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| **ITU-T Focus Group on AI for Health** |
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| **Purpose:** | Discussion |
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| **Abstract:** | We propose a new topic group for the "Artificial Intelligence for Health" project. The topic group will focus on the prevention, triage, diagnosis, prognosis and treatment of musculoskeletal (MSK) conditions with the applications of artificial intelligence and machine learning (including computer vision and augmented reality). Painful MSK conditions affect up to 33% of the world's population, while lower back pain has been the single leading cause of disability for a long time [1]. Applications of AI and technology have the potential to enable more affordable, accessible and accurate diagnostics, prevention and care for people worldwide. |

# Overview

We propose to create a topic group to focus on prevention strategies, triage[[1]](#footnote-1) (in particular identifying urgency), diagnosis, prognosis and treatment of musculoskeletal (MSK) conditions with the applications of artificial intelligence (AI) and machine learning (ML) approaches including computer vision (CV), augmented and virtual reality (AR/VR), natural language processing (NLP)/understanding and other approaches.

**Primary prevention:** early risk assessment, prognosis, risk detection of MSK trauma/deterioration and movement deficiencies using ML, CV, NLP to parse a patient’s input, as well as to incorporate existing electronic health records (EHR) and data analysis (including data from wearables with the patients’ consent).

**Triage and diagnosis:** assist in identifying the causes of a patient’s signs and symptoms including pain, with the use of chatbots and similar approaches as for **primary prevention**.

**Treatment:** use of AI with CV and AR to enable self-management and, where clinician's guidance/oversight/involvement is required, to assist in such management. AR and CV technology provide more effective treatment and improve patient engagement and experience with the help of speech-to-text and text-to-speech capabilities (in combination with the use of common technology by showing exercise reminders for example).

We suggest using topic group names interchangeably depending on context: “AI for MSK”, “AI for MSK Medicine”, “MSK” and “MSK Medicine”.

# Relevance

Painful MSK conditions affect 20-33% of the world's population [1]. According to the WHO, “MSK conditions are the leading contributor to disability worldwide, with low back pain being the single leading cause of disability globally. ... MSK conditions significantly limit mobility and dexterity, leading to early retirement from work, reduced accumulated wealth and reduced ability to participate in social roles. The greatest proportion of non-cancer persistent pain conditions is accounted for by MSK conditions. ... MSK conditions are commonly linked with depression and increase the risk of developing other chronic health conditions” [1].

Up to 30% of consultations carried out by primary care doctors in the UK (as an example) are for MSK conditions [2]. Together with the worldwide shortage of health professionals (including doctors and physiotherapists) [3], it is clear there is a pressing need to introduce, support and grow the potential use of reliable, safe, accurate solutions powered by AI and ML which is evidence-informed and co-produced with lived experience. This need exists across the world and the solutions must be accessible and affordable in order to provide universal coverage. The latter is especially important in the light of existing inequalities: AI applications have the power to reduce them but it also should be ensured that they do not worsen any inequalities.

There have been several developments in the last few years that are particularly relevant for this area:

* The development of the next generation of CV and NLP techniques. (In particular, recent CV technology that allows fairly accurate pose recognition using just one camera e.g. a smartphone camera, without the need for special equipment.)
* The spread of mobile devices with high-resolution cameras and with powerful microprocessors.
* The spread of wearable technology and the resulting accumulated data.

# Impact

Artificial intelligence and technology has the potential to enable more affordable, accessible and accurate diagnostics, prevention and care for people across the world who are either at risk of developing, or who have existing MSK conditions.

The use of AI for MSK conditions and physiotherapy (physical therapy) could provide (and is already doing so in limited, early settings) rapid access to the required prevention and care for the patients in need, especially those patients in some regions or countries who can't currently access such care. It also facilitates the work of clinicians, for example by identifying accelerated exercise-informed rehabilitation pathways and improving objective testing of patient movement abilities using CV and AR capabilities. In addition, it has the potential to reduce the burden on clinicians and healthcare systems by autonomously (or semi-autonomously in sync with clinicians) providing patients with triage, diagnosis, or treatment care where appropriate — allowing clinicians to focus on more complex or less typical presentations and other clinical work. This is especially important at present, because of the global shortage of health professionals [3].

