INTRODUCTION

The cost of poor health has in recent years caused an extensive economic burden to the state as expensive laboratory measurement methods are heavily relied upon. As we make effort to lower this cost researchers attempt to identify ecological real world techniques, which can monitor health indices on a day to day basis, whilst still being cost benefit. One such technique which has been identified has been the use of low cost inertial sensors such as accelerometers, gyroscopes and combined units. These units have been successfully utilised in home rehabilitation methods, in silver age technologies to detect falls (Nyan et al. 2008) and extensively in the measurement of physical activity levels across all age groups. Due to their success, nowadays a large market of inertial sensors are available to the researcher or diagnostian with various types on offer in terms of size, site of attachment, data collection type and data output. However, this enhanced choice therefore leads to an increased need to investigate on a sensor-to-sensor basis how feasible specific inertial sensors are when applied to longitudinal data collection.

![Image 1. Shimmer™ inertial sensing unit.](attachment:image1.jpg)

CURRENT RESEARCH & SENSOR CHALLENGES

In recent years there has been a shift in the purpose of inertial sensors. Whilst inertial sensors have been extremely dominant within the physical activity measurement realm nowadays we are seeing more research’s utilise them for their more basic format, acceleration. Recently, as part of a larger study, Shimmer™ 2r accelerometer (with combined gyroscope daughterboards) units were utilised in longitudinal data collection with varying results.

A popular inertial sensor designed to measure movement patterns in multiple positions of the body this study involved 2 Shimmer™ 2r units being worn up to 4 times a week for varying amounts of time generally lasting ~25 minutes. During this time subjects undertook moderate to vigorous activity (running). Whilst these units are carried within a lightweight, plastic casing allowing for a robust outer unit, inner processing board tact switches failed and needed replacement on numerous occasions. These switches provide the on/off switch for the overall sensor therefore leading to loss of data collection periods, vital in longitudinal studies. Along with this the units are decreasingly “user friendly” in terms of data collection procedures compared to other available units. Subjects are reliant on their understanding of LED lightings which occur on the unit to inform them as to whether the unit is turned on, collecting data or idle. This led to confusion during data collection as participants became familiarised with the units LED patterning. Also, as part a smaller pilot study it was investigated to see how subject inertial sensor self attachment compared to tester attachment and also how reliable subject sensor attachment was overtime. It was felt this would mimic public health measurement as many studies are subject led in terms of data collection. A single subject experiment examined how reliable a subject was at replicating sensor placement on the lower tibia on Day 1, 24 hours post Day 1 and 48 hour post Day 2. It also investigated as to also how valid the subject attachment was compared to when the tester attached the sensor. Sensor tilt angle was calculated and results showed that subject-tester attachment angle differences reached up to 14°, whereas subject reliability scores displayed greater consistency with a lesser range of 1.3° - 8.9° over the three testing sessions . This angle altercation is something which researchers must be aware of when analysing output data as it will alter parameters over longitudinal studies.

In terms of data output Shimmer™ 2r units also require an extensive amount of programming knowledge in terms of data extraction and parameter identification. Shimmer units output occurs in raw data signal which whilst calibrated to gravity is not represented in counts or METS and such parameters must be calculated through self created algorithms to deduce information. Depending on researcher skill level this can add a considerable amount of time to research dissemination and must be factored in prior to undertaking research.

FUTURE USES

Whilst challenges can arise when using inertial sensors in this manner there are also many advantages. For one, the output of raw data. Whilst requiring extensive analysis raw data can also be a major advantage within data collection as this allows for an increased amount of versatility in terms of the parameters identified. It means that researchers are not limited when analysing data and can allow for further investigation into patterns which may arise. This also increases the sensors uses across a range of activities. For example when attached to the lower leg an accelerometer which outputs raw data can divulge a range of parameters such as:

- Stride Time
- Ground Contact Time
- Peak Tibial Acceleration (see Figure 1).

![Figure 1. Sample data showing beginning of CT (small circle) and end of CT (large circle).](attachment:figure1.png)

Compare to this an inertial sensor which outputs METS or counts. This will tell us how much activity is occurring but not what is occurring within this activity.

CONCLUSIONS

Whilst inertial sensors will have an increasing role in public health measurement careful consideration must be undertaken when choosing the correct unit. Of vital consideration are the “user friendly” properties of the unit to increase application and validity of results. It is clear that subjects are more inclined to adhere to studies which utilise sensors which are easy to use and maintain whilst also minimising any impact upon the subjects activities. Also researchers should be aware of data output limitations.

REFERENCES


ACKNOWLEDGEMENTS

We would like to thank the Education and Health Sciences Department for funding this research.