"You can go out 14 miles away with the knowledge that you've got the battery to help you back if you need it!" Narratives of ranging behaviour and wellbeing in diaries of e-bike trial participants

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RESEARCH ARTICLE

"You can go out 14 miles away with the knowledge that you've got the battery to help you back if you need it!" Narratives of ranging behaviour and wellbeing in diaries of e-bike trial participants

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This paper draws on data from a large UK study that aimed to understand cycling among the older population and how this affected independence, health, and wellbeing. Part of the study involved an 'e-bike trial' where participants aged 50 and over, who were returning to cycling after a hiatus, were loaned an e-bike for an eight-week trial period. *Pre-trial* and *post-trial* cognitive tests of trial participants, reported previously (Leyland et al., 2019), demonstrated how e-bikes provide positive benefits to cognitive function and wellbeing. The paper builds on these findings, drawing specifically on the qualitative component, predominantly biographical interviews, written material, and visual material provided in rider diaries and a focus group discussion, to understand the reasons for this positive impact.

The findings demonstrate how power assistance can provide riders with the opportunity to extend the distance and types of area they are willing to cycle from their homes (their 'ranging behaviour') and how this can promote health and wellbeing. Our evidence suggests that e-bikes have the potential to support cycling for leisure as well as everyday travel and that consideration should be given to the positive effects of e-cycling on mental wellbeing in addition to physical activity. This is pertinent in the context of an ageing society, the push towards zero-emission cities, and the need to ensure socially inclusive mobility, particularly in the context of the Covid-19 global pandemic.

Keywords: e-bikes; ageing; wellbeing; social inclusion; qualitative approach

Introduction

Cycling is regarded by many as a solution for providing efficient and effective urban mobility, in terms of its contribution to reducing the negative environmental consequences of motorised transport while also promoting health through 'active travel' (Buehler and Pucher, 2021). However, over the last two decades, levels of cycling in the UK have remained stubbornly low relative to other northern European countries such as Denmark, Germany, and The Netherlands (Pucher and Buehler, 2008). Since 2002, the overall number of cycle trips has remained flat accounting for only 2 per cent of all journeys made (average 17 trips per person per year) while the average distance cycled has increased by 50 per cent (average 58 miles per person per year) over the same period (UK DfT, 2018).

The growth in market for electrically power assisted bikes, more commonly known as 'e-bikes' (and 'pedelecs'), could help to increase cycling uptake in the UK and diversify participation. E-bikes are essentially regular pedal cycles with the addition of an electric motor and battery that provide power assistance on condition that the rider also pedals (MacArthur et al., 2014). Although they account for only a fraction of all UK bike sales by volume (around 4 per cent), sales have continued to rise by around 40 per cent year on year equating to around 100,000 e-bikes in 2019 (Mintel, 2020). Furthermore, according to industry experts, e-bike sales across Europe, including the UK, continued to grow during the Covid-19 crisis and are projected to grow from around 3.4 million, sold in 2019, to 13.5 million, by 2030 (Heinrich-Böll-Stiftung, 2021).

In the United Kingdom e-bikes are regulated at 250-Watt maximum continuous rated power output providing a maximum speed up to 25 kmh (15.5 mph) per hour and a range of up to 100 km between charges. Over half (58%) of car journeys in the UK in 2018 were reportedly under five miles (eight kilometres) and four-fifths of journeys were under 10 miles (ibid.; UK DfT, 2018). It is often pointed out that journeys up to five miles are perfectly suited to cycling and could replace journeys currently made by car (Neves & Brand, 2019). E-bikes could make cycling accessible to people who would not otherwise contemplate cycling five miles, particularly in hilly areas, or who find difficulty partaking in regular pedal cycling for health or other reasons. While average cycling trips per year in the UK has stayed constant between 2002 and 2018, average cycle journey distance per year has increased by 50 per cent from 39 to 58 miles but still represents only one per cent of all distance travelled by all modes (UK DfT, 2018). E-biking could support longer distance cycle journeys, for example, between urban centres and outlying towns and villages where (in the UK) an older demographic is more common, and contribute to increasing overall mode share. Despite the misconception that e-bikes are 'cheating' (Jones et al., 2016), riders are still required to pedal, albeit with power assistance. E-biking could, therefore, help riders incorporate moderate exercise into everyday travel routines (Gojanovic et al., 2011; Louis et al., 2012; Sperlich et al., 2012). In environmental terms, replacement of car journeys with journeys by e-bike could contribute to a reduction in traffic congestion and air pollution because they place less demand on road space and produce zero emissions whilst in operation (Ji et al., 2012).

There are counterpoints to the benefits of encouraging e-biking in transport and health terms. First, is the fear that e-biking does not fit with an 'active travel' agenda because of the potential to wean people away from 'healthier' conventional cycling rather than tackling car use (Dons et al., 2018). Second, that e-biking can increase potential risk of traffic injury to riders or other road users unaccustomed to their higher speeds (Du et al., 2013; Papoutsi et al., 2014; Schepers et al., 2014; Yang et al., 2014). And third, that promoting e-biking could distract authorities from focusing on implementing good quality cycling infrastructure and measures that reduce road danger for cycling such as discouraging motor traffic on city streets and enforcing stricter speed limits (Whitelegg, 2013).

Despite these concerns, emerging evidence has demonstrated that e-biking can make a positive impact in terms of replacing journeys by car and supporting engagement in physical activity. For example, a recent scoping review of studies on the impact of e-bikes on travel behaviour suggests that the personal use of e-bikes is associated with a reduction in motorised vehicle use and the most frequently cited benefit was the opportunity e-bikes provide for riding longer distances than on a conventional bicycle (Bourne et al., 2020). Furthermore, a recent before-and-after study has also demonstrated that those who purchased an e-bike increased their cycle use by an order of four and their (e-)cycling mode share by between 17 and 49 per cent as a proportion of overall travel, compared to a control group (Fyhri & Beate Sundfør, 2020).

In terms of health outcomes, a systematic review by Bourne et al. (2018) identified moderate evidence that e-cycling provided physical activity of at least moderate intensity and concluded that e-cycling can contribute to meeting physical activity recommendations and increasing physical fitness. And countering the often-raised concern that e-biking may result in a substantial reduction of physically activity for traveling due to a reduction in required physical effort, Castro et al. (2019) found that physical activity from travel-related activities is similar when comparing physical activity levels of e-bikers and conventional bicycle users across Europe.

In relation to the risk of e-cycling vis-à-vis conventional cycling, Schepers et al. (2020) have reported that, after controlling for bicycle use, e-bike users are *not* more likely to be involved in a crash or to sustain severe injuries, although older female cyclists did have an elevated risk on e-bikes. Fyhri et al. (2019) have also identified that the overall accident risk for e-bikes vis-à-vis conventional cyclists is higher but only for female cyclists and that this is related to the higher prevalence of accidents resulting from balance problems.

Evidence of the potential of e-bikes to tackle issues associated with the environment and health has started to gain traction among UK policy makers. In June 2020, the UK government published, *Gear Change: A bold vision for cycling and walking.* This highlights how the restrictions put in place to mitigate the Covid-19 pandemic, and the corresponding rise in cycling, provide 'a once in a generation opportunity to permanently transform how people move around' (UK DfT, 2020, p8). The strategy commits government to establishing a national e-bike support programme noting: '[electrically-assisted bikes] could be hugely important in our goal of bringing non- traditional groups to cycling including older and disabled people. We will establish a national e-bike support programme, which could include loans, subsidies, or other financial incentives, using the learning from other schemes in the UK and abroad for e-bikes, adapted e-bikes and other e-vehicles' (ibid., p39). Reports suggest that the government is considering subsidising the purchase of electric bikes to encourage uptake (Norman, 2020). The growth in popularity of e-bikes and signalled support from central government is prompting municipal authorities to consider where e-bikes fit within wider policies to promote sustainable mobility and on requirements for planning and designing cycle infrastructure. In January 2017, for example, Transport for London (TfL) held its first e-bike summit at City Hall to explore the role of e-bikes in encouraging more people to cycle and how it could work together with the e-bike industry to support the use of e-bikes in London. The result was the launch of a website to encourage the uptake of e-cycling among Londoners through incentives such as discounts and improved access to e-bikes (TfL, 2018).

