

Is Soft Robotics the Future of Assistive Technology?

A SoRo-Health and TIDAL N+ Joint Seminar, UCL, 13.30-17.15, 10th December 2024

UCL East Management Education. Suite, London E20 2AE

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Background

In 2020, UCL were awarded an EPSRC Platform grant (CI Birchall) to develop the careers of promising researchers in the area of soft robotics for healthcare (SoRo Health). With collaborators at the University of Bristol's Bristol Robotics Laboratory (Rossiter), Imperial College London (Stevens) and latterly the University of Bath (Mehrban), three cohorts of early career engineers, materials scientists and academic surgical trainees had the opportunity to progress their careers through pump priming projects, leadership, development of their own groups and national and international networking. All have progressed to academic independence, including prestigious fellowships, and/or positions in industrial R&D, becoming influencers in this exciting nascent field of translational health science.

In parallel, an EPSRC Network+ grant, TIDAL N+ (Transformative Innovation in the Delivery of Assisted Living products and services, grant number [EP/W000717/1](#)), was awarded to a different group at UCL with collaborators at Salford, Nottingham Trent, Strathclyde and Loughborough universities. The project launched in January 2022 and finished at the end of December 2024. The purpose was to improve the quality of assisted living technologies and hence the lives of the people who use them, their families, carers and communities. The primary aims were to drive problem understanding, identify new research challenges, and co-ordinate, inspire and support underpinning research leading to the development of AT products and services. Key achievements include funding 9 pump-priming feasibility studies (several of which have led to journal publications and/or have been awarded follow-on funding), conducting five rapid reviews to map the AT innovation landscape, running an innovation accelerator for ECRs (early career researchers), and developing a series of videos on inclusive research to promote the involvement of disabled people in AT research and innovation. [Further information on TIDAL N+](#).

The need for assistive technology

Loss of motor function, including mobility, gastrointestinal function, and continence, is one of the biggest healthcare challenges, especially in ageing societies. Mobility is critical to quality of life and impacted by a wide range of temporary or permanent conditions including trauma, physical disability, degenerative disease, frailty, stroke, dementia. Reduced mobility can contribute to social isolation, unemployment, economic hardship and worsening of physical and mental health. Social care costs of immobility are c.£7 billion, weighted disproportionately towards economically weaker regions. Thus, maintaining, restoring, rehabilitating motor functions, then maintaining them through Assistive Technology, is one of the most compelling national and international healthcare needs.

Soft robotics is a bio-inspired field of science based around actuators (parts of devices that move) that predictably deform in response to specific impulses. Impulses may be pneumatic, electrical, or other. Actuator design is material dependent, and effectiveness depends on advanced control and/or sensing, bringing together multiple cutting-edge areas of science. To date, commercialisation and dissemination of soft robots is largely in fields other than healthcare, such as exploration, and military. However, alone or as hybrid devices, they have enormous potential to transform healthcare. Soft robots may offer new solutions to loss of motor functions, including mobility and continence. They may accelerate discharge from hospital, improve speed and quality of rehabilitation, and transform

the safety and experience of living with illness. Few such devices have been commercialised to date, such as hand rehabilitation devices, and although there are many late-stage prototypes in development, clinical trials are rare.

There are many scientific and commercial challenges to be overcome if soft robotics is to fulfil its potential to transform healthcare delivery.

The Seminar

In this Seminar, we brought together people with experience of impaired mobility, clinicians, engineers and tech entrepreneurs to discuss how we can match soft robotics to real needs and push/pull solutions through to help challenged people extend their reach with increased safety.

Workshop 1 asked, “what are the real-world unmet mobility and activity needs of those living with reduced motor function, such as stroke survivors, or those with severe arthritis”. Workshop 2 then matched rehabilitation technology entrepreneurs with engineers and asked, “how do we get new soft robotics solutions to these problems into people’s homes”.

This was an in-person, half day event hosted by two EPSRC-funded programmes spanning multiple disciplines and with national reach: SoRo for Health and TIDAL N+. Thus, the seminar was ideal for anyone wishing to learn more about unmet mobility needs, and the potential health impact of soft robotics, or for those wishing to understand more about the process of moving great assistive technology from the laboratory and into people’s homes. It attracted engineers, scientists, clinicians and those in HealthTech industry as well as persons with experience of disability and those close to them, with a final audience of 80 persons.

