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Movement Foundations. The perceived impact of a digital rehabilitation tool for returning to fitness following a period of illness, including COVID-19 infection: a qualitative study

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ABSTRACT

Digital interventions can increase physical activity (PA) levels in adults. However, the COVID-19 pandemic highlighted the complexities faced when guiding people to start or return to PA following illness or inactivity. A digital tool, Movement Foundations, was developed to provide remote guidance on building strength and capacity across functional movement patterns, with graduated progression based on user responses and input. This qualitative study aimed to explore the perceived impacts of using the tool. Nine participants aged over 35 years from the healthcare and academic healthcare sectors were recruited to use it and were subsequently interviewed. Thematic analysis identified three themes falling under the overarching concept of 'Capability, Opportunity and Motivation—Behaviour (COM-B) Plus', encompassing: skills and capacity for movement; opportunities, motivations and barriers for movement; and a personalised, safe space in which to develop. Participants felt that the digital tool increased their capacity and confidence in movement and positively impacted their daily activities. External factors such as illness and stress clouded perceptions of the impacts of PA. Time, work pressures and needing equipment were still considered significant barriers to PA. Still, participants appreciated the flexibility and non-prescriptive nature of the tool and felt that it helped movement to become opportunistic and habitual. Increased capacity for PA and feeling the subsequent physical and mental effects positively influenced motivation. Structure and guidance, with graduated progress, were seen as protective. Guided self-reflection helped participants understand their capacity and limitations with regard to movement and promoted motivation. Although acquiring technical skills to guide movement may be important for those recovering from illness, participants found that a structure promoting individualised guidance, graduated progression and guided self-reflection were important motivational factors for continuing use. Digital interventions should consider these aspects when seeking to promote habitual PA.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Digital interventions can increase physical activity (PA) levels in the short-term. Still, there are specific complexities when guiding people to start or restart PA following illness or inactivity.

WHAT THIS STUDY ADDS

⇒ A user-guided graduated digital tool that responds to daily interactions with participants helps with skills acquisition for movement. More importantly, increased capacity for movement and guided self-reflection positively increased motivation for PA.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Digital interventions should consider individualised guidance, graduated progression and guided self-reflection when promoting PA, particularly when aimed at individuals returning from illness or inactivity.

BACKGROUND AND RATIONALE

Physical inactivity is a major risk factor for non-communicable diseases and mortality.[1] Before the COVID-19 pandemic, approximately a third of adults were not active enough for good health as defined by UK Chief Medical Officer (CMO) or WHO guidelines.[2–6] During the COVID-19 pandemic, physical activity (PA) in adults decreased[7]; particularly in those with chronic health conditions,[8] and in those who were socially isolated, shielding or lonely,[9] risking further inactivity and deconditioning.[10]

There is no comprehensive framework to support or guide individuals wishing to start or return to PA following illness or prolonged inactivity. Traditional 'return to play' strategies guiding the resumption of PA were inadequate to meet the challenges posed by COVID-19 and its sequelae[11]; where a significant proportion of people reported postexertional symptoms as part of a Long

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COVID spectrum of disease, highlighting the challenges of unpredictable activity tolerance. People described conflicting advice on returning to PA following COVID-19,[12] demonstrating the need for clear guidance that is individualised, sensitive and provides people with tools for self-monitoring and signposting for further support where necessary.

Digital tools have shown promise in encouraging the uptake of PA.[13] A digital rehabilitation tool for potential use in primary care was developed to support people wishing to return to PA after illness or inactivity,[14] and tested by clinical and academic staff. This qualitative research was designed to capture the perceived impact and usability of such a tool following a period of illness, including COVID-19.

METHODS

Design of the digital tool (web app)

The Movement Foundations digital tool (web app) was developed between February and November 2021. The team consisted of medical professionals (DS and JK), exercise rehabilitation instructors (OH and DC), academic physiotherapists (AM and PLF) and Rehab Guru Software (a platform used by clinicians to support rehabilitation guidance) application designer (STaylor). The tool consisted of exercises based on functional movement patterns, with a graduated progression in volume (number of sessions per week and the number of repetitions of exercises) and intensity/load (relative difficulty of exercise repetition) (figure 1). Participants were entered onto a starting level based on an algorithm adjusted for the number of sit-to-stand (STS) repetitions over 1 min and the perceived degree of effort this required (Borg Category Ratio (CR)10 Scale). Participants with STS between 0 and 35 and Borg CR10 above 7, or STS 35–39 and Borg CR10 above 8 were signposted to seek medical advice before continuing. Levels of exercise were phased: each phase lasted 1-2 weeks and contained a variable number of sessions. For each phase, participants were able to choose exercises ranging in difficulty across functional movement pattern domains, empowering them to titrate exercise intensity as they felt necessary. When participants logged individual exercise sessions, they were asked to rate their perceived effort and subjective assessment of adherence to the exercises (how much they could do of what they intended).

Participants were asked to complete daily questionnaires on fatigue, sleep, muscle soreness and emotional stress, based on Hooper and Mckinnon scoring criteria.[15] An additional domain of recovery was added to account for postexertional symptoms or deterioration. Participants were asked if they had new or recurring symptoms of their illness and were signposted to seek medical advice. At the end of each phase, scores from the daily questionnaires, perceived effort and degree of subjective and objective adherence to the sessions were combined by an algorithm to generate options for the participant. These included progressing to the next phase, consolidating the previous phase, regressing a phase and signposting for further medical advice. A resource hub provided participants with information on deconditioning, PA following illness, functional movement patterns, Long COVID, planning sessions, rest and recovery, fatigue, sleep and muscle soreness.