This paper draws on data from a large UK study that sought to understand (e-)cycling among the older population and how this affected independence, health, and wellbeing. Part of the study involved an 'e-bike trial' where participants aged 50 and over, who were returning to cycling after a hiatus, were loaned an e-bike for an eight-week trial period. *Pre-trial* and *post-trial* cognitive tests of trial participants, reported previously Leyland et al. (2019),

demonstrated how e-bikes, provide positive benefits to cognitive function and wellbeing. This paper builds on these findings, drawing specifically on the qualitative component, primarily written and visual material provided in rider diaries and a focus group discussion, to understand the reasons for this positive impact. This information is important for informing future e-cycling initiatives and we discuss the implications for policy and practice.

Approach and Methods: The UK cycle BOOM Study

The large-scale UK Research Council–funded study cycle BOOM ran from 2013 to 2016. A key objective of the study was to develop a better understanding of how the design of the built environment and technology shapes engagement with and experience of cycling as people get older and how this affects their independent mobility, health, and wellbeing (Jones et al., 2016). To achieve this, a mixed-methods approach was adopted. This included biographical interviews with people aged 50 and over about their cycling histories to understand how ability and willingness to cycle is shaped by life course experiences and events; mobile observation and video elicitation interviews to capture everyday experience of and engagement with cycling in the outdoor environment; and finally, a quasi-experimental study in the form of a cycling and wellbeing trial (CWT), which is the focus of this paper. The CWT was conducted with new or returning cycle users and aimed to investigate whether pedal and electrically assisted cycling in the outdoor environment improves cognitive processes and wellbeing in terms of feeling better, happier, and more engaged with life. Our previous paper Leyland et al. (2019) reported the quantitative analysis of pre-trial and post-trial cognitive tests with trial participants and demonstrated the positive impact of e-biking in an outdoor environment on cognitive function and mental health. This paper focuses specifically on the qualitative findings that were generated during the CWT to understand the reasons for this positive impact. This was achieved through the analysis of diary accounts of e-bike participants who took part in the trial and a follow-up focus group.

Participants for the CWT were recruited using advertisement in the local press and at shopping and community centres in Oxford and Reading, UK. The advert stated that those eligible should be aged 50 and above; either new or returning to cycling (i.e., had either done no cycling in the past five years, or that their cycling had seriously diminished over that period); and willing to commit to using a loaned e-bike for at least three times a week for 30 minutes over an eight-week period. Those who responded to the advert were asked to complete a short screening questionnaire. A purposive sample was carefully selected to ensure a balance of males and females from different socio-economic backgrounds who were living in both urban and peri-urban locations.

Prior to commencing the trial, an accredited Bikeability cycle trainer (https://www.bikeability.org.uk/) assessed participants to determine whether they had the ability to cycle safely on the public highway (Bikeability Level 2 status) and to provide necessary support and training to ensure they met this standard. All participants passed the assessment before being loaned an e-bike for the eight-week trial. Instructions did not stipulate where, when or with whom their e-cycling should take place. A total of 38 participants took part and were aged between 50 and 82 years (Mean 61.9; SD = 7), twenty of whom were female. The trial took place on a rolling basis from August 2014 to December 2015 and therefore incorporated seasonal contrast.

At the beginning of the trial, a semi-structured biographical interview of approximately one hour was conducted to understand participants' cycling throughout the life-course (Chatterjee et al., 2012; Lanzendorf, 2010). During the eight-week trial, participants were asked to keep a 'Diary of Cycling Experience' (DoCE) where they were able to record basic journey characteristics in a tabular format (i.e., timing, purpose, locations, how they used power assist) (see **Figure 1**) as well as being provided with space to write brief notes about

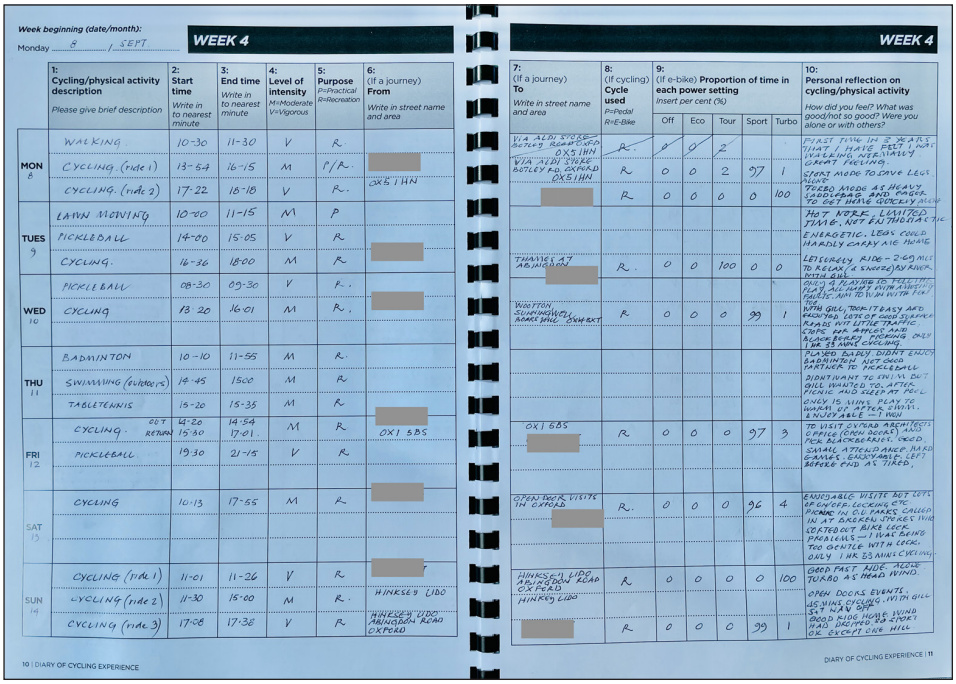

Figure 1: Diary of Cycling Experience (DoCE).

their experience. For each diary week, a blank A4 page was provided where participants were asked to volunteer their reflections on their experience in whichever format they wished (e.g., text, photographs, sketches). The aim was to enable more extensive, emotional, and embodied qualitative data to be generated that would potentially provide researchers with an insight into participant's wellbeing as the trial unfolded (Jacelon and Imperio, 2005; Milligan, Bingley, and Gatrell, 2005). Shortly after the trial, Oxford Brookes researchers invited Oxford participants to take part in a focus group at Oxford Brookes University to investigate shared cycling experiences. Seven were able to take part.

Biographical, diary and focus group analysis was undertaken by authors Jones and Spencer. This involved compiling biographical summaries, separate accounts of individual DoCE entries from all 38 diaries, and transcription and analysis of the focus group discussion. The act of analysis involved complete immersion in the data by the authors and a process of constant comparison. This closeness to participant data allowed discussion, reflection, and convergence upon what were identified as shared definitions and significant key themes. Adopting an idiographic approach that recognizes the unique and subjective experiences of participants, we selected six participants who provided significant insight into their e-bike experience. Particular attention was given to the location and types of journeys recorded in the six participants' diaries – their 'ranging behaviour' – and the written accounts of how e-bike experience unfolded over the trial period. The six participants also agreed to publicly share their experience through a series of video vignettes (available at https://www.cycle-boom.org/video/). Many of the themes that emerged were discussed and corroborated at the focus group discussion.

Joint thematic analysis was aided by using QSR NVivo version 11 (Braun and Clarke, 2006). Ethical approval for all components of the research was obtained from the University of Reading Research Ethics Committee (Registration No: 14/31) and Oxford Brookes University Research Ethics Committee (Registration No: 140813).

Results

Records of cycling activity in the DoCE established that e-bikers (n = 38) spent, on average, 2.39 hours (SD = 0.90) cycling each week[1] – an average of just over 60 minutes of what was requested of them. They also reported spending, on average, 15 per cent of their time cycling with power assist switched 'off'. **Figure 2** provides an illustration of participants' level of engagement with the trial in terms of average duration of cycling activity per week.

Findings from the quantitative component of the cycling and wellbeing trial, reported in Leyland et al. (2019), measured the impact of cycling (both e-biking and conventional pedal cycling) on cognitive processes and wellbeing. This highlighted increases in self-reported mental health and wellbeing and improved cognitive function, particularly among e-bike participants. We suggested that these results may have been related to the novelty factor of loan of an e-bike and the opportunity this provided for participants to get outdoors.