It is vital to develop and maintain a set of diversified and robust benchmarks to ensure accurate, safe, scalable solutions that are applicable for different patient groups with varying needs, depending on their specific MSK conditions.

# Existing Work

There are several companies and academic groups that focus on this area of work.

Different companies and groups work on different parts of clinical work (e.g. prevention, triage, treatment) and are usually *limiting* their present solutions to specific sub-areas of MSK medicine. The *limiting* happens naturally as it is still a new sub-field and it takes time and gradual effort to come up with and deploy solutions.

# Public Preparatory Meetings

Two public preparatory meetings have been conducted[[2]](#footnote-2) to help facilitate this proposal and the formation of this topic group. The goals of the meetings were as follows:

* To overview and discuss existing and emerging applications of AI and ML for MSK medicine.
* To brainstorm and scope out the vision, preliminary aims and objectives for this proposed topic group.
* To initiate the conversation and start establishing the network for this proposed topic group (including for the potential future membership).

Participants contributed by giving talks, comments and feedback both during and after the meetings.

The meetings were chaired by Andrew Bennett, an independent MSK expert. Andrew Bennett is a Health and Care Professional Council registered physiotherapist, member of the Chartered Society of Physiotherapy and a member of the Musculoskeletal Association of Chartered Physiotherapists. Andrew's current roles include being a Consultant Physiotherapist leading a community MSK service in London and National Clinical Director of Musculoskeletal Conditions at NHS England and NHS Improvement. The meetings were organised by Yura Perov, Kate Ryan and Peter Grinbergs with Andrew Bennett.

The preparatory meetings were attended by over 25 participants in total (not including the organisers). The participants were from private, public and other sectors and from different countries (including Canada, Denmark, Finland, Peru, UK, and US; there were also meeting registrants who expressed interest from other countries as well, including India and Saudi Arabia). The participants’ companies/institutions/organisations included[[3]](#footnote-3): AHI, Aparito, Back 2 Fitness, CAREM, Connect Health, Curaguard, Digital Health.London, dna, EQL, Imagine It If Marketing, Immersive Rehab, Joint Academy, organisations within the National Health Service (UK), prIME Assessments, Radiobotics, Soter Analytics, Southampton Football Club, the University of Hertfordshire, the University of Piura, the University of Warwick, United Nations Technology Innovation Labs - Finland, Vita Health Group and Yonah Fund.

More information about the preparatory meetings can be found here: <https://docs.google.com/document/d/1AjUEnobU_pDA3yWqP3RnedwB1jFB9wTp5wOJ4us6OGo/edit>

# Themes identified from the public preparatory meetings

Musculoskeletal Medicine (MSK medicine) is the diagnosis, prognosis, treatment and prevention of issues originating from the muscles, bones and joints of the limbs and spine. MSK problems are numerous, ranging from simple sprains to complex pain conditions and managing them well requires a biopsychosocial approach (which involves working with the whole patient and not just their biomedical aspects).

From a global perspective this complexity is compounded by interregional variability, not just in terms of the causes, risk factors and management of MSK conditions, but also in terms of psychosocial elements. For example, differing perspectives on pain, disability and expression of emotion.

This presents a significant challenge for the proposed AI for MSK group when creating benchmarks/guidelines for AI solutions. To be ‘fit for purpose’ anything designed by the group must have an overarching framework flexible enough to accommodate this interregional variability.

For such flexibility to be achieved, it will be essential for the ‘hard’ data aspects of AI creation to interface directly with the ‘lived experience’ of local patient communities and clinicians. Keeping open dialogues will also help with education to address barriers to adoption of AI technologies, such as patient tech literacy and clinician scepticism.

Safety and risk management need to be the one of the primary considerations for benchmarking. Whatever the AI focus there is a need to ensure serious conditions e.g. cauda equina syndrome can be identified and appropriate action taken as a result.

Following on from the above, sources of bias in AI products need to be identified and minimised (which may require multiple iterations to balance). For example, to what extent do risk factors reinforce bias and how strongly should they be weighted?

It is also very important that the AI for MSK group is led by the growing evidence base surrounding MSK conditions and pain management. Pain is one of the primary motivators for people to seek help for MSK conditions and is often given significant weight as an outcome measure by both patients and clinicians. However, current pain research has shown that too much focus on pain is detrimental to recovery and ‘threat’ reduction and functionality are more useful metrics to go by.