Study design

A thematic analytical approach was used, underpinned by subtle realist and interpretivist ontological and epistemological paradigms. This approach acknowledges that reality is understood through individual and socially constructed meanings and that the researchers' understanding impacts the research process and findings.[16]

Recruitment and data collection

Healthcare and academic healthcare staff who met eligibility criteria (box 1) were opportunistically recruited

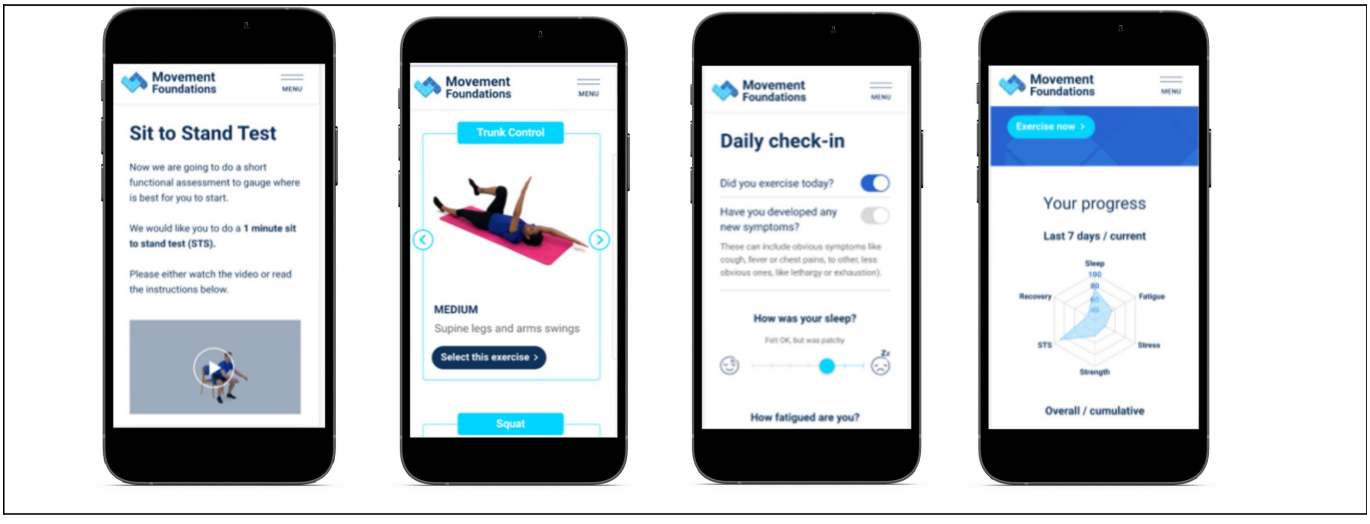

Figure 1 Representative screens from the digital tool showing sit-to-stand (STS) assessment, exercise selection screens, daily 'check-in' questionnaires and summary progress screens.

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Box 1 Eligibility criteria

Inclusion criteria
- ⇒ 35–60 years old
- ⇒ Able to give informed consent
- ⇒ At least 28 days asymptomatic post illness, including presumed or confirmed COVID-19 (no cough/fever/anosmia)
- ⇒ MRC dyspnoea scale 1: ('Not troubled by breathlessness except on strenuous exercise'); 2: ('Short of breath when hurrying on a level or when walking up a slight hill'); or 3: ('Walks slower than most people on the level, stops after a mile or so, or stops after 15 min walking at own pace')
- ⇒ Able to stand from sitting
- ⇒ Able to climb a flight of stairs
- ⇒ Imperial College or NHS Trust staff

Exclusion criteria
- ⇒ Pregnant/6 weeks postpartum
- ⇒ Admitted to hospital with COVID-19 at any point
- ⇒ Disease/disability that requires ongoing hospital treatment (stable disease or disease in remission, for example, diabetes/HIV requiring regular follow-up is exempt)
- ⇒ Chest pain at rest or on exertion
- ⇒ MRC dyspnoea scale 4: 'I stop for breath after walking about 100 yards or after a few minutes on level ground' or 5: 'I am too breathless to leave the house, or I am breathless when dressing.'
- ⇒ Ongoing, or relapsing and remitting, symptoms suggestive of Long COVID, including excessive lethargy, postexertional symptoms or impaired recovery following exertion
- ⇒ If using an oxygen saturation probe and are aware of desaturation (≥3%) associated with exercise or exertion

MRC, Medical Research Council; NHS, National Health Service.

from Imperial College Healthcare NHS Trust and Imperial College London email chains and WhatsApp groups from November 2021 to July 2022. Eligibility criteria were expanded to increase recruitment from March 2022 from a minimum age of 40 to 35 years. Recruitment continued until the research team were confident that data saturation was achieved. Data collection and analysis took place concurrently, with analytical data saturation considered at the point when no new codes were identified during analysis.[17]

On entry, all participants were asked to input age, gender, occupation, level of previous PA and whether their illness was COVID-19, in which case time since the illness was noted (online supplemental file 1). Approximately 3 weeks following entry into the study, participants were invited for semistructured interviews. These were conducted remotely using Microsoft Teams by a male researcher (DS) with a second (female) interviewer (STurner) present for the initial interviews to ensure standardisation. Interviews were based on perceptions of: entry to the web app; exercise suggestions provided; the relevance of the daily questions; the feedback provided to the participant; the progression through the phases; engagement and interface with the web app; fitness levels and well-being; and whether the participant would recommend the digital tool to others (online supplemental file 2). Interviews lasted approximately 30 min and were recorded, pseudoanonymised and transcribed verbatim.