To understand the reasons for this positive impact more fully, in this section, we report on participant experience of e-biking from the analysis of participant diaries (n = 38) and further in-depth analysis of qualitative data generated from six completed participant diaries, and their corresponding biographies, as well as the subgroup of seven participants who took part in a focus group discussion. We focus on themes that emerged within three broad topic areas: (a) motivation and preparation for taking part in the e-bike trial (b) how e-bikes were used and the types of 'ranging behaviour', and (c) how this impacted wellbeing. Most participants

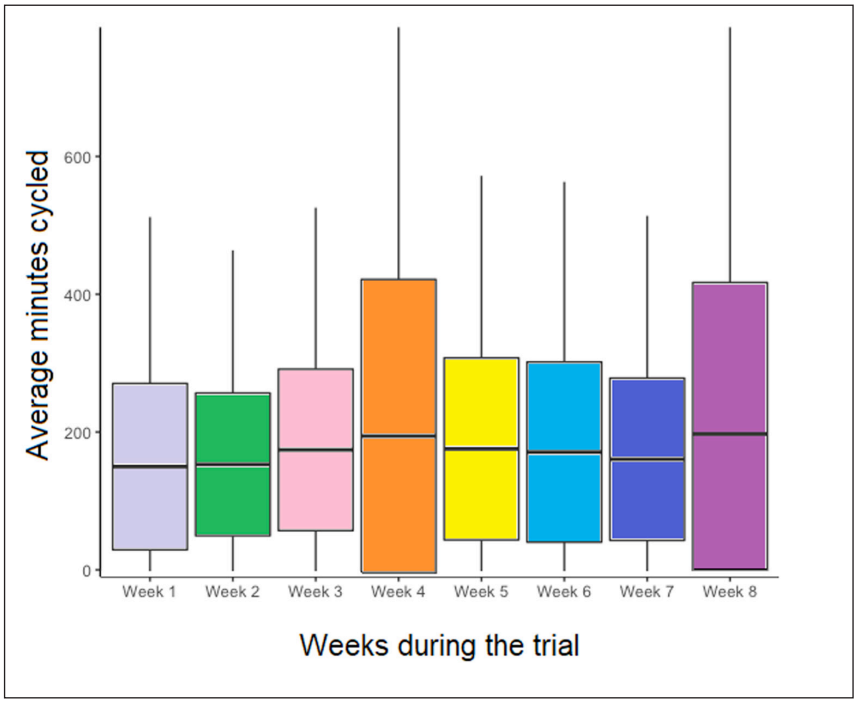

Figure 2: Average duration of cycling per week over the eight-week trial across all participants. n = 38.

[1] Records of cycling activity in DoCE established that e-bikers spent marginally more time cycling on average each week (M = 2.39 hours, SD = 0.90) than pedal cyclists (M = 2.07 hours, SD = 0.59) ($t(72) = 1.80$, $p = 0.076$).

represented in this article gave permission for their real name to be used and where this was not the case, pseudonyms have been used. **Box 1** provides brief vignettes of the six participants' 'cycling trajectories' over the life course from biographical interviews and the impact of the trial on their mobility and wellbeing.

Box 1: Participant Vignettes.

Brian (and Gill) Oxford. (See https://www.cycleboom.org/video/brian-hook/) Brian, in his 80s, and his partner Gill, had lived together in Abingdon, near Oxford, since 2012. Brian was born and grew up in Oxford and cycled extensively when younger for transport and sport. He worked for Oxfordshire County Council as a buildings officer, mostly commuting by bike until retiring in 1990. Since then, Brian had cycled locally on shopping trips and he and Gill had done a variety of regular local rides together for pleasure and for transport, often travelling up to 24 miles, mainly on cycle paths. They also took their bikes by car or train to more distant UK locations on holidays. They were generally very active, swimming and playing ball games. Brian's cycling had been curtailed more recently by time constraints of playing sport, a busy family life and a knee problem which made cycling painful, slowing him down. For Brian, the e-bike had made cycling enjoyable again. He found it comfortable and 'thrillingly fast to ride', without suffering any knee pain and still getting useful exercise. The e-bike replaced short car journeys and allowed he and his partner to venture further afield together, revisiting old haunts and discovering new places, safe in the knowledge that the battery would help him return home from longer trips if tired. Brian's partner also reflected on the significant positive impact e-biking had on Brian's overall wellbeing. Brian and his partner went on to purchase e-bikes after the trial.

Val, Oxford. (See https://www.cycleboom.org/video/val-scatchard/) Val, in her 60s, was retired and lived in the outskirts of Oxford with her husband. She had grown up in Oxford before going to London to do nursing training and then got married at 21 and moved to Southampton to work at the hospital where she drove to work. Val had lived in several places during her career and, although she had cycled to work when she had the opportunity to do so, she had stopped cycling several years previously and mainly used the car to get around. Val's reasons for getting involved in the e-bike trial were prompted by health issues which had limited her activities significantly in the last few years. These were a shoulder injury which took about two years of treatment and rehabilitation and elective surgery to correct foot defects. She considered those issues resolved but this had meant she had put on weight and was not as physically fit as she would like to be. She saw the study as a way of helping her get back into cycling for local trips, for example, to the swimming pool. Val expressed enjoyment and sometimes 'exhilaration' riding the e-bike. After initial anxiety, she gained confidence and found the e-bike more beneficial to her safety riding in traffic because of her ability to accelerate away from junctions and maintain momentum. She also appreciated the e-bike in tackling hills, and in seeking out new routes, she discovered new geographies and replaced journeys she says she would have otherwise made by car. Her only frustrations were carrying her shopping and cycling accessories when visiting multiple places/outlets and dealing with the plummeting temperatures during the trial which affected her hands and toes.

(Contd.)

Jon, Oxford. (See https://www.cycleboom.org/video/jon-cameron/) Jon, in his 60s, retired in 2008 and moved to a small village to the East of Oxford in 2013, where he was rebuilding a cottage shared with his partner. He had cycled extensively when growing up and had been given a Raleigh bike for passing his eleven plus exams. He recalled using the bike to go to school and to roam around with his brother and friends. Jon continued to cycle to school until it became 'uncool' and he graduated to bus, moped and then car. He had passed his driving test at 17 and had driven cars ever since describing himself as a 'bit of a car freak'. The only cycling he had done was while on holiday in the Channel Islands with his wife and with his son to teach him to ride. Jon had developed diabetes because of being overweight and had decided to retire from being an IT consultant to concentrate on his interests. Prior to the trial Jon did not own a bike. He had been advised by his doctor that he could improve his health by exercising and losing weight and thought the wellbeing trial was a good way of trying out cycling as exercise without any outlay. Jon described the enjoyment he got from using the e-bike, the benefits of the steady exercise, but also, on the flip side, how he was shocked by the poor state of cycling infrastructure and how vulnerable he felt at times while riding. He also described the challenge of riding in poor weather, some of the problems he faced operating the e-bike, and his shock in finding out how expensive e-bikes were to purchase.

Deborah, Oxford. (See https://www.cycleboom.org/video/deborah-ajulu/) Deborah, in her 60s, had been living on her own in sheltered accommodation in east Oxford since arriving as a refugee from Uganda in 1987. After retiring from an academic career, she continued to work voluntarily for a charity implementing community development projects in Eastern Uganda. Deborah learned to ride a bike as a teenager in rural Africa but after moving to Kampala she no longer had access to a bike and used taxis for getting around the city. Deborah gained access to a car when she got married but then left Uganda with her children and separated from her husband. When she arrived in the UK, having three children to transport meant having a car was important to her. Deborah cycled again in her early fifties when she went back to Uganda to work and was given a bicycle, but she only used it two or three times a year to make short journeys. After returning to Oxford in 2011, she no longer had a car. Instead, she bought a bike to enable her to move around more quickly than walking or using public transport, and at the same time, gain some exercise. She was not very confident cycling on the roads and frequently used the pavement but did not feel comfortable doing so. Deborah's cycling stopped one winter when she deposited her bike in the communal store where it fell into disrepair. Deborah was attracted to participate in the study to improve her health and lose weight and partly by the offer of cycle training. Deborah contrasted her e-bike experience with pedal cycles in terms of the additional skills needed to operate it and as well as the difficulty manoeuvring it because of the extra weight of the battery. She described the difficulty she had during the trial trying to ride in the rain while wearing spectacles and an incident where she fell off causing minor injury. Deborah reflected on how, despite this, the e-bike improved her local mobility and was particularly advantageous in helping her to tackle hills.

