INTRODUCTION
Pylon force transducers as an instrument for the biomechanical analysis of human gait were introduced together with the force plate in 1952, but were used in rare cases mainly due to accuracy and size limitations. The Intelligent Prosthetic Endoskeletal Component System iPecs™ (CPI 2012), is the first commercial compact load cell designed specifically for the direct measurement of amputee gait. In this study we underline a technical bottleneck in the interpretation of information collected by the iPecs device based on extensive application of this tool in different study designs. On the grounds of this, a method to improve upon the accuracy and deliver appropriate device calibration is presented so that the tool can be appropriately applied to very different clinical protocols.

METHOD

Subjects: One bilateral and six unilateral transtibial amputees participated in this study (Age: 65±16 years, body mass: 86±20 kg, body height: 176±7 cm, stump length: 15±4 cm).

Apparatus: All patients were fitted with both a Total Surface Bearing and an Elevated Vacuum system and with the iPecs™ device.

Procedures: All patients were asked to perform at their self-selected speed the Amputee Strenuous Activity (ASA) protocol which covers the most important tasks a person encounters in everyday life (Papaioannou et al. 2011).

Data Analysis: More than 3.4 million measurements were gathered for a total period of approximately 1.5 hours. For every sample the angle between the vectors of force and moment was calculated using the following formula which offers the greatest accuracy:

$$\theta = \arctan\left(\frac{F \times M}{F \cdot M}\right)$$

RESULTS
By definition the vectors of moment and force are perpendicular. Therefore the calculation of the angle between the load cell measurements can offer a way to verify its accuracy. The results of this study are summarised in figure 1 where the vector angles are presented as a function of the magnitude of the measured force normalized with respect to the patient’s weight. Based on this figure it can be easily concluded that the vectors of force and moment are not perpendicular for a large percentage of measurements. The variance of these angles is higher for the lower values of force where noise can greatly affect the output, but also for the values near the maximum technical specifications of the device.

DISCUSSION & CONCLUSIONS
In this study the accuracy of direct amputee prosthesis force and moment measurements was examined using as a tool the angle between the two vectors. The results prove the agreement between the iPecs™ accuracy and its technical specifications but more importantly underline a useful method for decreasing the instrument’s errors. The processing mechanism of the device can include this theory and thus create a self-correcting feedback loop that will increase the accuracy of the load cell. This will enhance the fidelity of clinical gait analysis for studies investigating prolonged mobility in the community only possible with the use of iPecs™. Another useful application can be in the initial calibration of the device as this rule can further optimize its results and therefore improve the total accuracy of the device.

CLINICAL APPLICATIONS
Improvement of iPecs™ accuracy and enhancement of its initial calibration process.

REFERENCES

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