Data analysis

Transcripts were managed using NVivo V.10.[18] Two authors (DS and STurner) independently coded two transcripts initially and agreed on a coding strategy. Themes and concepts from the data were developed using the principles outlined in Braun and Clarke's six-step process.[19] This included: familiarisation with the data, involving repeat listening and reading of interviews and transcripts respectively and checking for accuracy; generating initial codes; and developing, reviewing, defining and naming themes. Although an inductive approach was taken to coding in as much as possible, the research team approached the data with the Capability, Opportunity and Motivation—Behaviour (COM-B) model as a broad framework.[20] Coding and analysis were independently verified by AM and PLF.

Patient and public involvement

Participant and public involvement (PPI) groups were convened to outline the strategy and web app design. PPI participants were of a mix of ages and gender, and all had personal experience of COVID-19 infection or physical fitness rehabilitation following illness or inactivity. Comments and suggestions from meetings contributed to adjustments made in the interface of the digital tool and the study design. Key themes, codes and illustrative quotes were then discussed with PPI members to verify codes further.

RESULTS

Participant characteristics

Out of 22 participants who expressed interest in the study, 9 completed participation. Eleven did not complete the initial consent process and two started the study but could not complete it due to unrelated illnesses. Data saturation was observed following eight participants and confirmed following the ninth interview when recruitment ceased. Ages ranged from 42 to 59 years, with a median (IQR) of 50 (12) years. Four out of the nine participants had COVID-19: two in the previous 2 months and two between 2 and 6 months prior. A further two participants ('F' and 'H') had a recent non-COVID-19 illness. Three of the participants demonstrated baseline PA levels below CMO guideline amounts. Baseline STS scores for participants ranged from 25 to 54 per min, with a median (IQR) of 28 (5) repetitions. Borg CR10 scores for baseline STS assessments ranged from 2 to 7, with a median (IQR) of 3 (2) (table 1).

Qualitative findings

Coded data were initially sorted into subthemes and then clustered to form three key themes: (1) skills and capacity for movement, (2) opportunities, motivations and barriers for movement and (3) a personalised, safe

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Table 1 Participant characteristics

Participant	Sex	Age	Job	COVID-19?	Time since COVID-19 infection	Activity level	STS	Borg CR10 for STS
A	Male	58	Manager/admin	Yes	<2 months	Active	54	2
B	Male	54	Researcher	Yes	<2 months	Active	38	2
C	Female	42	Manager/admin	No		Active	25	5
D	Female	59	Clinician	No		Active	29	3
E	Female	45	Manager/admin	No		Below guideline	28	4
F	Female	50	Manager/admin	No		Below guideline	28	3
G	Male	42	Manager/admin	Yes	2–6 months	Below guideline	33	7
H	Female	51	Clinician	No		Active	26	3
I	Female	42	Clinician	Yes	2–6 months	Active	28	5
Mean (SD)		49.2 (6.8)					32.1 (9.1)	3.8 (1.6)
Median (IQR)		50 (12)					28 (5)	3 (2)

STS, sit-to-stand.

space in which to develop (table 2). From this thematic structure, a broad overarching concept was identified as 'COM-B Plus'.

Codes were not exclusive to specific subthemes. Codes, subthemes and themes are shown in online supplemental file 3. The themes are described below with direct quotes from participants.

Table 2 Subthemes, themes and over-arching concept

Subtheme	Themes	Over-arching concept
Physical literacy	Skills and capacity for movement	COM-B Plus
How to exercise		
Increasing capacity/capability		
Different and new muscle groups		
Different types of movement		
Conditioning for daily life		
Impact of illness	Opportunities, motivations and barriers to movement	
Opportunistic PA		
Scheduling		
Fatigue		
External factors		
Pressure, motivations and incentives		
Accessibility		
Progress	A personalised, safe space in which to develop	
Impacts, emotions and feelings		
Self-reflection		
Tailoring		
Gentle/graded		
Pushing/not pushing		
Guidance and structure		

COM-B, Capability, Opportunity, Motivation—Behaviour; PA, physical activity.

Skills and capacity for movement

Participants described how the digital tool contributed to their movement vocabulary and capacity. 'A' discussed how the tool provided access to exercises that he would not have necessarily done otherwise and 'I' explained how this breadth impacted her physical literacy, or understanding of movement, and its impact on her body:

> I think the exercises in general makes you a lot more aware of what you're exercising, you know, which muscles and things like that. So that was quite good feedback. And also, because it made you realise what parts of your body you might need to work more on.

The tool provided instruction to increase confidence with movement. 'F' talked about how this allowed her to 'reclaim (her) ability to move' and take control and direct her body. 'B' discussed how it was useful to be able to check, even if it was a simple exercise, that his form was correct 'Am I doing that the way it's supposed to be done?', and 'H' felt that adding the tool to her routine helped remind her about posture and core strength.

There was a perception that this breadth of exercises encouraged participants to engage a different and broader range of muscle groups. 'A' talked about how he felt an effect from this and 'B' described how this was particularly welcome in the post-COVID-19 period. 'I' felt that there were some exercises that were not 'captured' elsewhere, such as for the back. The digital tool prompted participants towards different movement patterns from those they routinely used. For example, 'B' discussed how this tool focused on tone and strength, and 'G' explained that he had previously held an inclination towards aerobic activity, as opposed to strengthening exercises, but without any reason or rationale. 'H' commented on how the 'general workout' was a positive experience rather than just being focused on a specific body area.