(Contd.)

Dave, Reading. (See https://www.cycleboom.org/video/dave-thurston/) Dave, in his 50s, lived in a quiet cul-de-sac in Reading with his wife and eldest son. He was recovering from a second heart attack twelve months previously and suffered from fatigue. He had cycled all his life until he became unwell in 2002 and was keen to see if cycling could improve his stamina and fitness. He was currently walking daily and volunteered at a cardio gym but did not own a bike. Growing up, Dave's parents didn't have a car and so they travelled by bike or moped. He learned to ride a bike in the close where he now lived and used a bike a great deal with friends, cycling to local weekly activities. When he and his wife got a car in the 1980s, it was mainly for his wife to go shopping and pick up the children from school. He had used a bike as his main mode of transport until he worked for companies too far away to cycle. Dave got involved in the study to improve his fitness and 'widen his horizons'. He described his preference for the upright riding position of the e-bike because it provided a more comfortable riding position. Dave appreciated the speed and reliability of the e-bike which gave him confidence getting home and led him to purchase one after the trial.

Jo, Reading. (See http://www.cycleboom.org/video/jo-baldock) Jo, in her 60s, had lived on the outskirts of Reading for 35 years and worked in the town centre. She often visited her daughters and sister who lived locally. As a child growing up in Scotland she cycled around the village with her sisters and friends but did not cycle to school as it was too far, instead, she would take the bus. Re-locating to Reading in 1980, she would cycle with her then young children carrying them on child seat attached to her bike. Although Jo taught her children to cycle and rode with them away from roads, she reduced her cycling in the mid-80s as she started to feel unsafe. More recently, she had been gifted a bike by her daughters but was not motivated to use it. Jo hoped the e-bike trial would help motivate her to exercise more and feel better. She described how she took to riding the e-bike quickly and the many benefits it provided in helping her to lose weight, sleep better and improve her balance. Jo's enjoyment from e-biking stemmed from it helping her to 'switch off' and feel more relaxed. Jo reported that aspects that could erode this enjoyment were the dangers of traffic and poor maintenance of cycle tracks. Despite this, Jo went on to purchase her own e-bike at the end of the trial.

Motivation

Across the whole cohort of 38 participants, cycling had featured in childhood and to varying degrees across the life course (Jones et al., 2016). However, it had diminished in adulthood and had been supplanted with other methods of getting around and accessing the outdoors because of changes in life circumstances. Participants generally reported being motivated to take part in the study because the e-bike trial offered a structured programme that enabled them to engage with an outdoor activity that was perceived to be beneficial to health. Typically, a combination of specific reasons was cited including the opportunity to test e-bike technology; lose weight and improve personal fitness and to ride socially with friends or another family member. A significant reason, as exemplified by the biographies of Brian, Val, Jon, and Dave, was a response to personal health issues, particularly physical limitations, and the desire to be more active.

> *I'd heard so much about cycling, it was an activity that you could actually do on your own, that you didn't have to be in a crowd of people. And you could take the bicycle, go*

and do your thing in your own time. And I think that was what appealed to me. That might make me feel motivated to be more active.

Jo, Reading.

I like cycling fast and furious, and really keeping fit that way. But I'm finding I was beginning to ease off a bit. And I could only do about six miles an hour, going down to the shops, and also, I had a very painful knee as well, I realised that possibly an electric bike would be useful to me, it makes life a lot easier.

Brian, Oxford.

I thought it was something that would appeal to me because I was recovering from a second heart attack. And I was suffering with a lot of fatigue…instead of being able to do just small circles, and ever decreasing circles, I could expand where I could travel to, and I know, confidently, that I could get back by putting on full power with not too much effort from myself. And I could widen my horizons, which really did appeal to me.

Dave, Reading.

Preparation

The Bikeability cycle assessment and skill development programme, which participants undertook as a condition of taking part in the study, was overwhelmingly regarded as important in helping understand how to operate an e-bike and to (re)gain confidence cycling. This was the case even among several participants – mostly male – who had expressed reservations about the need for training as they felt they already possessed the necessary cycling skills. In preparation for their eight-week trial, participants often reported investigating opportunities for cycling near their homes using paper maps and online mapping. Some purchased clothing and equipment, such as high-visibility jackets, to improve their feeling of safety or comfort or did so later in the trial.

I decided to get used to the bike and cycling by staying near home and out of the city centre. I realise my confidence needs improving.

Val, Oxford.

Ranging behaviour

During the initial weeks of the trial, participants generally recorded how they prepared and planned for journeys by testing the e-bike on local streets. Most completed shorter rides in familiar areas close to home, typically off-road, and sometimes accompanied by a partner or friend. Diary accounts revealed how, as the weeks passed, participants' confidence grew and their 'ranging behaviour' extended as they rode their e-bike for lengthier periods and discovered new routes. Accounts often included descriptions of finding low trafficked alternatives to busy main roads and traffic-free paths through urban areas and open countryside. Increasing confidence was often remarked upon in terms of feelings of improved riding ability and determination to explore unknown routes in the knowledge power assist was available if topography became challenging or tiredness set in.

Events that stymied rides included ill-health (typically colds and flu) and on rare occasions, minor injuries from falls (see accounts below of Brian, Deborah, and Jon). For some participants, poor weather, anxiety riding in areas with busy traffic, and lack of good quality supportive infrastructure could be a disincentive to go out or extend the range of their cycling activity.

Below we expand discussion of the ranging behaviour of the six participants over the trial period (touched on previously, in **Box 1**, participant vignettes) before we highlight how this supported (and detracted) from positive wellbeing. **Table 1** provides a summary of how participants' rides unfolded over the eight weeks and **Figure 3** provides illustration of their ranging behaviour from written entries in their diaries from their home location in the Oxford and Reading areas. Where the actual route travelled was not clear, a heuristic was employed identifying the only possible route, or where there were multiple route options, the route recommended by Google Maps cycling direction algorithm was plotted.

Brian made a series of solo and joint rides with his partner *Gill* around their local area during the first week – Gill had bought an e-bike in advance of the start of the trial in anticipation of riding together. These increased in length and duration. In week two they reported cycling to Oxford and back instead of using the car and experimented with different routes. Brian also completed a 24-mile return journey to Wallingford and ended the week with a *'good hard ride'* around the local area. In weeks three and four, Brian went on local rides around Abingdon, Wallingford, and Oxford with Gill and completed longer solo rides to smaller neighbouring villages. Some days they did multiple rides, and these were often combined with sports and cultural activities. Both had minor falls from their e-bikes, during the first half of the trial, but they both reported that none were too serious to warrant stopping riding. In weeks five and six, they extended their rides during warmer evenings to a wider set of local villages chancing new off-road routes that were sometimes blocked by stiles and gates. At the beginning of week seven, Brian experienced some misfortune when he had a puncture and had to walk 1.5 miles home. This meant his e-bike was out of action for a couple of days. When his bike was finally repaired, he stuck to local journeys to ensure all was working properly, before going on a two-hour solo ride to 'fill in' new sections of local roads he had not previously ridden (**Figure 4**).

By this point Brian has noted in his diary how he was anticipating reaching the 500-mile mark since the start of the e-bike trial and how he and Gill were using power assist to cycle faster. Brian's ultimate ride during the final week of his trial was what he described as an 'Abingdon mystery tour', which involved meandering through areas he had not visited before. At the end of the trial, he calculated that he had ridden a total of over 540 miles and commented, 'I would never have achieved this on my push-bike, nor even contemplated doing the journeys I have done'. Both he and Gill summarised the possibilities that e-biking had opened to them as a couple:

> *You can also go out somewhere, you know, maybe 12 miles, 14 miles away, and you've got that knowledge that the battery is there to help you back a bit if you need it.*
>
> Brian, Oxford.

