhere, then obviously it goes up. Some days are better than others, obviously. One of the benefits is keeping track and monitoring your exercise*;

and being a "reference":

*P*7: *You either sleep well, or we don't sleep well... I just use it as a reference really... so if you need to adjust or amend*.

Several participants used the Fitbit to keep an "eye on" and monitor their heart rate, taking action accordingly:

*P*12: *I'll just keep an eye on it... the other day it went up to about* 140 *so I sat down and then it come right back down*.

The Fitbit gave instant feedback to the participants (P1: *Getting feedback is good. It's instant so it is just there on your wrist, and you can check it*). This allowed them access to patterns in relation to their sleep and exercise (including heart rate), providing a point of reference and way of validating or confirming things:

*P*3: *I'm looking at it now to see. Sixty, oh it says* 60. *Sleep stages, no deep sleep, mostly light sleep, I did have a bad night, and then mostly light sleep. It is useful if you have had a bad night, you can see it on the watch*.

3.2.2. Motivated and Encouraged to Implement Healthy Lifestyle Behaviours

The Fitbit facilitated individuals to implement certain positive healthy lifestyle actions e.g., better sleep habits:

*P*2: *It comes up what time you go to sleep, I am looking at it, so I started going to bed a bit earlier, because I didn't realise that it was that late we were going to bed. It's made me look at what time I go to sleep and not sit there too long when I did go to bed, reading, or doing puzzles or looking at the phone*;

drinking more water:

*P*1: *It just makes you a bit more aware that you could look after yourself probably a bit better, like with dehydration especially, I think that's a bit low, I'll drink a litre, half a litre of fluid or whatever*;

and managing their weight:

*P*4: *I lost weight earlier in the year, I don't want to put it back on again. I feel better without that weight on, so, I look at the amount of calories that according to it I have burned, and try to keep it within them*.

By far the biggest impact on lifestyle behaviours was the positive impact that the Fitbit had on exercise and physical activity. Participants discussed how the Fitbit encouraged and motivated them to do more exercise, to hit targets and goals, and make sure they were achieving their daily "steps":

*P*10: *You look at it* [*Fitbit*], *and you think—oh, I've got to do a bit more. You know, you've set a goal and sort of think, right, I'm gonna do that. I think you set some more goals to try and achieve and that makes you do more. I think it's helped my motivation*.

*P*11: *I look at it* [*Fitbit*] *it encourages me to do more steps, and then when I check out, it makes me feel good to see that I'm doing as many steps as what I am. It encourages me to go out more*.

3.2.3. Facilitated a Shared Interest and Conversations

The Fitbit was a useful tool to use with other people such as partners, to support useability and engagement. Partners were also found to look at the watch and

help with monitoring. For some of the participants, it meant they became accountable to their partners as well, through the sharing of the data:

*P*3: *She's* [*wife*] *just found the cardio fitness on the on her phone. It is* 42 *to* 46*—excellent. She looks after me on the phone. I say I am going for a walk, and she says alright and she will check me out.*

For some participants, the information collated on the Fitbit was helpful for use with other health professionals; it provided a basis to be able to open up conversations with other professionals, share this information, and then to be able to act accordingly:

*P*9: *I am using a Fitbit to monitor things, and then discuss it with my diabetic nurse. I do speak to the diabetic nurse and show them that and talk about it.*

3.2.4. Benefitted from Staff Being Helpful and Supportive

Participants commented on how they also liked having staff to support them. They found the staff were helpful:

*P*3: [*Name of staff*], *she's marvellous. She came along and showed us all what we had to do, helped me out with what I could do.*

Through the support given, engagement with the lifestyle intervention was facilitated. By staff being approachable, available to give information and willing to help the person to understand it, participants were able to make best use of the intervention and use it to its full potential:

*P*10: *Supportive. Really friendly, help, they explain things—it's really good. ... giving me the information and helping me to understand it. This has meant I can use the Fitbit more and engage with it.*

3.2.5. Did Not Remember or Forgot about the Help Information Sheets

None of the participants utilised the supporting sleep or exercise information sheets that were given to them as part of the intervention. For many of them, they simply did not remember being given them in the first place, and as such did not look or read them at all:

*P*6: *Oh, I don't remember getting them, but I expect we did, and I suspect they're in our folder.*

For others, they had some recollection of the sheets, but discussed how they did not read them, or put the information away and forgot about it and therefore were not able to benefit from the guidance:

*P*5: *Well, I suppose I forgot* [*the information sheets*]. *I suppose, I haven't used them, really because I've forgotten about them.*