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This breadth also contributed to an increase in their capacity. 'G' explained how he felt engagement with the tool meant that he was using his rowing machine more. Participants also discussed the impact that even the short duration of participation had on activities of daily living. 'B' felt that the exercises might have helped with his capacity to walk up the escalators at a train station, and 'H' felt that the exercises, and STS movements in particular, helped with her ability to climb stairs. This was related to general perceptions of the relationship between moving more and ageing, and the role of interventions. 'F' discussed how increased movement and PA meant that she felt she was moving with less inhibition, particularly compared with people of her age, for whom standing up 'always seems to be accompanied by an oooph (laughter)'.

'G' discussed his perceptions of the impacts of PA on longevity, highlighting the relevance of this tool in the context of ageing and bereavements:

> I know it's coming and I just want to try and make sure that I'm doing everything I can to be in as good a position as possible when it comes along. So it's partly a self-preservation strategy, partly it's because I want to be around for as long as possible for my kids.

Opportunities, motivations and barriers to movement

This theme describes how participants perceived the factors that helped enable or obstruct movement with regard to the digital tool. The impact of illness and fatigue was prominent but perhaps contrary to what was anticipated. 'B' felt that the broad range of movement, without feeling the need to push himself, helped reduce fatigue. 'I' discussed how her experiences of fatigue following COVID-19 meant that she was apprehensive about starting the digital tool, but despite some surprise about how tiring the exercises made her feel, she was happy and motivated to continue using it.

The relationship between the impact of external factors, such as illness, with how people felt following PA and exercise was confusing, particularly when answering the daily questions posed by the tool. 'D' felt that the question about aching muscles did not take into account her joint pain, and 'B', 'H' and 'I' discussed how extraneous factors, such as having a cold, the time of day, and daily stress, all clouded this relationship.

Time and work pressures were seen as barriers to participating in PA and were not necessarily overcome by the digital tool. 'D' discussed how trying to fit time to be physically active around a busy schedule was stressful. 'C' discussed the scenario of getting home, doing house chores and then feeling exhausted when she found time for herself. However, 'D' felt the digital tool was not prescriptive about timing and provided flexibility for people to organise their PA schedule themselves, allowing for 'crazy days'. 'G' felt that it helped him define time for scheduled PA around the hectic pressures of family and work life and that this had the potential to become habitual. Scheduling was felt to be important for habit formation. For example, 'A' referred to the need to schedule a time to do the exercises on a calendar as being particularly important, and 'E' felt that an automated notification system would help her incorporate brief PA into her daily life and around meetings. 'A' reflected that it did not take long to complete an individual session: approximately 20–25 min, which was feasible.

There was a perception that the tool allowed for opportunistic bouts of PA: 'E' described the beneficial impact of being able to incorporate the exercises into a day at the office rather than sitting at her desk for prolonged periods. 'H' discussed how not requiring any special equipment meant that she could do her exercises anywhere, such as when travelling for work.

There were certain barriers to use, such as the equipment specified. 'E' and 'D' reflected on the need for tins, or a suitable step, impeding their capacity to schedule the exercises, such as when at work. Having space available was also perceived as a barrier and a potential issue for inclusivity. 'G' felt that his arm span meant that finding enough wall space for some of the exercises was difficult.

Related to the previous theme, there was a positive cycle of increased capacity to move that then increased motivation:

> So, I think it's as you do more, you're able to do more, and then you want to do more, and it becomes less of a chore to go upstairs and get the thing you just left in your bedroom because you've got brain fog, but you just go, "Oh, right, okay, I'll go back up three flights of stairs to get my glasses again," and you don't mind. ('F').

'C' and 'I' described how feeling the impact in their muscles, or stiffness the following day, motivated them to continue, and 'B' reflected on the beneficial impact on his mental health, which was motivating:

> […] it was mentally uplifting to do this broader set of exercises and realise that actually, they were good things to do, if you see what I mean, that it was helping me use muscles that I wasn't really using or even trying to avoid using.

A personalised, safe space in which to develop

'B' described how having a structure and guidance within the tool gave him 'permission' to not push himself too hard when exercising. He discussed how this 'carefully guided situation' reduced the stress he associated with exercise, as he felt less risk of pushing himself too far and getting 'into more of a downward spiral again'. Participants reflected that the pressure to push themselves could come from external sources as well and that the digital tool reduced this. 'E' felt that there was no pressure to complete all sessions and that the tool made it clear that she could progress at her own pace, which was a positive feature for her. Similarly, 'H' discussed how the

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tool gave her the information she needed but did not force her into doing anything. 'B' stated:

> None of us are used to stopping ourselves pushing ourselves harder, you know, or having a structure that keeps ourselves back, […] that terrible phrase no pain no gain […] so, you know, having that structure that says, "No, no, hang on, just stay back, just, you know, do these," […]… I would recommend it. (laughs).