> *[The e-bike(s)] Enabled us to venture out further, much further, and easier than, you know, we would have done otherwise [on pedal cycles]. We knew when went to Wallingford we had a bit of assistance to help coming back, without thinking,*" Oh, I've got 12 miles of slog to get back home". *We are now looking at electric bikes as he [Brian] has to have one to keep up with me and also to keep us fit, interested and active for the next 10 years or so – hopefully!*
>
> Gill, Oxford.

Val started her first week with a couple of short recreational rides and a short practical round-trip of three miles from her home and to the local shops in West Oxford. She noted how she lacked confidence on the roads resulting in her staying close to home and avoiding

Table 1: Summary of Participant Engagement with E-bike Trial.

Participant/ Location/Trial period	Week 1 & 2 E-bike activity duration (hours) Activity/key events	Week 3 & 4 E-bike activity duration (hours) Activity/key events	Week 5 & 6 E-bike activity duration (hours) Activity/key events	Week 7 & 8 (& 9 where applicable) E-bike activity duration (hours) Activity/key events	Ave. e-biking activity duration per week Total duration over trial (Hours)
Brian Oxford Aug-Oct 2014	Wk1: 10.56hrs | Wk2: 8.92hrs Made series of solo and joint rides locally increasing in duration. Week 2: joint cycle to Oxford and back. Solo 24 mile return journey to Wallingford. Completes week with a 'good hard ride' locally.	Wk3: 10.28hrs | Wk4: 22.17hrs Mixes local rides with partner around Abingdon and to Wallingford and Oxford with longer solo rides. Multiple rides some days. He and partner have minor falls.	Wk5: 12.18hrs | Wk6: 11.42hrs Extended riding to a wider array of local villages exploring new routes and sometimes backtracking because of blocked access.	Wk7: 1.7hrs | Wk8: 8.93hrs Wk9: 2.48hrs Puncture and bike out of action for a couple of days. Recommences with solo ride to 'fill in' new sections of local roads not previously ridden. Using power assist to cycle faster. Finishes the week with a solo 'Abingdon mystery tour'.	Ave. 9.85 hours p/w Total. 88.65 hours
Val Oxford Oct-Dec 2014	Wk1: 1.92hrs | Wk2: 3.28hrs Reconnaissance ride around home area trying to avoid main roads. Week 2: running errands and shopping in Botley area approx. 2.5 miles from home at top of long hill in Cumnor village.	Wk3: 2.97hrs | Wk4: 1.78hrs Local recreational rides near village and shopping trips in Botley area.	Wk5: 2.5hrs | Wk6: 1.92hrs First ride during dusk. Longest ride from home to Temple Cowley shopping area, Oxford – approx. 8 miles. Developed head-cold – time off e-bike. Some local recreational rides near home.	Wk7: 2.62hrs | Wk8: 1.37hrs Local recreational rides near home. Journey from home to Oxford city centre (4 miles).	Ave. 2.29 hours p/w Total. 18.35 hours

(Contd.)

Participant/ Location/Trial period	Week 1 & 2 E-bike activity duration (hours) Activity/key events	Week 3 & 4 E-bike activity duration (hours) Activity/key events	Week 5 & 6 E-bike activity duration (hours) Activity/key events	Week 7 & 8 (& 9 where applicable) E-bike activity duration (hours) Activity/key events	Ave. e-biking activity duration per week Total duration over trial (Hours)
Jon Oxford Sep-Nov 2015	Wk1: 2.05hrs | Wk2: 1.65hrs Initial journeys along A40 segregated cycle track from home in Forest Hill to east Oxford – approx. 4.5 miles. Week 2: Develops a head cold. Time off e- bike.	Wk3: 4.27hrs | Wk4: 3.72hrs Mainly journey from home to nearby villages and shops in east Oxford along A40 cycle track. Longest journey from home, approx. 6 miles.	Wk5: 2.08hrs | Wk6: 2.83hrs Journeys to nearby local villages and to Doctors <2 miles from home in Wheatley.	Wk7: 1.58hrs | Wk8: 3hrs Wk9: 2.17 Further journeys to shops in east Oxford and Doctor's in Wheatley. Becoming more frequent during final week,	Ave. 2.59 hours p/w Total. 23.35 hours
Deborah Oxford Jul-Sep 2015	Wk1: 0.48hrs | Wk2: zero Initial journey of approx. 2 miles from home in Iffley Road area to church and back. Week 2: Falls off, injures knee. No cycling.	Wk3: zero | Wk4: zero Time off bike for recovery from fall.	Wk5: 0.13hrs | Wk6: 1hr Cycled to park to practice/ regain confidence. Rode longest journey – approx. 3 miles – to leisure centre from home. Local journeys <2 miles,	Wk7: zero | Wk8: 1.25hrs Wk9: 1.25hrs Torrential rain during week 7 – reverted to walking/ bus. Final weeks: Local journeys <2 miles	Ave. 1.08 hours p/w Total. 5.4 hours
Dave Reading Nov-Jan 2014/15	Wk1: 2.08hrs | Wk2: 1.75 hrs First ride in fair weather, couple of recreational journeys along the Thames Path near home, Week 2: couple of 20-30 minute journeys including first ride in the dark for 25 years.	Wk3: 5.73hrs | Wk4: 3.27hrs Starts to feel more confident and travel further afield rediscovering past routes. Still enjoys e-biking despite extreme cold.	Wk5: 2.33hrs | Wk6: 2.75hrs Integrates e-biking with family commitments over the festive period. Continues trips to river.	Wk7: 2.92hrs | Wk8: 3.87hrs Wk9: 2.28hrs Continues to enjoy e-biking by river. Rode further, to Woodley (5 miles) and Emmer Green (3.5 miles) despite	Ave. 2.99 hours p/w Total. 26.98 hours

(Contd.)

Participant/ Location/Trial period	Week 1 & 2 E-bike activity duration (hours) Activity/key events	Week 3 & 4 E-bike activity duration (hours) Activity/key events	Week 5 & 6 E-bike activity duration (hours) Activity/key events	Week 7 & 8 (& 9 where applicable) E-bike activity duration (hours) Activity/key events	Ave. e-biking activity duration per week Total duration over trial (Hours)
Jo Reading Aug-Oct 2015	Wk1: 1.63hrs | Wk2: 1.75hrs Week 1: Performs three 30-minute recreational journeys after work sticking to cycle paths. Week 2: Journey to Twycross, Wargrave and Sonning all <3 miles from home. Getting used to the e-bike and gearing/power assistance.	Wk3: 2.08hrs | Wk4: 1.88hrs Repeats pattern of previous weeks. Establishes regular route. Increases intensity of exercise.	Wk5: 2.25hrs | Wk6: 3.33hrs Continues in the same pattern but cycles a longer journey than normal around local villages.	Wk7: 3.11hrs | Wk8: 1.57hrs Continues in same pattern but started to cycle for longer duration than initial weeks.	Ave. 2.20 hours p/w Total. 17.62 hours

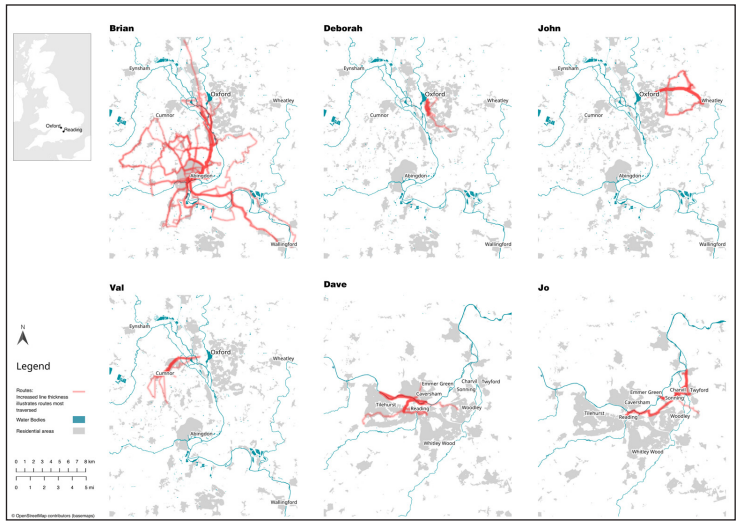

Figure 3: Illustration of ranging behaviour of six participants.

