An action plan for production of the next generation of movement rehabilitation technologies

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Technology promises to revolutionise physiotherapists' provision of movement rehabilitation in the 21st century.

Just consider the increase of publications in PubMed from 24 in 2001 to 415 in 2017 (search terms 'rehabilitation' and 'technology' and 'physiotherapy'; *Figure 1*). The global interest in rehabilitation technology was clearly evident by 2012[2]. Physiotherapists' interest has continued[3,4] driven by clinical challenges such as how to provide sufficient intensity of therapy to improve patient outcomes in the face of increasing financial pressures[5]; over-stretched resources mean that therapists are searching for creative ways to deliver evidence-based rehabilitation[6]. The use of rehabilitation technologies promises opportunities for: increasing intervention intensity[7]; enhancing ongoing assessment and measurement[8]; monitoring adherence to prescribed interventions[9]; improving motivation for participation in rehabilitation activities through enhanced interest [10,11] or immediate biofeedback[9]; providing opportunities for self-management[7,8,10]; provision of intervention in peoples' own environments[7]; enhancing rehabilitation efficiency[5]. All of these advantages are expected to lead to enhanced interventions and outcomes and potential for efficient redesign of existing rehabilitation pathways. Such advantages are within reach, especially as the popularity of smartphones and tablet computers mean that mobile health technologies such as apps and computer games, virtual or otherwise, may be more feasible than ever[10]. Indeed, specific evidence-based apps for stroke rehabilitation are available[12,13]. Yet, widespread everyday use of movement rehabilitation technology is not evident in clinical practice and governance around the introduction of such technology can pose challenges to ensuring a robust safety framework exists[14]. This situation is worthy of further debate.

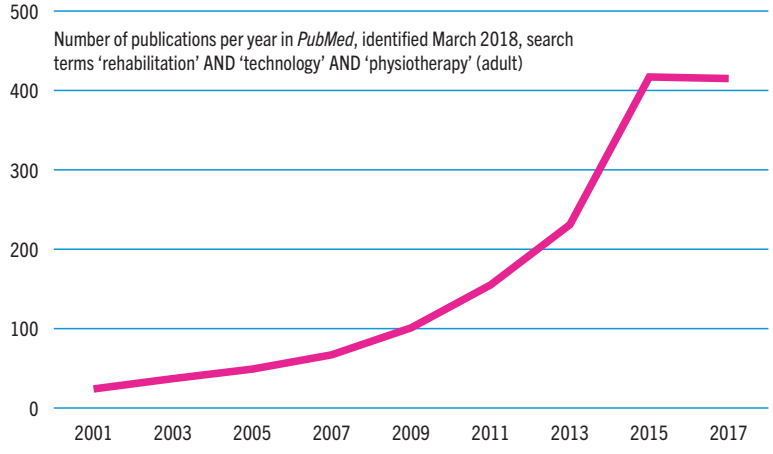

Figure 1 Physiotherapy rehabilitation technology publications per year 2001-2017

So, to explore the current landscape of the use of rehabilitation technology in everyday practice the Acquired Brain Injury Rehabilitation Alliance (ABIRA) hosted a workshop for the East of England section of the Association of Chartered Physiotherapists in Neurology (ACPIN-East; *Appendix 1*). Subsequently, ABIRA and the NIHR Healthcare Technology Co-operative for Brain Injury (NIHR HTC-BI) held a multi-professional workshop that focused on the current landscape for linking research and practice around rehabilitation technology (*Appendix 2*). An action plan for future developments, which emerged from these workshops, is proposed, and we invite comment and contribution on this outcome from the workshops.

The rehabilitation technology innovation and implementation landscape

Despite a wealth of technological advances in rehabilitation in recent years, and the myriad of products commercially available, there is variable uptake and use of new rehabilitation

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technologies by end-users[eg 15], defined here as clinicians, service users, commissioners and social care providers. Part of the challenge is reflected in four categories of knowledge of rehabilitation technologies: non-awareness; awareness; interest; and use[16]. In addition, delegates at both events reported that they experienced a confusing landscape not least because of the multiple stakeholders in rehabilitation technology evaluation and adoption.