Participants also described the protective effects of the structure of the digital tool. 'C' discussed how she felt the graduated progress in intensity was very helpful and easy to follow. 'B' felt that the structure was useful for allocating dedicated time to the exercises and feeling he had achieved something. 'F' described how the phased nature of the tool, and the structured guidance, would be useful for people with chronic conditions who are not physically active. The intensity of exercises was seen as gentle and graded. 'B' described it as a 'steadying hand' on the rate of return to PA, 'F' regarded the increase in the difficulty of exercises as 'surreptitious', and 'D' described how she noticed the gradual increase in intensity and felt that it was positive so she could continue. 'I' reflected that the graded approach, feedback and daily guided self-reflection aspects would be valuable for friends and family who were not physically active. 'H' felt that the tool gave her the 'chance' to introduce movement and PA, rather than it feeling 'invasive'. However, she felt that this might not be enough when the discipline to do movement activities were lacking. The tool and the initial assessment part were described as 'non-judgemental' by 'I'.

Participants reported a positive impact on their state of mind from PA in general and not specifically from the tool;

> it definitely makes me feel better. […] So I actually look forward to it because I feel like I'm doing something good for myself, and I don't know if it's that that makes me feel better or it's the actual exercises that are making me feel better, but it's definitely positive ('H').

'G' described feeling better knowing he was doing some exercise and feeling improvements. He also described feeling more positive and fewer negative emotions as a result of being physically active. 'A' felt this motivated him to continue using it, and as a reason to recommend it to others.

Using the tool prompted a reflective approach which contributed to increasing physical literacy and helped participants understand their current capacity and limitations. 'F' explained that the daily questionnaires were helpful for checking in with herself to reflect on how she was feeling, which was something she wouldn't normally do. Similarly, 'I' explained that the feedback provided a realistic understanding of how much activity she actually did rather than the idealised perception she might have otherwise held. 'D' similarly reflected that the initial assessment gave her a realistic appraisal of how fit she might actually be, but this motivated her to use the digital tool.

Finally, participants valued that the tool felt individualised for their level of physical fitness in some respects. 'A' appreciated that the tool contained guidance relevant for someone of his demographic background, and 'D' explained:

> I think for all the bog-standard, even a nervous person, it would make you feel reassured that it was tailored to you and not to superman next door.

However, some felt the tool was not individualised enough. 'H' felt that the digital tool felt quite 'general' rather than specific to her. Moreover, some participants felt empowered to tailor advice to their own circumstances. 'B' felt that he could eventually do more than what was guided within the digital tool, and 'D' felt she could ignore guidance to take some time to recover, as she felt her poor sleep was unrelated to the exercises. 'I' discussed how she thought it useful that she could tailor less intense exercises for her upper body but more intense exercises for her lower body, which was stronger, and she appreciated this flexibility.

Attitudes

Transcripts were further coded for positive and negative attitudes. How attitudinal codes intersected with each of these subthemes was examined to identify features of the digital tool which contributed positively or negatively to interaction with participants, and their exercise experiences, highlighting areas for future development (table 3). Positive attitudes outweighed negative ones for most subthemes, including physical literacy (21 positive/4 negative); pressure, motivations and incentives (31 positive/8 negative); and self-reflection (24 positive/7 negative). Negative attitudes were more prevalent when participants discussed the impact of external factors on health and well-being (2 positive/18 negative). Key actions from this exercise included: improvements in design; the use of prompts and notifications; adjusting user feedback to capture a more general reflection of health status; and providing a wider range of suggestions for non-specialist equipment to increase the accessibility of the exercises.

DISCUSSION

Key findings

Themes were developed under an over-arching concept of 'COM-B Plus'. This refers to the behaviour change framework of capability (skills and capacity for movement), opportunity and motivation (opportunities, motivations and barriers for movement)[20]; with additional aspects of guidance, structure and permission not to push oneself too hard (a personalised, safe space in which to develop), that participants felt enabled a protective and beneficial effect.

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Table 3 Attitudinal coding for subthemes

Subtheme	Keywords (negative attitude)	Keywords (positive attitude)	Actions
Accessibility	(11) interface, familiarity, resources, space	(14) range, video, reinforcement, instruction, transportability, general	► Audio support for videos ► Ultimately will become an app which will increase accessibility ► A wider range of suggestions for non-specialist equipment to increase accessibility/transportability ► Clearer exercise selection function
Conditioning for daily life	(1) routine	(19) capability	► Integrate push notifications ► More explicit explanations of how exercises are related to function/daily activities
Different and new muscle groups	(0)	(14) upper body, core, back, relaxation, stretched	
Different types of movement	(2) aerobic	(6) tone, strength, general	► Emphasise the relationship between exercises and aerobic gains
External factors	(18) unrelated tiredness, sleep, joint pain, stress, time, other exercises	(2) spider chart	► Emphasise that questions are general and do not have to be related to exercise
Fatigue	(2) demotivating to be aware of it	(10) contradict expectations, needing time	
Gentle and graded	(0)	(9) steadying hand on return, nice and safe, non-judgemental, non-invasive	
Guidance and structure	(1) not using daily	(11) step by step efficiency	► Emphasise structure and progress ► Push notifications to encourage daily interaction
How to exercise	(3) interface, space, familiarity	(10) videos to check, easy to follow, posture	► A wider range of suggestions for non-specialist equipment to increase accessibility/transportability ► Clearer exercise selection function
Impact of illness	(2) brain fog impacting usage	(11) motivational, helped with energy levels	► Clear and uncluttered menu/interface
Impacts, emotions and feelings	(2) impact on sleep	(12) mentally uplifting, relaxing, distracting, enforces break/time, mental break from work, positive emotions, doing something good	► Suggest exercising timings that might have a negative impact
Increasing capacity and capability	(2) equipment reduces transportability	(18) breadth, do at work, do quickly, accessible as on the phone, user-friendly	► Audio support for videos ► A wider range of suggestions for non-specialist equipment to increase accessibility/transportability
Opportunistic PA	(5) no time	(13) take anywhere, incorporate into the day, find time, accumulate throughout the day	► Reminders/push notifications ► Emphasise that able to divide sessions throughout the day as able
Physical literacy	(4) cannot see progression easily—variability	(21) breadth, motivational, monitoring, understanding level, awareness of the capability	► Introduce a clear progression tracker
Pressure, motivations and incentives	(8) other tools have a greater capacity to personalise the experience, cannot see progression easily—variability	(31) mentally uplifting, regular use prompt habit and benefit, distracting, not too pressured, motivating	► Introduce a clear progression tracker
Progress	(0)	(3) increasing challenge	
Pushing and not pushing	(0)	(10) permission to hold back, suggestions rather than prescription, own pace	
Scheduling	(6) stressful finding the time	(9) plan relatively easily, 20–30 min only, can do at work	► Reminders/push notifications ► Emphasise that able to divide sessions throughout the day as able