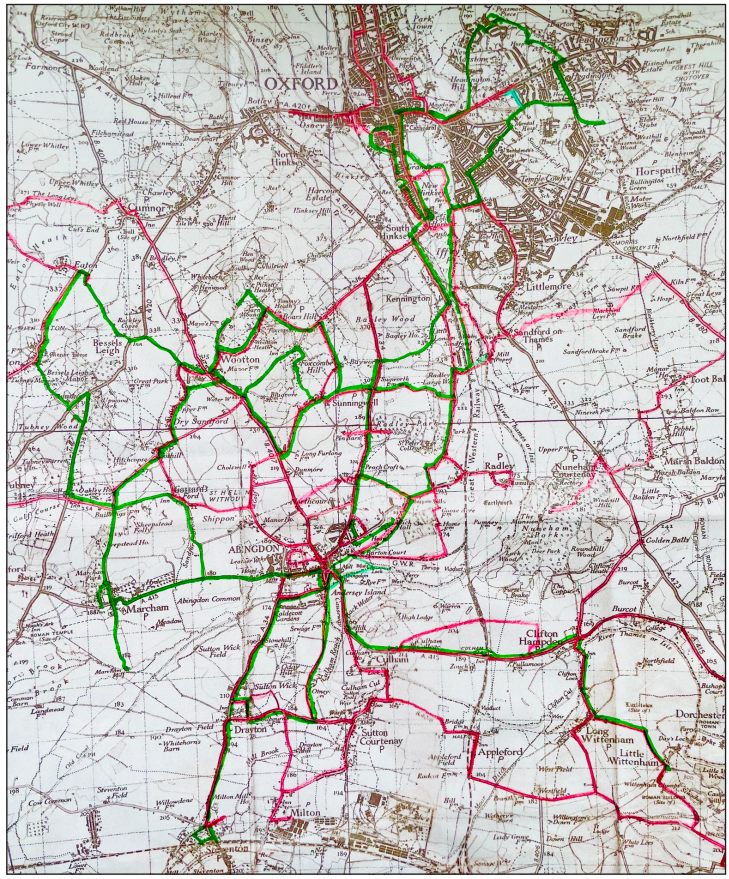

Figure 4: Map highlighting some of the routes Brian and Gill explored. (source: participant's diary).

city-centre traffic. By week two Val had already started to make lots of little errands on the e-bike. By week four, she reported that improvements in the weather meant she was making local errands where she would have previously used the car. Midway through the trial she e-biked into Oxford city for the first time (her longest ride) and reported feeling more confident. Overall, she regarded the e-bike as an asset on hills and for safety in traffic. Her only frustration seemed to be poor weather and having to carry shopping and accessories when stopping at different outlets. All her journeys were performed on her own.

> *Went exploring locally, where [I] had driven past side roads and wondered where it went, don't do it in the car as ridiculous, don't on foot because if you can't get through [you] have to turn back, perfect on a bike, go exploring all over, really enjoyed that, got to know where side roads go.*
>
> Val, Oxford.

Jon had little bit of misfortune at the beginning of the trial. After conducting three thirty-minute practical journeys by e-bike, from his home in a village located just east of Oxford city, he managed to fall off the bike after encountering a slippery surface on a nearby cycle track. He also developed a head cold just as he was getting to grips with riding. After making a full recovery, Jon continued to make journeys along the same cycle track along the A40 that linked the village where he lived to Headington shops in east Oxford. He also ventured along quieter country lanes to nearby villages. Jon described himself as a 'bit of a car freak' and commented negatively on the cycle infrastructure he encountered during the trial. He compared deficiencies in surface quality when using cycle tracks along the A40 to the better-quality road and problems with overhanging vegetation and leaf-fall which gave him 'serious doubts about being able to complete my participation in this project much further into the autumn'. Jon compared his childhood cycling to present-day cycling in a busier traffic environment. He felt that the quality of cycle infrastructure around his home was generally poor which stymied his appetite to cycle more. As a result of taking part in the trial, however, he reported that he was more aware of cyclists when driving his car.

> *Footpaths and cycle tracks are rough and very uncomfortable to use. Roads in general are smoother…cycle paths do not get nearby undergrowth cut back very often. This sometimes results in slippery algal growth. Rainfall and autumn leaf-fall is a dangerous combination as the cycle paths do not get cleaned.*
>
> Jon, Oxford.

Deborah was initially anxious about using the e-bike and conducted her first journey to church, some ten minutes riding time from her home, mostly along the pavement. Unfortunately, during week two, Deborah injured her knee after falling from the bike – she had felt anxious about a bus travelling close behind her and fell as she tried to leave the road and cross the kerb onto the footway – and this meant she was out of action for over two weeks. At the beginning of week five, she managed to undertake 40 minutes cycling off-road on paths in the local park just around the corner from her home to regain confidence. She also made her longest journey – to the local leisure centre a couple of miles from home in the eastern suburb of Oxford – and reflected positively about her achievement. In subsequent weeks, Deborah's journeys continued to be made locally – to the community centre, local shops and to church. She reported feeling 'relaxed' for journeys where she avoided busy roads but feeling 'very involved' where she could not avoid busier areas such as local shopping streets. Overall, Deborah persevered with the trial despite the setback from her tumble that caused her injury

and her anxiety riding in busier spaces. Despite her anxiety and setbacks, she reflected on the benefits of e-bikes compared to conventional pedal cycles once she had learned to cope with handling the bike and its technological features:

> *The fact that I have an e- bike will make it much more attractive to go and it's even more encouraging because you know you have a means for getting there.*
>
> Deborah, Oxford.

Dave's first week of rides were recreational journeys along the Thames Path near his home in Reading when the weather was fine. In week two, he expanded his range by making a couple of twenty-to-thirty-minute journeys on the e-bike. One of these was a journey home from his yoga class in the dark – the first time he had ridden in the dark for 25 years. Dave reported enjoying repeating recreational journeys down on the river path and stated that he enjoyed feeling 'part of a community' of people exercising down by the river. As the trial unfolded, Dave started to make extended recreational journeys to places further afield, including Woodley, Caversham, and Emmer Green (approximately six-mile-round trip) taking in the river paths. He also used the e-bike to make a journey across Reading town centre on a week-day during the rush hour where he appreciated the journey time reliability of the e-bike but not the 'challenge of riding in traffic'. Overall, Dave reflected on how the e-bike allowed him to reconnect to many places he used to ride in his youth.

> *My last week of cycling in the trial. I have clocked up many miles on my e-bike. Had some great times re-visiting many of the places I would have cycled to as a teenager.*
>
> *Now I do it [e-cycling] as a matter of preference. Only take the car now, if [wife] wants to come with me. So, I do as much as I can on the bike or go into town on the bike or go shopping on my bike or go and see friends on my bike.*
>
> Dave, Reading.

Jo made three thirty-minute recreational trips after work from her home in Reading during the first week of her trial. She reported that the traffic was bad and that she 'felt better on the cycle path'. She repeated this pattern over the next couple of weeks generally getting used to the e-bike and gearing and power assistance and making local journeys to Twyford, Wargrave, and Sonning, all less than 3 miles from home. By week four she was repeating the same journeys and reported that her balance and confidence was improving and her levels of anxiety decreasing. After going away for work for a period, Jo returned to cycling and noted how she 'really missed it' while she was away and how it made her 'sleep better and feel more alert'. She also noted how she had 'noticed weight loss'. In week six Jo reported 'really enjoying planning where to go', 'cycling for longer' and 'feeling much fitter'. She made some further recreational trips around local villages and reported becoming ever 'more confident with the bike' and 'using the gearing a lot more' particularly to help her up the hills – which she 'felt guilty' about. By the end of the trial, she had fully mastered the technology and was cycling for a longer period of time and making longer journeys from her home to the centre of Reading along Route 4 and 5 of the Sustrans National Cycle Network.

> *Working the gears and the power of cycle really well. Using them to help just enough to not have to struggle. Last few weeks each journey has been over one hour. A huge increase on first weeks.*
>
> Jo, Reading.