For one of the participants, while they remember receiving the sheets, they could not remember what was on them, and therefore the information would not have been utilised:

*P*12: *I can't really remember a great deal about what was on them.*

3.2.6. Unable to Fully Utilise All Functions of the Fitbit

Some participants discussed how they did not necessarily engage with all the

functions that the Fitbit offered. Some participants felt that they did not have a need for all functions e.g., those who felt they already exercised enough, or who did not have a problem with sleep. However, in some cases, they acknowledged they felt they had missed out on useful and helpful information:

*P*8: *I don't know if the steps would help me because I think I take enough walking anyway. Certainly, the sleeping side if I'd have taken a bit more time to look at that and see what it does, I probably would have used it a lot more than I did.*

For a couple of the participants, they felt that the technology could possibly be a little beyond them, which stopped them from exploring and using various functions:

*P*1: *I am not a techy fellow though so getting all that stuff up will be a bit much.*

Some participants felt they needed more support and help with identifying what the Fitbit could do and how then to use the different features available to them:

*P*7: *I haven't used all the assets of the Fitbit, I have not set it up properly. Maybe that's something that I'd like more help with. Some more help with actual watch itself and all the features.*

4. Discussion

Through the analysis of the interview data, an understanding was gained into how the participants viewed exercise and sleep as part of their lifestyles. An insight was also gained into how they experienced a healthy lifestyle intervention, the impact of this, and what worked well and what did not work as well. Overall, it was found that sleep and exercise were important for patients' overall health (physical and mental) and wellbeing, and that the lifestyle intervention employed can encourage patients to examine and understand their physical activity and sleep related lifestyle behaviours and take steps to implement positive healthy lifestyle behaviour change.

When engaging in physical activity and exercise, patients acknowledged this can bring about a sense of wellbeing. They discussed how exercising gives them more energy, and makes them feel more positive in relation to their mood. They also perceived exercise as being beneficial to their physical and mental health, both by the action of actually doing the activity, and the social element that can come with exercise (walking with others/gym classes); this aligns with existing research findings [41] [42]. There is a wide-ranging positive impact of physical activity and exercise on self-esteem, cognitive function, mood, and quality of life, as well as in decreasing stress tendencies which is associated with aggravating mental and physical disease [43]. There is a link between exercising with others and feelings of social bonding and belonging [44], which is associated with motivation [45].

Sleep was acknowledged as important for the participants, in that quality sleep was associated with a positive emotional state, and poor sleep impacted nega-

tively on physical and emotional functioning. This aligns with previous research, where it is acknowledged that sleep loss and poor-quality sleep disrupts how the brain processes emotions [46]. Reduced sleep has been associated with decreased positive affect [47]. Parsons *et al*. [48] found that sleep quality was associated with increased intensity and duration of positive emotion, decreased intensity of negative emotion and reported use of positive emotion regulation strategies. This highlights the need for individuals to seek ways to try and ensure they get quality sleep. This could be achieved by addressing some of the barriers to quality sleep identified in this research: thoughts (overthinking and ruminating) and physical issues (pain, physical illnesses).

The participants expressed how the Fitbit was a beneficial element of the intervention, providing them with a tool to check, monitor and validate their healthy lifestyle behaviours such as exercise, giving them a point of reference. This aligns with research suggesting that wearable fitness trackers encourage and increase physical activities and reduce barriers and promote behaviour change [28] [29] [30]. Equipment such as Fitbits have been found to be beneficial as part of an intervention for older people. Wu *et al*. [49] found that wearable trackers were effective for adults age 60+ in increasing daily steps, but that this was more effective when incorporated with other intervention components (such as telephone counselling, goal setting and self-monitoring). In this study, the Fitbit was found to encourage individuals to set targets and goals, motivating them to achieve these through the feedback received and the ability to monitor what they were doing. Goal setting is a widely acknowledged and accepted strategy for promoting physical activity [50], and the National Institute for Health and Care Excellence [51] state that goal setting should be present in any type of intervention looking to change behaviours. The Fitbit's impact went beyond exercise goals, as it was found to influence broader lifestyle behaviours. This suggests a ripple effect, where positive changes in one aspect, such as exercise, cascade into improvements in mood, sleep, and other behaviours. Understanding these interconnected effects could guide the design of comprehensive lifestyle interventions.

Participants expressed some barriers to undertaking exercise with a common theme being due to bad or unfavourable weather, which aligns with prior research [52]. Participants don't just view poor weather as a logistical challenge but express an emotional aversion to unfavourable conditions. Exploring the emotional impact of weather-related barriers on motivation and exercise adherence could offer insights into tailoring interventions to address emotional as well as practical aspects of engagement. Investigation is required as to how the Fitbit could play a role in mitigating this barrier, and whether Fitbit features or notifications tailored to weather conditions could enhance motivation and exercise.