Continued

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Table 3 Continued

Subtheme	Keywords (negative attitude)	Keywords (positive attitude)	Actions
Self-reflection	(7) other tools allow for more self-analysis, can be more aware of negative impacts	(24) reality check, motivating, reminding to seek further information, ability to reflect, signposting, more aware of the body	
Tailoring	(3) not specific to me	(12) appropriate for capability, select the level of challenge, flexibility in adaptation	

PA, physical activity.

Capacity to be physically active

This study falls within the broader context of poor adherence to PA guidelines in the UK and the additional complexities and challenges of supporting individuals returning to or starting PA following illness or prolonged inactivity. Current interventions for PA in UK healthcare are based on education. This is despite limited knowledge of CMO guidance and low confidence among practitioners in delivering exercise guidance,[21] and a small effect that likely wanes over time.[22] Moreover, practitioners point towards the need for more individualised approaches for PA guidance that use resources effectively.[21] Interventions to increase knowledge on how and why to engage in PA may not be enough.

In a prospective study of the predictive validity of the COM-B model for PA,[23 24] 'capability' was defined almost exclusively by psychological aspects, such as self-monitoring, habits and action planning, and was itself a motivating factor. Knowledge itself did not contribute, emphasising that capability for PA might be more about the capacity to control and apply habits rather than knowing how to do something. However, participants in our study did highlight the benefit of skills acquisition related to safe PA and expanding a vocabulary of movement. These aspects might therefore be important in subgroups with specific needs, such as those recovering from illness, and less so for generic PA guidance. In their study of the validity of the COM-B model for PA, Howlett *et al* identified that habits and autonomous actions increased PA via the motivational impacts on self-identity.[23] Our participants discussed the relationship between the impacts of PA, such as on mental health, reclaiming control over what one can or cannot do, feeling stiffness the following day, or seeing self-monitoring scores, and subsequent increased motivation to be physically active. Therefore, reflecting on the impacts from a pattern of PA that is becoming habitual can feed into a cycle of increasing PA, and guided self-reflection might be an important motivating tool.

This concept of physical literacy, a subtheme, encapsulates the domains of motivation, confidence, physical competence and knowledge and understanding with regard to PA and has generally been applied to children and younger adults.[25 26] However, it has not been robustly defined, and a national UK consultation to develop a shared definition, led by Sport England, is underway to address this.[27] Initial findings suggest that people regard affective elements of a relationship with physical movements, such as motivation, self-perception of competence and enjoyment, more than technical, physical skills when considering physical literacy. A framework for physical literacy for older adults proposed that confidence in movement, and perceived self-efficacy, are important elements.[25] This indicates that, although interventions might consider technical movement skills in the capability domain, it is the self-efficacy, self-perception and confidence from habitual use that translate into increased PA and movement rather than simply knowing how to do an exercise. Therefore, when seeking to engage those unfamiliar with PA or recovering from illness, digital tools should consider adopting individualised, non-judgemental approaches with graduated progression and guided self-reflection, as reported by participants in this study.

Digital tools and habitual PA

Digital tools have the potential to increase PA in adults,[28] based on the ubiquity of smartphone devices and the capacity to provide cost-effective and wide-reaching guidance. However, little is known about their long-term impacts. For example, PA coaching using smartphones effectively increased step counts in adults in a US study. Still, it demonstrated decreasing interaction from users, with only a small number completing their assigned interventions.[29] Generally, impacts of digital PA tools are measured at less than a year in adults and older adults.[13 28] Therefore, concepts of physical literacy are likely to be important to translate the short-term impacts of digital interventions into meaningful longer-term habitual activity. This work suggests that a COM-B Plus model, based on guided self-reflection and graduated progression, might be of value for future digital interventions with longer-term follow-up.

Limitations

There are limitations to the generalisability of our findings. First, less than half of those who expressed interest in the study participated. This is concerning given that NHS staff, targeted for recruitment, have a 46% higher rate of absence than other sectors and high costs of retirement

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from ill health.[30] Therefore, it is likely that digital tools such as this cannot overcome initial barriers to PA and that the participants in this study, overwhelmingly from the academic sector, had fewer barriers to being physically active than others. Second, it is also possible that respondents were more digitally and health literate than the general population, coming from clinical, research and management domains. This might affect the impacts of tools such as this when disseminated more widely. Future development of this work must focus on ensuring inclusivity when using digital approaches.[31] Finally, this study recruited opportunistically, and the diversity of participants in socioeconomic status is unclear. Again, this will likely impact usability and interaction with digital tools, demonstrating the importance of ensuring inclusivity in future research to evaluate this approach.