These summaries highlight how ranging behaviour unfolded for our six selected cases and the experiences they reported in diaries (and at the focus group discussion). The ability to use power assist gave riders the confidence to engage in a range of journeys that they may not have otherwise made because of the challenge of hills or distances that they perceived would have been too challenging by regular pedal cycle. These examples also demonstrate that ranging behaviour depends on perceived supportive infrastructure that enables riders to feel safe and confident and journey beyond their immediate home surroundings. While there were obvious cases of participants using the e-bike for everyday journeys, and in some cases, replacing journeys by car with cycling, for the most part, e-cycling was recreational and driven by the desire to get outside and engage with the outdoors for purposes of promoting health and wellbeing – only a few of our participants used e-bikes for commuting. In the next section, we briefly summarise evidence of how e-cycling contributed to positive wellbeing but also the negative aspects that detracted from the overall experience.

Factors that enhanced wellbeing: Satisfaction, accomplishment, and self-esteem

Across the 38 diaries, written narratives were identified where participants expressed either positivity or negativity in relation to events, situations, and interactions, and how this made them feel. A significant positive theme was expressions of growing confidence in using e-bikes and statements around satisfaction and sense of accomplishment. We highlighted above, how the typical trajectory during the eight-week trial was initial trepidation and preparation, followed by experimentation along routes and extended ranging behaviour as confidence grew. Participants' written entries typically conveyed astonishment and sense of achievement at the journeys that they had accomplished that they could never have ordinarily imagined being made by bike (**Box 2**). Often this was reported as appreciation of how e-bike technology gave confidence to reach destinations that were otherwise regarded as unachievable through conventional pedal cycling because of the ability to get home under power assistance.

Participants also reported how e-biking had helped them to *'lift their mood'* either through connecting with personal self or with significant others and with nature and the public. The e-bike provided the catalyst to motivate oneself to get outdoors, and this had a positive effect on self-esteem. Some participants reported what they regarded as positive changes in physical state including improved leg strength and better endurance as well as losing weight. Others reported improvements in their mental state such as feeling more relaxed, enjoying better sleep, and in one case, that their spatial awareness had improved. These were all factors that appeared to have improved participant self-esteem. For example, Sophey, at the focus group discussion, expressed delight that she was able to go further than her usual boundaries, while Brian expressed that he had regained his 'fighting spirit' after a knee problem had previously curtailed his cycling activity something that was evident to his partner Gill (**Box 3**).

Factors that negatively impacted the e-biking experience: Weather, infrastructure, technology

Despite the positive reports of e-biking experience, diary entries often reported how poor UK weather had discouraged going out on the e-bike or made it an unpleasant experience. While some participants endured wet, windy, and cold conditions, this had, in the main, stymied motivation to go out e-cycling as Harvey (60s, Oxford, DoCE) testified, 'Definitely a fair-weather cyclist. Much as I am enjoying the exercise and freedom I won't go out if there is a possibility of rain. Don't like getting wet or having to clean the bike afterwards'. Participants generally reported trying to avoid busy roads and manufacturing their own 'safer roads'. There was consensus about the poor state of cycle infrastructure and expressions of anxiety

Box 2: Satisfaction and sense of accomplishment.

I felt that I'd really accomplished something. If you'd suggested this to me a year ago, I'd have dismissed the possibility of cycling this distance out of hand [14-mile round trip].
Harvey, 60s, Oxford, DoCE.

I feel more confident now with the E-bike. I am discovering that it makes me feel safer using 'Eco boost' in traffic and at traffic lights to get off to a good wobble-free start. It's especially good if on an uphill start.
Val, 60s, Oxford, DoCE.

Brilliant & thrilled! When [the cycle trainer] initiated me on the bike he said, "You could go to Henley!", and I fell about…"dream on!" So today I decided to go and try it! Hooray, did it all, no problem!
Binky, 60s, Reading, DoCE.

I felt pleased that I had managed a 9-mile ride into work and had used a road that I had been nervous to tackle.
Alysia, 50s, Oxford, Focus Group Discussion.

It helps me to get out and about, so I know my limits. And I don't push the limits. But the bike has opened my world up because I can go further…I don't just go around the block. I know I can comfortably go along the river or towards Pangbourne. And I know that I can get back so I can spend time there on the cycle.
Dave, 50s, Reading DoCE.

One of the pleasures is doing it with someone else. Can just get a bike and head off to the gym etc. better motivation if two of us, once she's got bike cleaned up, I've got no excuse!
Brandon, 70s, Oxford, focus group discussion.

when riding on the road, even in Oxford, which has a higher level of cycling relative to other cities in the UK and that has been officially proclaimed as 'a cycling city' by the local authority (Grubb, 2018). Brandon's (70s, Oxford) comment, during focus group discussion, epitomised this sentiment, 'Infrastructure: the most obvious thing if you haven't cycled for a while, is how poor the conditions are for cyclists in terms of availability of cycle paths…even in town I would recommend that people don't use roads… don't go anywhere near main roads, that is the message for a lot of Oxford'. Participants often commented on the weight of the e-bikes vis-à-vis conventional cycles which made manoeuvrability difficult particularly when parking as Brian (80s, Oxford) noted in his diary, '…with weight of bike, got to remain conscious of how heavy. One occasion, went sideways when stationary and was heavy enough to knock me over. Standing there, both feet on the ground, caught my leg, toppled a bit and I was over flat on the ground. So got to remain conscious of how heavy it is and keep it upright'. Despite these factors, participants often conveyed regret in their written diary entries about having to return their loaned e-bike when the trial was complete. While some were fortunate to be able to purchase their own e-bikes, there was general acknowledgment that their relative expense might hinder wider uptake, 'They are always going to be a small end of the market, unless the price comes down phenomenally you are not going to get every cyclist switching to an e-bike because of economics' (Livy, 50s, Oxford, Focus Group Discussion).

Box 3: Health and wellbeing

On Sunday I took the bike out for the afternoon to cheer myself up. Gloomy day but the countryside around is lovely so felt better when I came back!

Alysia, 50s, Oxford, DoCE.

I wasn't using a bike before for a long time. [You are] still using energy and getting exercise and can choose level of assistance. I'm going a lot further already than would have done on bike so "same amount of exercise but more pleasure because going further than my usual boundaries". Idea is to cut down car journeys and to use bike instead, instead of sitting in jams.

Sophey, 50s, Oxford, focus group discussion.

Eventually, as the weeks were going on, I did completely forget that it was a trial, it was so enjoyable. But I did notice that I slept better. I lost weight. I felt that when I came home from work, I actually looked forward to making that time. And before I just wouldn't have made the time, it would have been a drudge to think, "oh, I'm going to a health club or I'm going to the gym". But it didn't become like that.

Jo, 60s, Reading, video vignette.

Spatial awareness, I feel that has definitely improved; noticeably; don't know if it will show in the tests, but that is how I feel, much safer.

Val, 60s, Oxford, focus group discussion.

I have regained interest and fighting spirit which was absent during most of the trial period and before.

Brian, 80s, Oxford, DoCE.

I think Brian became a happier person, and more positive, as a result of his bike trial.

Gill, Oxford, video vignette.

Discussion

This paper has built upon our previously reported findings Leyland et al. (2019) that demonstrated the positive benefits of cycling for cognitive function and wellbeing among participants aged 50 and above who took part in an eight-week cycling and wellbeing trial. By drawing on rich qualitative data to understand e-bike user experience, we demonstrated how e-bikes offered participants the opportunity to overcome personal physical limitations, develop capability and increase confidence, increase knowledge of cycling geographies, gradually extend their 'ranging behaviour', and make journeys that may not have been made by conventional pedal cycle. It was the development of personal capability to (re)discover new geographies and connect with self, others and nature that was significant in providing improvements to physical and mental wellbeing. However, we also revealed the factors that can serve to diminish the e-bike experience. In summary, our qualitative findings were able to help elaborate the quantitative element of our study to reveal the potential mechanisms behind the positive response attributed to e-biking (ibid.).

We revealed how participants were drawn to the e-bike trial for a combination of reasons but primarily because it offered a structured programme to test an e-bike and engage with an

outdoor activity that was perceived to be beneficial to health or to overcome health related issues. Although cycling had commonly featured in childhood, it had varied across the life course and had significantly diminished or was not part of participants' regular activity in the years prior to taking part in the trial. An unexpected outcome of our research was how cycle training and assessment was well received, even among those who regarded themselves as already possessing the necessary skills to cycle. We also underestimated how the trial would motivate participants to cycle by providing a sense of structure and goal-oriented activity – the majority exceed the expected 30 minutes cycling, three times per week, over the eight weeks.