Introduction to the Seminar

Martin Birchall, lead for SoRo Health and academic surgeon at UCL, and Richard Bibb, co-lead for TIDAL N+ and Associate Dean of Research for the School of Art & Design, Nottingham Trent University, presented on the importance of and opportunities presented by soft robotics for persons with mobility and other motor issues. This was followed by an overview of soft robotics in healthcare by Jonathan Rossiter, Professor of Robotics at the University of Bristol, with insights into devices at low and high levels of technology development, including “The Right Trousers”, wearable smart material clothing to help mobility. Jonathan also outlined the considerable challenges for translation of this technology, including engineering, control, power, social and ethical issues.

Workshop 1: What are the real-world unmet mobility and activity needs of those living with reduced motor function?

Panel: Jakub Vajner, brain injury survivor, Husnara Begum and Tanya Motie, people with experience of severe rheumatoid arthritis, Anne Lavery, experience of Ehlers-Danlos Syndrome, and Gous Uddin who has right upper limb weakness secondary to brachial plexus injury at birth.

Personal stories

The comments and stories of the panel are here presented uncurated, with permission.

Tanya: lots of devices over the years that has not really helped and has better ideas.

Anne: Explained the effect of Ehlers Danlos Syndrome, with an incidence of up to 1:500 people. As well as motor issues, the GI tract doesn't move.

Husnara: childhood onset of RA. Never really under control. Limited hand and neck movements. When young was anti-gadgets as embarrassing and emotional challenge, but now "bring it on".

Explained the Social Model of disability: it's the environment around me that makes me feel disabled.

Gous Uddin: injury to right brachial plexus in childbirth. Various gadgets that didn't work and was naturally right-handed. Head of consulting for an IT company and has always been interested in building new things.

Jakub: 13 years ago, had a road accident with brain injury. Can understand everything but it is difficult to talk. Now has two children and life had a lot of meaning despite the disability. Had a wheelchair for up to three years. Wants to drive.

Challenges/needs/wants

Tanya: Diagnostics are very difficult. It's really difficult to have smear tests and mammograms. Endoscopies are a big challenge. You also need access to diagnostics to have health care equity. Lack of access to diagnosis is discriminatory.

Anne: Hand manipulation, gripping, holding, pushing a button are generally problematic and can lead to dislocation. Can only walk for 30 seconds. Gripping the throttle is very hard on a mobility scooter and even maintaining the pressure on a wheelchair joystick.

Husnara: Falling is major concern, as cannot get back up again and have had a few of these. Elderly need several people to help them get up. People's partners may also have limitations so cannot always depend on them.

Also, hand movements are a problem, especially repetitive or stable, like holding a phone to the ear or working the wheelchair.

Any kit that helps with personal hygiene, washing back and hair, putting on shoes and socks would be welcome.

Gous: There is much more to life than just your needs, we want to reach beyond that to our "wants". Childcare: lifting and carrying children. Cannot press buttons with right hand anymore. Wants to get back into gaming. Cutting up a steak, which is favourite food.

Jakub: agrees that steak is an annoyance. Driving is a major challenge. Has tried Tesla a few times, "but it is stupid". Charging devices. It is difficult to enjoy sex.

Jakub has toyed with AI: great, but difficult if you have speaking difficulties. Also typing is tough.

Tanya: Driving was a massive part of independence, but car seat for children was tough. Cannot turn the wheel very easily and ankle fusion means you must hover the foot over the accelerator. Having a fused neck means you can't look around you. Something that gave 360-degree vision would make it safe and possible.

Anne: Also issues with driving, with joint slippage if pressing on pedals, also moving the head. Physios are concerned about robots as if you are not using your existing muscles this means they waste, and you lose them. Something that means you still have to use your muscle sometimes is preferable.

Husnara: Wants to be less reliant on the electric wheelchair. It must look good. Aesthetics is a massive deal, especially for younger users, as this will increase uptake and increase the pleasure of using it.

None of us here are profoundly disabled, but people need to think about supporting people with partial/specific problems with ordinary tasks and pleasures.

Gous: Pushing a pram is tough as so many obstructions on the paths, so pushes on the road instead. Need to think about one handed operation of devices.

Jakub: Dyspraxia is really a problem for voice activation as well as for control.