Within this current landscape, translating 'laboratory'-generated technology into clinically viable products and vice-versa is multi-faceted. This challenge is not unique to rehabilitation technologies; indeed, it echoes that already described for the two-way translation between findings of fundamental science and clinical practice in neurorehabilitation[17]. In effect, a disconnect exists. This is despite:

- an explosion in the use of accessible, health-related technologies in everyday life eg smartphone apps for health and activity monitoring[18]
- an alignment of the desire to use new rehabilitation technologies with national policy[1,19]
- the knowledge that safe, affordable, well-designed technologies have the potential to meet clinical and service challenges, including optimisation of care pathways for improved patient outcome[20]

The reason for the disconnect between the development and use of rehabilitation technology too is multi-faceted. Not least in importance are the different drivers and timelines of the multiple stakeholders. In addition, engaging with rehabilitation technologies brings its own challenges including: incorporation of rehabilitation technology into evidenced-based clinical services; maintenance of a current awareness of the fast-paced development of ICT-enabled rehabilitation technology[8,21]; understanding of how to combine different rehabilitation technologies for best therapeutic benefit for individuals and for services; and lack of an organised system for provision of rehabilitation technology[7]. Participants in the workshop highlighted their experience that the NHS has a wide variety of service delivery models that are often time- and resource-limited. This is frequently at odds with service users' ambitions for their rehabilitation, who are well-informed about the benefits of therapy and often seek on-going input from neurorehabilitation professionals. This situation has been eloquently articulated by Andrew Marr following his stroke and lack of expert physiotherapy soon afterwards[22]. All of these factors are thought to underlie reports that people participating in rehabilitation do not have access to rehabilitation technology through statutory services and therefore obtain this from manufacturers without any professional advice and guidance[7].

Participants at both workshops expressed a need to diminish, and hopefully demolish, the current challenges to the implementation of evidenced-based rehabilitation technology. But for this to happen, an understanding of best practice for rehabilitation technology design is required, not only by research teams and product design engineers but, more importantly, by those who will be using the technologies on a daily basis. This requires work across agency, professional and institutional boundaries and the development of a shared language to ensure effective communication, from the early generation of ideas, through concept design and onwards to safe implementation.

Best practice for rehabilitation technology design

A solution-focused design should be the primary goal of any rehabilitation technology development process. Moreover, the investment of limited resources should be centred on technologies that have emerged via such a process. The current best design practice stipulates that the 'solution' should be defined by the end-user. Indeed, users should generate the initial questions to underpin prototype developments. Essentially, researchers and engineers need to work with users to design solutions for problems identified by the user themselves- hence we lose 'end-user' and simply engage the 'user' – the end is, after all, far too late for engagement in the technology development and transfer pipeline. This also reduces the risk of 'concept death blows' being delivered far down the design pipeline when considerable resource has already been expended. A joined-up, inclusive, iterative approach to device design and evaluation can result in the generation of rich data to inform every step of the process, from evolving ideas to end product. Indeed, the *Accelerated Access Review*[1] drives clinicians to lead, support and publish clinical evaluation of technologies in real world settings, to facilitate easier access to potentially life-changing innovations for patients. Hence, user involvement must reflect true partnership working, not cursory consultation about an already fixed idea. Usability is key to successful implementation, and usability can only be defined by users engaged to drive development, prioritisation, evaluation and adoption at the earliest stages in the life of an innovation.

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The action plan

Physiotherapists are well placed to contribute to the development of rehabilitation technologies[23]. Indeed, a knowledge-to-action framework has already been used to support

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clinical decision-making for selection and application of Kinect games for individuals [24] and a valid and reliable *Level of Knowledge* survey tool is available [16]. Emphasised is the need to integrate technologies into rehabilitation programmes rather than for stand-alone use[5] and therefore choice of technology requires consideration of: what is important to stroke survivors and their caregivers; that equipment is easy to set up; and that usability is a top priority[25]. However, there is a need to move beyond such frameworks that help with appropriate selection of existing rehabilitation technologies. We propose that what is needed now is truly collaborative, joint working between end-users, product engineers and clinical researchers to develop specific rehabilitation technologies to address rehabilitation needs directly. This innovative approach will avoid the often encountered situation that available rehabilitation technologies were developed primarily for another use[2].

