Short communication, special issue: A global approach to healthy ageing

Wearables beyond boarders: A case study of barriers to gait assessment in low-resource settings

[1]A Godfrey, [2]C Aranda, [3]A Hussain, [4]ME Barreto, [5]T Rocha, [6,7]R Vitório

[1]Department of Computer and Information Sciences, Northumbria University, Newcastle upon Tyne, UK
[2]Medical Physics and Biomedical Engineering Department, University College London, London, UK
[3]Institute of Translational Medicine (ITM), University of Birmingham, Birmingham, UK
[4]Computer Science Department, Institute of Mathematics and Statistics, Federal University of Bahia, Salvador, Brazil
[5]Department of Business Administration, Faculty of Economics Federal University of Minas Gerais, Belo Horizonte, Brazil
[6]Department of Physical Education, São Paulo State University, Rio Claro, Brazil
[7]Department of Neurology, Oregon Health and Science University, Portland, OR, United States of America

Corresponding author
Alan Godfrey BEng, PhD, MBA
Dept. of Computer & Information Sciences
Northumbria University
Newcastle upon Tyne
NE1 8ST,
United Kingdom
Email: alan.godfrey@northumbria.ac.uk
Phone: 0044 191 2273642

Word count: 1177/1000

References: 10/5

Keywords: inertial sensors; informatics; low-resource; objective assessment;

Abstract (unstructured, 121/100 words):

Currently, there are major EU-based projects funded to better utilise wearables as useful diagnostic aids/tools in clinical settings as well for deployment in the home to capture habitual ageing processes. To date, there is little investigation to discuss the translation of those tools beyond the geographical regions in which they are developed and implemented. Our objective was to examine pragmatic issues/challenges facing use of wearables in a diverse low resource, middle-income country like Brazil. We found barriers to their understanding and adoption converge on three themes: (i) regional inequalities; (ii) knowledge and resources and; (iii) trust. Current large scale projects should consider the scalability and implementation of their methods given those themes, facilitating a stratified and global approach to healthy ageing.

1.0 Introduction

Wearable technologies are reshaping healthcare and transforming approaches to how patients should be diagnosed, treated and managed. Wearables are enabling healthcare professionals to break free from the shackles of traditional approaches to assessment, monitoring beyond the clinic [1]. Habitual assessment with wearables can provide objective, continuous (and big) data, revolutionising approaches to common practise compared to snap shot, clinical assessments. Accordingly, wearable healthcare data is perceived as an extremely valuable resource, described as the new blood [2].

Recently, low-cost inertial wearables have leapt to clinical attention within ageing studies by enabling quantification of functional activities, e.g. balance and gait [3]. The latter is being used to investigate habitual-based digital biomarkers in diagnostic or predictive medicine [1]. Recent launch of large multisite studies such as Mobilise-D [4], a collaborative project between academia and the pharmaceutical industry to deliver a valid solution for real-world mobility through wearable gait assessment, is seen as a game changer. But what challenges would future tools and techniques (e.g. those developed in Mobilise-D) face when used beyond the geographical regions in which they are developed? The aim of this work is to raise pragmatic challenges facing adoption of inertial-based wearables as gait assessment tools for healthy ageing. Here we focus on low-resource settings by examining a case study of a middle income country[1], Brazil.

2.0 Methods

A qualitative study design was used to gain insight into basic challenges associated with inertial-based wearable adoption for pragmatic use in clinical and research settings in Brazil. Semi-structured interviews using open-ended questions were undertaken with clinical and research staff, to understand experiences and explore reasons for lack of wearable adoption and development in multidisciplinary studies (appendix A). Rigour in the design and reporting of the study is based on the RATS framework [5].