Audience Interaction

Kaspar Althoefer, QMUL: Which is more important: function or aesthetics, and if it's not aesthetic would you not use it?

Husnara: as a youngster where body image is everything, aesthetics is massive.

Tanya: Had orthotic shoes made but daughter laughed as they looked like clown shoes. Didn't wear them to pick her daughter up from school in case she embarrassed her. You don't want to be focus of attention.

Peter, UCL: Its about looking routine and ordinary. 30-40 years ago had a lift device for arm and wanted it to match her wheelchair. We will all need these things when we are older so not just younger disabled people.

Richard Bibb, NTU: A wearable could assist, but also resist in other situations where you want rehab or prevent muscle loss. Walking aids generally work well on the flat, but on rough ground really struggle.

Giacomo, QMUL: How does the feeling connect you with the real world? Sensory input necessary.

Gous: Has no partial sensation only in the right arm, and sensing tech would really improve lots of daily activities.

Jakub: Lacking sensation means falls over, but also cant manipulate properly and also has some hypersensitivity.

Anne: Try unlocking a door with a glove on. That is what is like if you have peripheral neuropathy.

Nicolas, Univ of Sussex: People aren't trying to design things that won't be used. What is your advice to us as we design new things.

Jakub: All the devices he has used have useability issues. So work more with users. E.g. can't get plugs in, batteries run down and charging is really expensive. Magnetic charging would be much better.

Husnara: Wheelchairs and scooters need storage and transport. Ask about cost versus benefit. Also, people ignore solutions that are staring them in the face.

Richard Bibb, NTU: may need different versions of things depending on the setting. Loughborough have a restriction suit to bring it home to designers what it is like having motor limitations.

Workshop 2: How do we get new soft robotics solutions to these problems into people's homes?

Panel: Richard Bibb (Nottingham School of Art and Design), Aalok Rai (UpLyft), Elena Giannicci (Aberdeen), Kaspar Althoefer (QMUL)

Elena: The focus of her contribution was on adaptability and re-usability of soft robotic devices. She presented the example of a soft robotic wearable device for upper limb rehabilitation that exploited the inherent adaptability of soft actuators for adaptability. The wearable device uses a soft pneumatic actuator that does not need precise fitting on the user's arm. This is an advantage of soft robotics because often rigid exoskeletons need their joints to be perfectly aligned with the biological joint. This is not a requirement for soft robotics wearable devices that bend throughout their bodies.

Because of this adaptability, the wearable device could be used in co-design and feedback sessions where users with different arm lengths and arm size could all wear the same device. This work showed the adaptability of wearable soft robotic devices.

The importance of the co-designing and feedback sessions for the improvement of the device was also highlighted. The sessions highlighted the importance of ease of donning and doffing of the device, comfort and perceived safety.

The work also stressed the importance of receiving not only the feedback of end users but also the feedback of the clinicians and carers who will need to learn how to use the soft robotic device before using it with end users. Their feedback is of great importance to improve the usability and adaptability of the design.

Kaspar: Extending from Elena's overview of her soft robotic wearable device for upper limb rehabilitation, Kaspar introduced the exoskeleton glove that was developed at QMUL. During the panel session, Kaspar focussed on explaining the function of the soft exoskeleton glove. In particular, he explained how air pressure can be used to bend the fingers of the fabric-based exoskeleton glove and how this, in turn, bends the fingers of the user inwards. The main use of this device is to provide physical assistance to the user in picking up and handling everyday objects. The device is also suitable for rehabilitation allowing the user to strengthen their muscles when opening their hands against the pressure developed by the device.

The device is made from soft fabric and highly compliant and hence suitable for different people adapting to different hand sizes whilst allowing a comfortable wear. During the panel session, Kaspar supported by his colleague, Cem Suulker, did a live demonstration of the prototype developed and its function became apparent, by inflating the glove it bent Kaspar's fingers. Discussion points were on aesthetics, ease of putting the device on the user's hand and how to integrate with daily activities.

After the panel session, Kaspar and his team gave attendees of the workshop the opportunity to try the exoskeleton glove. Vital feedback was provided on how to improve the fit for the user's hands and to ensure that the applied pressure does not create any pain to the user. Overall, the device was seen as comfortable to wear and to have the potential to provide assistance with grasping objects.