CONCLUSIONS

Accounts describing users' experience of a digital tool designed to support people returning to PA after a period of illness or inactivity clustered around three themes: skills and capacity; opportunities, motivations and barriers; and personalised, safe spaces. These were encapsulated under the overarching framework of COM-B Plus. Safe and graduated progression and self-reflection were important elements which increased motivation beyond simple learning of technical skills for movement. These self-efficacy components of physical literacy are important considerations for digital PA tools that promote PA following illness or inactivity.

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Patient and public involvement statement Participant and public involvement (PPI) groups were convened to outline the strategy and outlook of the web app design. Participants were of a mix of ages and gender, and all had personal experience of COVID-19 infection and/or Long COVID, or of physical fitness rehabilitation following illness. Comments and suggestions made from the initial meetings contributed to adjustments made in the interface of the digital tool, wording of participant-facing literature, and in the study design. Key themes, codes and illustrative codes were then discussed with members of the PPI groups to further verify and refine codes.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants. This research was approved by the Imperial College Research Governance and Integrity Team (RGIT) (12 August 2021; 21IC6693). All participants were required to provide informed consent before taking part in the study. Data collected as a part of this study are anonymised and kept strictly confidential in accordance with the UK General Data Protection Regulations (2016). Participants gave informed consent to participate in the study before taking part. Copies of this study will be disseminated to all PPIE and study participants.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Transcriptions with deidentified participant data may be made available on reasonable request to d.salman11@imperial.ac.uk.

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Supplementary File 1: initial, and daily, questions on web-app

(i) We would like to ask a couple of questions about you and do a short activity test. This shouldn't take long:

1. How old are you (select age from drop down menu)
2. Are you male or female
3. How active are you?
   -Active (At least 150 minutes of moderate activity e.g. could talk but not sing while performing; or 75 minutes of vigorous activity, could not talk while performing per week).
   -Not very active (Less than 150 minutes of moderate activity e.g. could talk but not sing while performing; or less than 75 minutes of vigorous activity, could not talk while performing , but more than 30 minutes of activity per week)
   -Inactive (less than 30 minutes of physical activity per week).

4. Have you suffered any illness within the last year? Yes/ No

5. Was the illness COVID-19? Yes/ No

6. How long ago did your symptoms subside?

-Less than 2 months ago

-Between 2 and 6 months ago

-Between 1 year and 6 months ago

-Over 1 year ago

7. What is your job/occupation <free text>

(ii) Please provide an email address. This will be used to provide you with daily notifications to complete the daily check-in. This will be securely stored, and will not be shared with anyone else. Once the study is completed, it will be deleted.

Daily wellbeing questions

Have you developed any new symptoms? Yes/No

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These can include obvious symptoms like cough, fever or chest pains, to other, less obvious ones, like lethargy or exhaustion *(we will expand this text to include other symptoms to better guide the individual)*

How was your sleep?

1: I slept very, very well 4: I slept ok 7: I slept very, very poorly

How fatigued are you?

1: I do not feel fatigued at all (fatigue levels are very, very low) 4: I feel a bit fatigued 7: I feel very, very fatigued

How emotionally stressed has today's activity made you feel?

1: I do not feel stressed at all (not) 4: I feel a bit stressed 7: I feel very, very stressed (elastic band completely stretched, feel anxious, panicked)

How sore are you?

1: My muscles are not sore at all 4: My muscles are a bit sore 7: My muscles are very, very sore

How recovered do you feel (to be able to do day to day activities)?

1: I feel completely recovered and can do all activities as normal (battery completely charged) 4: I haven't recovered completely (battery on half) 7: I haven't recovered at all and feel unable to do most or all day to day activities (battery completely depleted)

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Supplementary File 2: topic guide for semi-structured interviews

Setting

Thank you for joining an interview regarding the digital rehabilitation tool for returning to fitness following illness such as Covid-19 infection. Please note that we will be collecting information from your study number only, and would be grateful that you do not refer to names, places or any other information that could identify you personally.

Questionnaire

(i) Entry

How did you feel about your initial assessment and starting exercises?

Can prompt with:

- How did you find the initial assessment (sit to stand) and how you were started with exercises?
- Did you feel that you were placed into an appropriate level for your capability?

(ii) Exercises

How did you feel about the exercise suggestions you were given?

Can prompt with:

- Did you feel they were appropriately easy to follow and do?
- Did you feel that they were beneficial to you?

(iii) Daily checks

How did you feel about the daily questions you were asked to complete?

Can prompt with:

- Did you feel that they captured how you felt at the time?
- Did you feel that they were appropriately easy to complete or too time consuming?
- Too many questions, missing any obvious questions?
- Did you understand what they were asking?

(iv) Feedback

How did you feel about the feedback you were given in response to the questions?

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Can prompt with:

- Did you feel it accurately captured how you were feeling?
- Did you feel that it was easy to interpret?
- Did it change what you did?

(v) Progression

How did you feel about your progression through the exercises?

Can prompt with:

- Did you feel that you were advised appropriately with regards progressing, staying put or stepping back?
- Did you feel that your progressions were reasonable, or too big a step?

(vi) Engagement

How did you feel about the level of engagement required from the web app?

Can prompt with:

- Did you feel that it was asking too much or a reasonable amount of your time?
- Did you feel motivated to engage with the app, and why or why not?