An initial interview guide was developed based on tacit knowledge and experiences of two researchers (AG, RV). Drafts were produced until the researchers were satisfied with the content and phrasing of the questions and prompts posed. Each interview lasted approximately 45minutes and were conducted at the Department of Physical Education, UNESP, Rio Claro, Brazil. The researcher (AG) introduced himself, explained the study and obtained written consent from all interviewees. Questions were posed in English using open ended language and in accordance with the semi-structured nature, varied in phrasing and order posed with each participant. Where interviewees failed to fully understand questions, a second researcher (RV) translated into Portuguese. Responses

[1] Defined by the Development Assistance Committee (DAC) list of official development assistance recipients

were recorded using an audio device to better understand responses that needed to be translated (by RV) during interviews.

Interviewees were multidisciplinary, bilingual (English, Portuguese) researchers with clinical backgrounds in physiotherapy and neurology, where one had technical skills in data analytics and algorithm development. Both had research experience (5-10years) pertaining to the development and application of inertial wearable in clinical research from different geographical areas throughout Brazil and Europe.

3.0 Results

Those interviewed mainly worked with older adults who experience mobility issues resulting in poor gait and falls, including those with a neurological condition. There were three main themes uncovered during analysis.

Regional inequalities: Wealth, culture and education

This theme captured technology attainment and acceptance when considering variations between regional states such as wealthier southern states (e.g. São Paulo) compared to poorer northern states (e.g. Amazonas). Accordingly, cultural and educational (e.g. language and health) barriers were raised where use of wearables amongst adults to assist clinical diagnosis where perceptions were that they could be met with hesitation and uncertainty. For example, physiotherapy is believed by patients to be therapeutic only, rather than a need to understand underlying neurological symptoms evidence from other nations.

"*They* (the patient) *don't understand what assessment is. What are you doing, hooking this device on me asking me to walk? This is physiotherapy*"

Knowledge and resources

Topics relating to robust assessment and quantification of the complete gait cycle to generate clinically relevant digital biomarkers were discussed. It was generally assumed that there is a complete lack of appreciation for this research within Brazil due to a dearth of professional networks to permeate information. Current mechanism to upskill are at the discretion of the individual only.

"*I think, physiotherapists in Brazil don't understand the, how important it is to have very precise outcomes, that's the issue*"

Furthermore, those wanting to complement clinical practise with academic innovation are met with collaboration barriers and timely administrative delays, systematic within Brazil. Approaches to multidisciplinary and integrated work are lacking.

"*…and another thing in Brazil, is that, engineering is so far away from health.*"

Trust and reference standards

The profound factor influencing use of wearables for gait assessment is "*trust*". Current knowledge of gait assessment extends to use of reference standards only (e.g. instrumented walkways). Ad-hoc and heterogeneous development of wearables, including a plethora of algorithms to quantify gait stemming from EU and US-based studies, has resulted in apprehensiveness for those familiar with the field. Additionally, cost associated with commercial wearable systems are beyond budgets while lower cost device lack inbuilt analytical platforms for ease of use.

4.0 Discussion

Large middle-income countries like Brazil have obvious challenges given geographical spread and extreme variations between urban and rural life, economic and social factors (Figure 1). Uptake of technology, even those detailed as low-cost, will have significant cost implications when considered at scale which may be beyond any realistic use. Yet, adequate use of wearables in Brazilian-based clinical settings will ultimately depend on integration to information and communication technology infrastructures, which although still limited, have advanced in recent years [6].

There seems to be disparities between professions within Brazil and a need to instil a culture of multidisciplinary teams working towards the development and deployment of wearables to aid healthcare. Perhaps lack of joined up thinking, negatively impacting shared knowledge for healthcare professionals, contributes to failings to better understand how gait and other traditional assessments could be objectively quantified. Integrated approaches and more collaborative efforts between (e.g. healthcare and engineering) professions could lead to greater innovation, stimulating sharing of knowledge to further economic growth for this economy [7].