The Fitbit was a good way for many participants to check, monitor and validate their sleep. For some it just provided them with knowledge and understanding about their sleep and sleep patterns; for a small proportion it also fa-

cilitated the implementation of healthier lifestyle actions such as better sleep habits and routines, going to bed earlier, and refraining from using phone and computer screens in the period immediately before sleep. It is becoming recognised that there are several potential benefits of using wearable sleep trackers, including that they enable easy accessibility to information about sleep and other behaviours, in an individual's own natural environment, for extensive periods, providing data that can be collected at any time with little active engagement from the individual (just need to wear the device), and providing data in summary form [32].

In the current research, the Fitbit was mostly used for information gathering and checking, so perhaps participants could be directed or taught on how to utilise this information to facilitate behaviour change and implement good sleep hygiene. Liang *et al.* [53], identified that there is limited support to help individuals make sense of sleep data they receive, so designed a web-based tool (*SleepExplorer*) to remedy this, finding that the visualisations of sleep data and contextual factors (exercise, mood, caffeine consumption) helped individuals make sense of their data, and guided them in taking actions to improve their sleep. In addition, participants did not engage with the information sheets about sleep hygiene and exercise so this also needs to be remedied; it might be that information needs to be discussed more in face-to-face interactions, reiterated over the course of using the Fitbit or could be incorporated as part of a web-based tool, like *Sleep Explorer* [53] and offered as part of the intervention.

The Fitbit was a tool that could promote and encourage social interactions, all of which were found to be beneficial. The information that the Fitbit provided was shared with other people to open conversations to support useability and engagement and attend to other potential health issues. Participants' partners were found to look at the watch and help with monitoring. This unique aspect suggests that wearable technology can not only empower individuals but also actively involve their support networks. Therefore, understanding the dynamics of partner involvement through technology could be pivotal in designing effective interventions. Involving partners also promotes accountability, which has been found to increase effort, and when fitness goals are made public or shared and they require some form of accountability (i.e., in this case sharing of Fitbit data) it can increase physical activity [54]. Outdoor activities, interactions with others, and the sense of community contributed to overall wellbeing. Next steps should investigate features or functionalities within Fitbit that contribute to the sense of community, potentially enhancing its role as a holistic wellbeing tool beyond exercise tracking. Finally, in the current research, the data was used by the participants to share with health professionals to open conversations about other physical health issues (e.g., diabetes) and discuss these to address them. Patients therefore become more active users of healthcare, not passive consumers. This unique function transforms the Fitbit from a personal tracking device into an information communication tool, positively influencing patient and healthcare

provider interactions and treatment plans.

Limitations

Participants were recruited from memory assessment services in one NHS trust, and were a relatively small purposive sample, thereby limiting the generalisability. However, generalisability of qualitative research findings is normally not an expected attribute [55], so instead credibility, transferability, dependability, and confirmability of the data [40] was sought. Participation was voluntary and those who agreed to participate, on a self-selective basis may introduce bias in that they are potentially more likely to have had a positive experience; the data didn't capture those who did not engage with the service and/or dropped out and who may have offered a different perspective. This includes those who felt they could not take part in the study as they didn't feel able to make use of the technology or were not comfortable using devices such as Fitbits. In addition, it was beyond the scope of this paper to examine the direct impact of the intervention on memory, focusing on impact on areas that could be associated with ways to help and support memory (i.e., exercise, sleep), and so this needs addressing in ongoing research.

5. Conclusion

This research has found that there is benefit in offering individuals who are experiencing age-related cognitive impairment or who have been diagnosed with MCI, a healthy lifestyle intervention to facilitate and promote engagement with exercise and better sleep hygiene and routines. Active Feedback offers a suitable structure for delivery of a healthy lifestyle intervention. Active Feedback encouraged individuals to understand the role of exercise and sleep in their lives, and to use wearable tracking technology (Fitbits) to encourage positive healthy lifestyle changes. This was found to be beneficial in relation to mental and physical health and wellbeing—which could in turn have positive impact on cognitive function memory; this warrants further exploration to examine for causal relationships. Active Feedback can be integrated into memory assessment services to have positive impact on wellbeing, mental health and physical health, and enable these services to deliver healthy lifestyle interventions, something that is currently high on the agenda for national governments and health services.

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Conflicts of Interest

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

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