Workshop participants devised an action plan for end-users to work alongside researchers and product designers to form a platform for development and evaluation of rehabilitation technologies (*Figure 2*). Such a plan aligns with current government advice that the NHS must collaborate with innovators to generate valuable evidence of impact and efficacy [1]. The key nodes in the action plan are an ACPIN-East MoveTec group within ABIRA and with NIHR HTC-BI connectivity. Each node has a different key role. The NIHR HTC-BI provides the link to emerging technologies, design engineers and technology producers. ABIRA is the network linking rehabilitation researchers with rehabilitation providers. The MoveTec Group forms the practice test-bed. Essentially, this is a co-production action plan devised to reduce the current translational disconnect and promote experiential learning by all concerned. Arguably of greatest importance is having the potential to

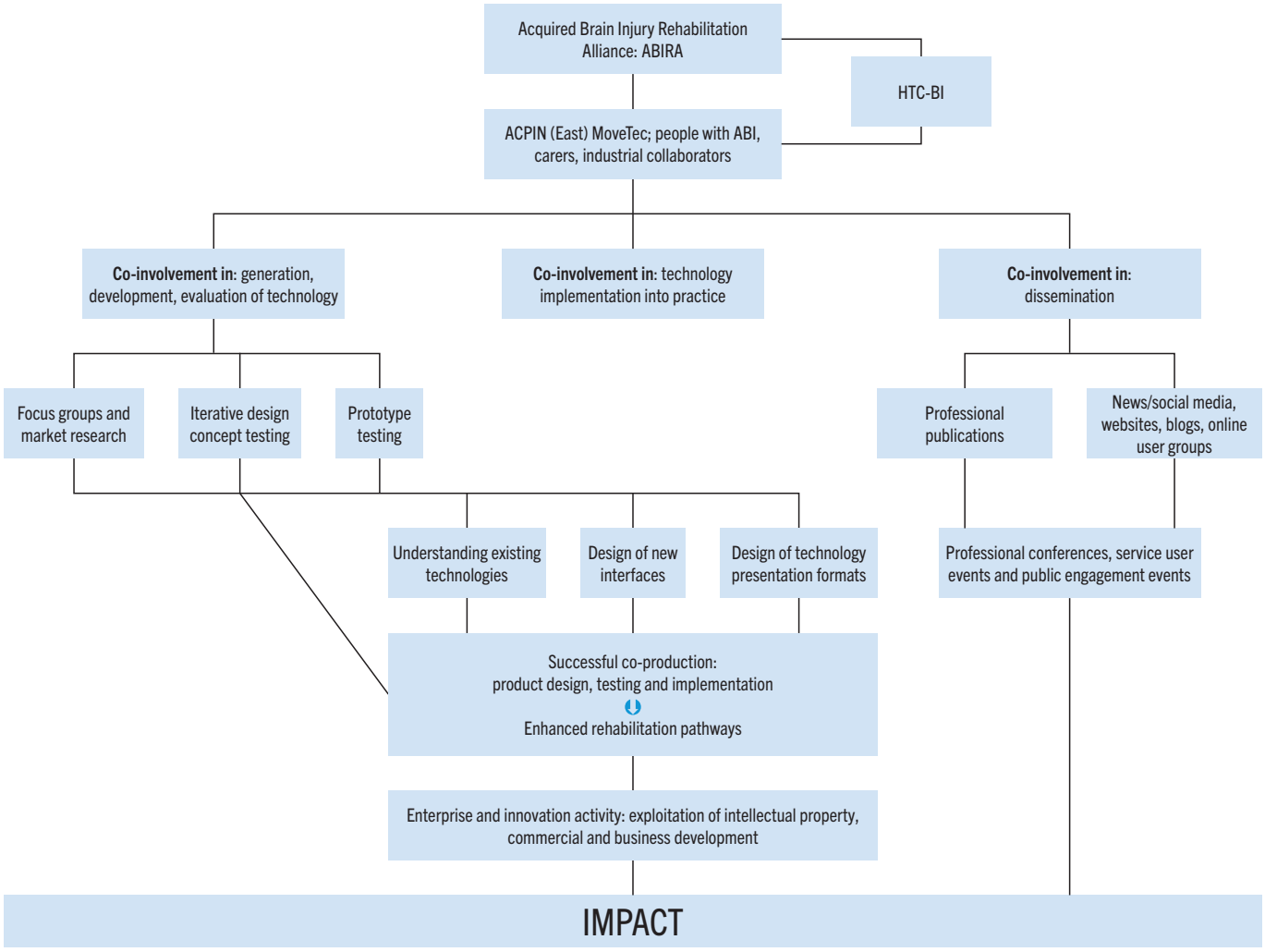

Figure 2 Schematic – a blueprint for the use and development of rehabilitation technology

pool and focus resources on the problems that matter most to end-users.

