What are the relevant measures of balance to inform human health research?

Genevieve KR. Williams[1], Naser Taleshi[1,2], Xiaohan Xu[1], William Young[1], Matthew Smith[2], Sallie E. Lamb[2]
[1] Dept. of Public Health and Sport Sciences, University of Exeter Medical School, Exeter, UK
[2] University of Exeter Medical School, Exeter, UK
Email: g.k.r..williams@exeter.ac.uk

Summary

The aim is to present and discuss the efficacy of commonly used and state-of-the-art methods of quantifying balance performance of humans. The purpose is to openly consider the pros and cons of the variety of methods available and to debate with the ISB community how, or whether indeed we should, reach a consensus on the metrics of balance performance used in health contexts to facilitate future meta-analyses.

Introduction

There are many areas of health research where quantifying balance performance is necessary to provide insight into functional motor control. For example, one important area is that of falls and fall risk, particularly for the ageing population. To date, interventions for preventing falls have predominantly prescribed exercise to improve strength, or multi factorial falls prevention approaches. There is resounding evidence for the low levels of effectiveness of these interventions [1, 2]. Recently, a high-quality pragmatic trial (>14,000 participants) reported that exercise had a modest, short-lived (4-month) effect on falls, but did not reduce fractures, while multi factorial falls prevention has no effect on falls or fractures [1]. The conclusion ensues that we need new approaches to preventing falls [1]. However, outcome measures based on fall events and resulting injuries are influenced by many random and extraneous factors.

Randomized control trials, where collecting data is challenging based on high participant numbers infer that balance can be assessed via the timed up and go (TUG), and Berg balance score (BBS) [e.g. 3]. However, TUG is not directly assessing balance in a mechanical sense, while BBS is assessed qualitatively. Both biomechanically and practically, balance and balance recovery strategies are key to reducing falls and increasing functional capacity in older adults and others for whom reduced functionality is related to poorer health and quality of life.

Gaining a mechanistic understanding of balance is complex, controlled by the proper integration of information from the vestibular, proprioceptive and visual systems leading to a successful balance control or recovery strategy executed by the neuromuscular system in a timely fashion.

In biomechanics, we have many measures of human balance performance and control. This talk will discuss the efficacy of these measures for use in large scale health research.

Results and Discussion:

Tasks: Balance function is commonly measured in both static (standing) and dynamic (e.g. walking) situations. These activities are reflective of those performed in daily life. However, they do not stress balance capacity, and trial-to-trial or within-trial variation in balance or walking strategy can occur due to redundancy in the system. Increasing task difficulty can be used to push the system into using a consistent strategy that demonstrates the limits of balance control, for example, balance with maximal lean. To further increase complexity, and to provide a task where a response to a suddenly unstable balance situation is presented, the use of mechanical perturbations is a growing area of research. For example, challenging balance and balance recovery with unanticipated underfloor motions during standing or walking. A key question here is, how close are individuals to the limits of their balance control?
Other tasks include performing certain movements (with dual tasks) with or without biofeedback, for example, moving the CoP through a certain path or tasks instructed through exergame. These examples raise questions on the efficacy of using self-generated vs externally generated motion and which is more likely to be related to functional balance performance, as well as the task specific nature of outcomes.

Measures of balance: We measure balance at different levels of the system, for example macro levels such as CoP or CoM (relative to BoS) motion, through kinematics and joint kinetics, to micro levels such as the onset of muscular response after a perturbation. At each of these levels there are plethora of different metrics presented in the literature, each related to the task being performed. Still, the issue remains, what level of the system do we measure, and how do we deal with intra- and inter- individual variability in responses?

Figure 1: Link to Padlet page for sharing ideas!

Conclusions

Considering the multidisciplinary underpinnings for fall risk, we need to consider as a community what the best biomechanical and neurophysiological measures of balance are, that are practical for larger scale data collections.

Acknowledgments

Funded by ERC Advanced Grant STEPPING OUT. Supported by Uni. of Exeter Biomedical Research Centre.

References

[1] Lamb, S et al. (2020). *N Engl J Med*, ***383*(19)**: 1848-1859.
[2] Bhasin, S et al. (2020). *N Engl J Med*, ***383*(2)**: 129-140.
[3] Papalia GF et al. (2020). *J. of Clinical Med*, 9.8: 25.