Given the complexity of normal or pathological gait analysis, abundance of devices, wear locations and complex algorithms developed ad-hoc [8], it is little wonder why wearables lack trust. Typically, gold/reference standards have been the accepted norm, benefiting from a legacy of historical use originating from expensive equipment and used in elitist settings only. Efforts by projects such as Mobilise-D seek to harmonise the field of wearables by developing agreed standards with regulators to establish a new international basis for disease-specific and cross-condition digital biomarkers. Although difficult to disseminate technology, approaches to share knowledge of how gait could be assessed with wearables may be achieved through multilingual massive open online courses (MOOCs), recently discussed within Brazilian contexts [9]. Global approaches to utilising MOOCs are evidenced through recent dementia care [10]. Additionally, more stringent efforts to guide validation

and verification processes with wearables [11] should instil trust, facilitating more pragmatic gait assessment approaches to define healthy ageing in any global region.

Figure 1: From the Brazilian motto "Ordem e Progresso", order and progress may be achieved in the use of wearables as clinical tools by improved education on the use of technology but faces challenges in a geographical and socially diverse country. Creation of multidisciplinary projects/institutes, better sharing of knowledge/ideas and global initiatives to enable agreed translated standards on wearables and arising digital biomarkers is key.

Contributors

AG and RV contributed to the study design and interviews. AG and RV analysed the data and drafted the manuscript with input from CA, AH, MEB and TR. RV translated Portuguese phrases into English. Each author contributed to revision of the manuscript as well as agreeing and approving the final text.

Funding

The Royal Academy of Engineering (RAoE) funded this study through it Frontiers of Engineering seed funding tranche 6 (FoESF1819\T6\21). The RAoE was not involved in the study in other respects.

Ethical approval

The Faculty of Engineering and Environment, Northumbria University research ethics committee granted ethical approval (Ref 9203). Participants gave written informed consent, agreeing to anonymised direct quotes being presented in this text.

Acknowledgements

We are grateful to the Royal Academy of Engineering for funding this study and the volunteers who participated.

References

1. Del Din, S., et al., *Analysis of Free-Living Gait in Older Adults With and Without Parkinson's Disease and With and Without a History of Falls: Identifying Generic and Disease-Specific Characteristics*. The Journals of Gerontology: Series A, 2019. **74**(4): p. 500–506.
2. Perakslis, E. and A. Coravos, *Is health-care data the new blood?* The Lancet Digital Health, 2019. **1**(1): p. e8-e9.
3. Godfrey, A., et al., *iCap: Instrumented assessment of physical capability*. Maturitas, 2015. **82**(1): p. 116-22.
4. Mobilise-D. *Connecting digital mobility assessment to clinical outcomes for regulatory and clinical endorsement (Mobilise-D)*. 2019 [cited 2019 15 July]; Available from: www.mobilise-d.eu.
5. Clark, J., *Peer Review in Health Sciences*, ed. F. Godlee and T. Jefferson. 2003, London: BMJ Books.
6. Matta-Machado, A.T., et al., *Is the Use of Information and Communication Technology Associated With Aspects of Women's Primary Health Care in Brazil?* J Ambul Care Manage, 2017. **40 Suppl 2**: p. S49-s59.
7. Wolniak, R. and M.E. Grebski, *Innovativeness and creativity of the workforce as factors stimulating economic growth in modern economies*. Zeszyty Naukowe. Organizacja i Zarządzanie/Politechnika Śląska, 2018.
8. Del Din, S., et al., *Free-living monitoring of Parkinson's disease: Lessons from the field*. Mov Disord, 2016. **31**(9): p. 1293-313.
9. Brites, L.S. and C.M.F. Rocha, *Massive Open Online Health Courses (MOOCs): Brazilian Initiatives*, in *The Internet and Health in Brazil : Challenges and Trends*, A. Pereira Neto and M.B. Flynn, Editors. 2019, Springer International Publishing: Cham. p. 297-311.
10. Newcastle University. 2019 [cited 2019 Nov 25]; Dementia Care: Staying Connected and Living Well]. Available from: www.futurelearn.com/courses/dementia-care.
11. Goldsack, J.C., et al., *Verification, Analytical Validation, and Clinical Validation (V3): The Foundation of Determining Fit-for-Purpose for Biometric Monitoring Technologies (BioMeTs)*. npj digital Medicine, 2020. **In Press**.