Lastly, facilitation of closed loop feedback from across the global MSK/AI community (including data scientists, biomechanists and clinicians), is vital to inform improvements to the current systems and best practice management.

# Feasibility

We believe the work that this topic group is proposing is feasible. The scope of the work is already partially covered elsewhere, but this topic group will help to facilitate it and cover the remaining parts.

The work of the topic group could be guided by the following directions:

1. Scoping the existing and emerging applications of AI for MSK medicine.
2. Looking for new topic group members and facilitating the collaboration between existing topic group members.
3. Facilitating the aggregation, publication, processing (including anonymisation) of data for training and testing.
4. The creation of benchmarks (including prototypes and guidelines) and support of the benchmarking process.
5. The creation and support of guidelines for reliable, interpretable and explainable AI applications in MSK medicine.

# 6-9 Data Availability, Data Quality, Annotation/label quality, Data Provenance

To the best of our knowledge, there is generally no publicly available data for the training or testing of AI for MSK and physiotherapy applications.

There is however a lot of non-publicly available data held by different entities including public and private medical bodies, academic and research institutions, and private companies. There is also a significant amount of data for training and testing AI algorithms for similar applications (e.g. for human pose recognition without specific clinical applications). One of the functions of the topic group could be to facilitate the collection, publication and processing of such data.

The participants of the preparatory meetings (as discussed above) stressed the important opportunities for this topic group to facilitate and co-lead the data sharing between different parties for AI for MSK applications.

For benchmark development and usage, it is important to consider approaches, which have part of the benchmark process conducted in live environments (or in similar settings). That can be conducted only assuming it is fully safe and regulated.

As part of the topic group, it is important to ensure that guidelines cover requirements for unbiased data that represents regional variability.

# Benchmarking

The table below shows the possible applications of the AI for MSK medicine and physiotherapy and the possible benchmark details.

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| **Application** | **Type of Data** | **Metrics / What to Benchmark** |
| MSK Risk Prediction and Prevention | Longitudinal datasets.Datasets of patients with their medical history.Wearables data collected for a long time.Video datasets of patients' movements and similar multimedia. | Predicting the chance of developing a condition and of risk reduction/prevention. |
| Triage and Diagnosis, including Clinical Support[[4]](#footnote-4) | Datasets including patients' signs, symptoms and medical history — including EHRs from primary care, secondary care and physiotherapists.Photo/video datasets of patients' objective tests (such as the ability to move their neck), patients' movements and their visual signs (such as bruises) and symptoms. | Predicting the differential diagnosis and accurate and safe triage. |
| Treatment Determination | *Similar to the above.* | Predicting an appropriate, accurate and safe treatment plan based on a patient's history, signs, symptoms, triage & diagnosis (if any). |
| Treatment Follow-up | *Similar to the above.*Continuous records of a patients’ history, treatment and outcomes. | Predicting the appropriate, accurate and safe adjustments to, or progressions of (if any), treatment plans. |
| Treatment / Injury Management, in particular Physiotherapy (Physical Therapy) exercises | AI/ML models of treatment (e.g. decision trees).Patient data.Photo/video datasets where patients are performing physiotherapy exercises. | Accuracy and safety of treatment models.A patient's accuracy in performing physiotherapy exercises and any modifications to the treatment plan (for example in relation to possible adjustments in the treatment plan if a patient struggles with the current level of exercises).Outcomes of the treatment plan (including patient recovery, pain reduction, etc.). |
| Data Collection, Extraction & Management; Analysis of Electronic Health Records (using NLP, CV, optical/intelligent character recognition) | Text/structured records/images/videos.Clinical ontology and classification. | *To be identified as part of the topic group.* |

# Other applications might be identified and studied as part of the topic group, including: Robotics; Medical Devices that use AI/ML; and Virtual & Augmented Reality.

While we would like to start the work of the group with scoping all major existing and emerging applications, it is appropriate to expect that it is likely that this topic group will focus on 1-2 significant applications (at least at the beginning), e.g. on MSK Risk Prediction and Prevention and/or on MSK Treatment / Injury Management.