The action plan has three key areas of activity for an inclusive approach: generation, development and evaluation of rehabilitation technology; implementation of safe and efficacious technology into practice; and dissemination. Recognised is that there is unlikely to be any 'quick fix'. Developing a rehabilitation technology from idea, through to prototype, proof-of-concept, clinical evaluation and finally implementation is likely to take several years. The action plan meets current leading design principles by engaging end-users iteratively in the earliest stages of technology development to ensure that implementation of evaluated technology is optimised.

Next steps

ACPIN East MoveTec is now poised to work within ABIRA and with NIHR HTC-BI to operationalise the action plan. Work is progressing to identify prototype rehabilitation technologies that could be evaluated in real world settings for usability and potential clinical benefit, including optimisation of care pathways. Whatever the results of the initial examination/s there is no doubt that the experience will refine the action plan. Work to date represents initial steps made within one geographical region towards a suite of rehabilitation technology designed specifically to provide solutions to the challenges faced by end-users. It is expected that with use and refinement the action plan would be transferable to other health conditions. To that end, we would be delighted to participate in open conversation and correspondence, via *Synapse* or email to Dr Nicola Hancock, n.hancock@uea.ac.uk, about the proposals herein.

APPENDIX 1

The ACPIN-East workshop

In 2015, the ABIRA team at the University of East Anglia (UEA) hosted the inaugural meeting of the ACPIN-East Movement Technology Cluster (MoveTec), with a follow-up meeting in autumn 2017. ACPIN-East MoveTec consists of clinicians with a special interest in neurorehabilitation and rehabilitation technologies. The inaugural workshop centred on the question: 'What is the role of technology for rehabilitation of movement control and function after acquired brain injury?' Approximately 20 clinical physiotherapists participated in 'café conversations' to focus on the clinicians' views on what was crucial for *delivery* and *measurement* in neurorehabilitation practice, with a particular emphasis on co-creation of new technology. Hence, the meeting engaged clinical partners to generate questions first, then explore possible solutions – the ACPIN members acting as 'technology conduits'. The open discussion allowed the exploration of both tacit and explicit knowledge, enabling a deeper understanding of experiences and views, not only those of the clinicians but also recognising the expertise of the ABIRA team in understanding rehabilitation and recovery. A truly interactive, two-way learning opportunity was exploited.

Participants highlighted that as many clinicians take steps to increase the use of technologies in their rehabilitation practice, they want:

- to know that they have been evaluated rigorously for safety and efficacy and
- to use them for capture of objective performance data.

The latter is key to the measurement of small changes which in turn would allow accurate treatment progression. Therapists wanted data to provide targeted, personalised feedback in a meaningful and accessible manner, thus allowing a common language to be used to discuss and progress interventions and self-management strategies. They recognised the importance of activity monitoring and that user ownership of this evaluation could, potentially, enhance motivation and engagement in the rehabilitation process.

The MoveTec discussion further considered the vital role of informal caregivers in neurorehabilitation and recognised their engagement with rehabilitation technology was an essential consideration in its development. Additionally, it was felt that technology offered a potential solution for service users who do not have carers, by offering alternative support solutions and potential remote access to tracking and support. Technology was recognised as a way of achieving more targeted and personalised rehabilitation, in particular allowing tailoring of input to the appropriate level and providing ownership and autonomy of participation. Members expressed the importance of variety and adaptivity to aid motor learning and increase motivation, and recognised that technologies have a part to play in supporting learning.

APPENDIX 2

The call-to-action event of the Acquired Brain Injury Rehabilitation Alliance (ABIRA)

In June 2016, an interdisciplinary, inter-sectorial 'call to action' workshop on rehabilitation technology was hosted by ABIRA and the NIHR HTC Brain Injury. This subsequent workshop again enabled dynamic interaction between delegates, this time from wider professional backgrounds and organisations. The aims were to explore the landscape for linking rehabilitation technology research and practice, identify opportunities to support innovations, and to determine the actions needed to deliver the development, evaluation and implementation pathway for people with an acquired brain injury.

Participants identified a confusing landscape in terms of the rehabilitation technology development, evaluation and adoption pathway, with many stakeholders involved. This was reported to be further complicated by a mismatch of clinical, academic and industrial timelines and drivers. A key challenge identified was that many technologies have insufficient end-user involvement during the development stage and that this needed to change.

Two key actions were identified centred around strengthening the linkage between ABIRA and the NIHR HTC-BI to:

- enhance bi-directional communication between end-users and rehabilitation technology developers
- identify rehabilitation technology with proof-of-concept and promise for clinical benefit, working collaboratively towards securing sufficient funding for robust cost-effectiveness evaluation.

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