(vii) Interface

How easy did you find it to use the web app?

Can prompt with:

-Was it clear?

-Could it be improved in any way?

(viii) Fitness

Did you feel that using the web app had an effect on your fitness?

Can prompt with:

-Did it impact on your physical strength (feeling stronger)?

-Did it impact on your capacity to do things in daily life eg. running for a bus/walking distance/stairs?

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-Impact on mental health (feeling positive or low/anxious)?

-Impact on fatigue (energy/tiredness levels)?

(ix) Recommendation

Would this be something you would consider recommending to a friend or family member to use?

Supplementary File 3: codes, subthemes and themes

Code	Subtheme	Themes
Being more aware and concentrating on certain parts of the body, Beneficial because I'm not used to exercise, Broad set of movements, Doing exercises that don't necessarily do, Exercises make you more aware of what muscles you are exercising, I'm not into exercising, knowing my limits, Mismatch between perception and reality, Monitoring wellbeing, Pattern of moving, Reclaiming ability to move,	Physical literacy	Skills and capacity for movement
Am I doing it the right way, Apprehensive about starting, Baseline fitness, Engagement, Adding to physical activity repertoire after illness	How to exercise	
Accessability, Exercises worked parts of my body that don't normally target, General impact, Muscles are stretched, Doing more exercise after doing MF, Doing new things, Reclaiming ability to move	Increasing capacity/capability	
Exercises worked parts of my body that don't normally target, Exercising new muscle groups, Impact on core strength	Different and new muscle groups	

Salman D, *et al. BMJ Open Sp Ex Med* 2023; 9:e001557. doi: 10.1136/bmjsem-2023-001557

Strength, Tone and strength as opposed to aerobic, Wanting to do aerobic exercise, Working all muscle groups	Different types of movement	
Conditioning, Cycle of increasing fitness and capacity, Exercise helping with resilience, Feeling stronger, Get into it as get used to it (gradual), Helping with stair climbing, Impact on ADL, Impact on core strength, Impact on fitness, Exercise for self-preservation	Conditioning for daily life	
Brain fog and covid, Impact on fatigue, Motivated to get back on track, Physical activity after covid, Put on weight with Covid,	Impact of illness	Opportunities, motivations and barriers to movement
Breaking sitting time, Busy job as barrier to being physically active, Forming habit, Incorporating exercises into daily life, More productive from being physically active, No need for special equipment, Realisation that can carve out time to be physically active, Spreading exercises over time,, Can focus on exercises, Children as barrier to time to be physically active, Clear and feasible to exercise in designated time, Being busy as a barrier	Opportunistic PA	

Salman D, *et al. BMJ Open Sp Ex Med* 2023; 9:e001557. doi: 10.1136/bmjsem-2023-001557

Able to schedule in exercises, Allowed for crazy days, Time to do the exercises, Timing,	Scheduling	
Children contributing to fatigue, Demotivating to see how fatigued I am, Fatigue after covid, Impact on fatigue,	Fatigue	
Doing other forms of exercise, Impact of external factors,	External factors	
Being part of a study helped someone focus on physical activity, Feeling pressure to exercise, Feeling stiff the next day helps me feel I have done something, Felt more motivated as I went on, , I didnt have time, I dont have the motivation and time, I'm not into exercising, Impact on mental health, Monitoring wellbeing, , Motivated to exercise to feel better, Motivated to get back on track, Motivated to lose weight, Motivation, Motivation to target stress, Relaxation after exercise, Spending time thinking about exercise but not doing it, Thinking about response gives motivation and monitoring of progress, Unless you have a natural interest you will not engage,	Pressure, motivations and incentives	

Salman D, *et al. BMJ Open Sp Ex Med* 2023; 9:e001557. doi: 10.1136/bmjsem-2023-001557

Used as a motivational tool, Using it to help with motivation,		
Accessability, Engagement, Exercises are transportable, Initiation, Logging into a website presenting an extra barrier, No need for special equipment, Not having equipment to do exercises, Not having space to do exercises, Working all muscle groups,	Accessibility	
Feel that straining more, Get into it as get used to it (gradual), Helpful to see my progress,	Progress	A personalised safe space in which to develop
Positive effects on me, Relaxation after exercise, Harder to sleep after exercise, Feeling happier, Feeling more positive, Impact on mental health	Impacts, emotions and feelings	
don't think too much about how you are feeling as doesnt truly reflect, Exercises make you more aware of what muscles you are exercising, Hard to distinguish how I'm feeling, Impact on core strength, It made me feel less fit than I thought I was, Knowing what I have to work on, Making more aware of stress, Monitoring wellbeing, Proved that I needed to get fitter, Seeing how I'm doing as an aid to wellbeing, self-reflection, Signposting to self,	Self-reflection	

Salman D, *et al. BMJ Open Sp Ex Med* 2023; 9:e001557. doi: 10.1136/bmjsem-2023-001557

Understanding progress, Useful to have information available, Useful to see how I'm feeling,		
Adapting the exercises for myself, Flexibility with exercises, Relevance or tailored for that person,	Tailoring	
Gentle, Graded approach, Not invasive, gives the chance to do it, Steadying hand, Step by step approach is useful, Surrepitious exercise, safe exercises unlikely to cause injury, Non-judgemental,	Gentle/graded	
Own pace no pressure, Permission to not push, Pushing and not pushing,	Pushing/not pushing	
Guiding hand, Impact on fitness, Structured,	Guidance and structure	

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