Richard: Discussed the importance of a fully user-centred approach, recognising the psychological, social and economic needs and desires of not only the primary user but also their clinicians, carers, families, friends, employers, etc. He explained how devices that originated in technology push rather than user pull often fell into the development “valley of death” as they were too expensive, overly complex or failed to match users’ needs or expectations.

An example was given where patient choice had a positive influence on acceptability and compliance with orthotics such as wrist splints for arthritis sufferers. The ability to choose pattern and colour and to have multiple products for different situations was essential to users but not previously economically feasible but advances in parametric computer-aided design and 3D Printing now made this feasible. This example also emphasised the need to co-create with clinical specialists to harness their expertise and use new technologies to improve quality, speed, efficiency and cost rather seeking to have technology for its own sake.

He closed by encouraging the researchers present, especially early career researchers, to embed themselves in users’ and clinicians’ environments and adopt methods that enable co-creation / co-design and engagement throughout the research, development and evaluation stages of a project.

During the discussion with the audience, Martin invited David Buckley, R&D at Duchenne UK, to describe the development of an arm support device and the challenges that they encountered. This again highlighted how early testing of prototypes and listening to the opinions of potential users is vital.

Discussion of the day and future direction

Martin Birchall
Husnara Begum
Richard Bibb
Jonathan Rossiter

Martin: Day provided a brilliant overview of individual and general impairment challenges given by patient panel and reflected in questions. Far-ranging. Social model introduction for engineers and clinicians was really important.

Husnara: The people behind behind the tech need more end-user engagement. Social networks, not for profits, providers, people dealing with people with chronic illnesses/post-trauma. Any community that will make that interaction real is really needed. Students at the meeting had a distorted idea of what someone with a disability is like prior to listening to the panel.

Husnara: Education is needed: balance between curing and helping people live with the disability.

Survey engagement is low and people express extremes of views so you need to go to a diverse range of people, and be mindful of bias.

There is a societal lack of understanding of how each disability impacts life in very different ways. Most engineers do not understand the health conditions that they are trying to navigate. Who are they trying to help? Otherwise chasing rainbows.

Patient forum should be assembled to progress these proposals but how do you choose, and how do you cover the range?

Richard: One of the key aspects of a future network would be to deliver exactly this. Put researchers into homes, clinics, hospitals.

Industrial design and human factors community can be the interface/interpreters. There are lots of designers out there who do exactly this work. There are people who do that out there.

Husnara: There is also a lack of understanding about the commercial world. I have worked in this all my working life. e.g. a smart trousers idea similar to that developed by Jonathan. The developer is working in sport as there are far fewer regulations in the sports world. Who is the end consumer? What are the margins?

At the moment, private equity is crawling all over med tech. The health sector is being steadily commercialised. But you cannot launch tech without consumer work.

Martin: We should design a Dragon's den session at next meeting to bring in more commercialisation awareness?

MB: So such a network should focus on the REAL: two worlds to interact people with disability and commerce. (Maybe throw the third domain of surgery and endoscopy in as well).

Richard: NIHR healthtec research centre Dan Clark UH Nottingham. Keen to do joint events. Based around innovation from fundamental into clinical application, so good chance to build communities between rehab community and engineers

EMERGE: Place based rehab accelerator with Nottingham Trent: startups and translation to industry. The two are inter-connected. John Hunt in med tech innovation facility leads this. Starting in the Spring 2025.

TIDAL N+ Team are meeting soon to discuss what comes next, as all the legacy communities from the programme's work aren't going away and the work needs building on.

Another Network + application could be proposed at the intersection of soft robotics and rehab. Working with those who worked with TIDAL and with a previous rehab N+ grant in Nottingham and Empower, VIVO, EMERGE. This would provide funds and network development to make a really big impact.

Husnara: I have a wide breadth of commercial/corporate experience, married to personal and family experience of disability. Happy to assist as (working title) Special Advisor on disability, for example.

Anne: I urge engineers/designers who wanted feedback on ideas, or to test out prototypes, to get in touch directly with charities representing people with disabilities. Ehlers Danlos Support UK is very happy to circulate calls for research participants. (this in response to comments that it can be very difficult and cumbersome to go through the NHS).

Meeting close

Meeting closed with plans for further planning meetings and focused seminars