Evidence-based clinical outcome measures need to be embedded (alongside the AI specific ones), throughout all the applications listed above. These are necessary to ensure the efficacy of any treatments offered by AI applications are recorded in a clinically meaningful way. A range of qualitative and quantitative metrics will be required, which are both body site-dependent and independent. For example, base quantitative metrics such as treatment duration (body site-independent) are required to facilitate inter-condition and inter-application comparison. However, condition-specific outcome measures are also necessary to capture relevant changes in quality of life and function, e.g. range of motion, strength and the Keel Start Back Tool [5] (a well validated metric for collecting prognostic indicators of low back pain).

# Organiser

EQL is a digital health-tech organisation based in London, UK, which focuses on MSK conditions and physiotherapy. EQL’s product, *Phio Access,* provides a conversational AI-enabled digital solution to support triage for MSK conditions. EQL is currently working on its next-generation products, with the extended application of AI and ML techniques for MSK medicine and physiotherapy.

Yura Perov is Head of AI and Data Science at EQL. Yura is a Chartered Scientist, Chartered Mathematician, Member of the Institute of Mathematics and its Applications, and Professional Member of the British Computer Society. He has studied and carried out research in Computer Science, AI and Mathematics at the University of Oxford, MIT, EPFL and Siberian Federal University. Yura was previously a senior research scientist at Babylon Health, co-leading the development of the AI-triage/diagnostics product for primary care which was utilised by Babylon, Samsung and Prudential worldwide. Yura has been contributing as a member of the Symptom Assessment topic group of the ITU/WHO focus group AI for Health.

Peter Grinbergs is a Co-founder and the Chief Medical Officer at EQL. Before EQL, he founded two medical companies (including a nationwide physiotherapy chain) and was CMO for a large medical reporting agency. Peter is a Member of the Chartered Society of Physiotherapy, where he sits on the Digital and Informatics Physiotherapy Group. He is also on the Health and Care Professions Council. Under his direction, his company, Physio 1st, grew from a single site to a team of over 50 people across 35 locations in 20 major cities, delivering in excess of 50,000 physiotherapy treatments a year. Earlier in his career, Peter was Birmingham City FC team’s physiotherapist for two years (a season in the Championship, followed by a season in the Premier League).

Kate Ryan is MSK Data Science Clinical Expert at EQL. Kate is a chemistry academic, turned MSK physiotherapist. She studied and conducted research at the University of Southampton, the University of Oxford, Argonne National Laboratory and King's College London. Over the course of her doctoral and postdoctoral work, Kate has co-authored numerous highly-cited research papers and several successful grant proposals.

# A. References

[1] "Musculoskeletal conditions" on WHO website. <https://www.who.int/news-room/fact-sheets/detail/musculoskeletal-conditions>. Accessed on the 24th of June 2020.

[2] "Musculoskeletal" page on NHS England website. <https://www.england.nhs.uk/elective-care-transformation/best-practice-solutions/musculoskeletal/>. Accessed on the 24th of June 2020.

[3] "Health workforce requirements for universal health coverage and the Sustainable Development Goals", Human Resources for Health Observer, Issue No. 17. <https://www.who.int/hrh/resources/health-observer17/en/>

[4] Joseph, C., Morrissey, D., Abdur-Rahman, M., Hussenbux, A. & Barton C., 2014. Musculoskeletal triage: a mixed methods study, integrating systematic review with expert and patient perspectives. Physiotherapy, 100 (4). pp. 277-289.

[5] Hill, J.C., Whitehurst, D.G., Lewis, M., Bryan, S., Dunn, K.M., Foster, N.E., Konstantinou, K., Main, C.J., Mason, E., Somerville, S. and Sowden, G., 2011. Comparison of stratified primary care management for low back pain with current best practice (STarT Back): a randomised controlled trial. The Lancet, 378 (9802), pp. 1560-1571.

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1. Note that there are other definitions, in particular in relation to MSK medicine [4]. One task of the topic group is to define and investigate this further. [↑](#footnote-ref-1)
2. Note: the meeting was organised and sponsored by EQL Limited, a company registered in England and Wales (UK), registration number 11806513. [↑](#footnote-ref-2)
3. Note that the countries and companies are listed based on the registrants’ information and to the best of knowledge. [↑](#footnote-ref-3)
4. This particular application is also related to the work of the topic group on Symptom Assessment, with which we expect to collaborate closely. [↑](#footnote-ref-4)