We gave participants the opportunity to engage in a series of cycling experiences of their own choosing. Cycling activity was mainly for recreation although participants did use their e-bikes to make short local errands and a few of them who were in employment used them for commuting. Our findings showed how engagement was shaped by personal cycling capability and perceived affordance for safe cycling in the immediate proximity of the home. This is important given that older sections of the population place significant attachment to home and place particularly following retirement and if they have spent a long time in living in the locality (Buffel, 2020).

Cycling in the UK typically requires sharing the public highway with motor traffic and sometimes requires intense concentration which can demand sensory overload (LifeCycle, 2010; World Health Organization, 2002). It became clear from our study that participants actively sought opportunities to cycle off the highway along purpose-built cycle tracks and paths through green, and alongside, blue spaces, by first consulting maps and reconnoitring routes. Where participants felt uncomfortable riding in traffic, tactics were employed such as riding on pavements, to avoid potential conflict with motor vehicles.

Over the course of the trial, participants' ranging behaviour did expand into new and unfamiliar geographical domains. Participants developed the confidence to (re)discover geographies that they had not ever visited by cycle or had not done so for some while. Power assistance offered riders the confidence to investigate unfamiliar routes safe in the knowledge that they could turn back if this was inaccessible or not suited to their capabilities. This corroborates recent research with older e-bikers in Flanders by Van Cauwenberg et al. (2019) who reported that the most important benefit of e-bike use was to be able to bike longer distances, and also the study (cited earlier) by Fyhri and Sundfør (2020), which found that, people in Norway who purchased an e-bike, increased their bicycle use from 2.1 to 9.2 km per day on average (and that this was not just a novelty effect).

Travelling far and covering vast geographical areas was *not*, however, required for participants to reap wellbeing benefits. Diary narratives revealed participants' appreciation of the opportunity e-biking provided for them to simply get outdoors alone or in the company of others. The therapeutic qualities of the act of simply moving from one place to another, what we might call 'therapeutic velomobility' (Gatrell, 2013), was evident even for short rides in and around the local area. We argue that it was the 'mobilisation of the self' (Ziegler and Schwanen, 2011) through e-biking and the sheer joy of power-assisted pedalling across physical space that provided a sense of purpose and accomplishment and allowed participants to flourish – this is evident in the way our six participants articulate their experience and convey positive non-verbal gestural and facial expressions in our video vignettes (see https://www.cycleboom.org/video/). However, we also pointed out how wellbeing can be diminished through journey stress because of the lack of supportive infrastructure and the fear of having to interact with traffic. Despite this, and examples of some minor cycle crashes, participants developed coping strategies and tactics in terms of timing of their cycling events and spaces where they felt comfortable cycling.

Implications for policy and practice

While our participants were drawn from the older population living in the Oxford and Reading areas of the UK, we believe that our results are pertinent for a broad spectrum of people of different ages and abilities living in different geographical regions. This is because e-bikes provide support to overcome barriers that can be a deterrent to regular pedal cycling such as hillier terrain and climatic conditions such as wind, rain and more extreme temperatures (Parkin et al., 2007). The positive engagement with e-biking among our older cohort also provides lessons for policy makers seeking ways of encouraging individuals to stay active for longer to enhance quality of later life and reduce end-of-life morbidity as part of a healthy ageing agenda (WHO, 2015). This is particularly pertinent for neighbourhood planning where consideration needs to be given to enhancing independent mobility to support people to 'age in place' (Pani-Harreman et al., 2020; Wiles, 2012).

A UK national e-bike strategy should acknowledge e-biking as 'active travel'. Messaging should be framed positively and promote the short-term health and wellbeing benefits of e-biking (Williamson, 2020) through facilitating access to the outdoors and the potential for social interaction (Jones and Spencer, 2020). The strategy could focus on supporting uptake in suburban and peri-urban areas where the population tends to be older, where journey distances are typically greater and transport options are more limited (Fyhri and Beate Sundfør, 2020; Philips et al., 2020). Our results demonstrated concerns about quality of cycle infrastructure, and therefore, strategy should support municipal authorities to provide good quality separated cycleways along major roads linking towns and outlying areas, routes through low traffic neighbourhoods, and opportunities to access green and blue space from home.

Whilst more supportive (separated/segregated/protective) infrastructure for e-cycling is necessary, the broader economic, social, cultural factors that currently inhibit cycling also need to be addressed (Pooley et al., 2013). Publicity campaigns to promote cycling should represent e-biking as a normal part of the mobility landscape, particularly in the UK where cycling is regarded as abnormal and where e-biking likely to already be perceived as a 'sub-culture within a sub-culture' (Aldred, 2012; Horton and Jones, 2015). The potential for e-biking for everyday travel and outdoor recreation could be promoted by providing opportunities for real life experience of e-bikes through try-out events in public space, public hire schemes, and recreational outdoor settings such as forest parks. We highlighted how all participants appreciated cycle training, but also, how some experienced minor cycle crashes. Cycle skills training programmes, using an 'e-Bikeability' model (https://bikeability.org.uk/), could be offered to local communities to support new and less-confident riders. The high cost of e-bikes was commented upon by our participants. Generous tax incentives could help support purchase of e-bikes.

Limitations and future research

This trial focused on an adult population aged 50 and above living in the Oxford and Reading areas. Findings are therefore not generalisable to the adult population across the whole of the UK, but they do provide important insights and an opportunity for comparison with how similar e-biking trials may be received.

The Diary of Cycling Experience (DoCE) was primarily used as a tool to capture participant experience and meaning through written narratives. This meant we only obtained a general sense of where, when, and how people cycled and sometimes this data was incomplete. Future studies could place emphasis on capturing the 'brute facts' of travel such as the specifics (and logic) of the routes taken and distance travelled through participant mapping exercises and the inclusion of tracking through GPS and mobile phone applications. This could also include

emotional mapping to understand spaces that enhance and diminish wellbeing (Pánek and Benediktsson, 2017).

We were also not able to determine whether e-bikers conducted more frequent or longer journeys than pedal cyclists (Fyhri and Fearnley, 2015) although we did establish that e-bikers spent, on average, more time cycling than their conventional cycling counterparts (Leyland et al., 2019). Ideally, we would have been able to investigate whether e-biking was sustained and whether this translated into modal shift or long-term improvement or enhancement to health and wellbeing. Resource constraints meant that we were unable to do this.

Active travel studies and campaigns have traditionally focused on active travel benefits in relation to physical activity (Darker et al., 2007). Future research should focus on broader conceptualisations of 'active travel' with attention given to the potential wellbeing benefits of (e)cycling (Delbosc, 2012; Nordbakke and Schwanen, 2013; Vos et al., 2013). This could include techniques to understand the moment-by-moment embodied experience of cycling as well as investigating the broader impact of cycling on human flourishing (VanderWeele, 2017). Simple monitoring of e-biking in the UK National Travel Survey would provide intelligence on how e-bikes are being used as is currently the case in The Netherlands (Harms and Kansen, 2018). Finally, E-bikes require different demands on space and facilities vis-à-vis conventional pedal cycles and the impact of this warrant further investigation as part of a place-based understanding of a socially just transition to net zero transport (Powell et al., 2021; van Lierop et al., 2020).

Conclusion

This paper has demonstrated how e-biking can provide riders with the opportunity to extend the distance and types of area they are willing to cycle from their homes (their 'ranging behaviour') and how this can promote health and wellbeing. Our evidence suggests that e-bikes have the potential to support cycling for leisure as well as everyday travel and that consideration should be given to the positive effects of e-cycling on mental wellbeing in addition to physical activity. As societies begin to repair the threads of social connectedness following the Covid-19 pandemic the desire to travel physically to be co-present with others will be heightened following an extended period of virtual co-presence (Morina et al. 2021; Urry, 2002). E-biking, within the context of an ageing society, therefore, offers an important technological tool to support social connectedness and wellbeing, while at the same time contributing towards a green transport recovery.

Data Accessibility Statement

Supporting data is available on request by contacting Oxford Brookes Research and Digital Assets Repository (RADAR) at radar@brookes.ac.uk DOI 10.24384/g2k3-sm81.

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Competing Interests

The authors have no competing interests to declare.

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