

# PREDICTING THE ANTERIOR-POSTERIOR COMPONENT OF GROUND REACTION FORCE FROM WEARABLE INSTRUMENTATION

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## INTRODUCTION

Force platforms, embedded in the surface of a runway, are the 'gold standard' contact measurement technique for the collection of ground reaction force (GRF) data during running. However, this technique requires that data is collected in a laboratory environment and factors such as targeting and limited successive foot contacts restrict the knowledge that can be gained by this form of instrumentation.

In recent years the availability of miniature electromechanical transducers suitable for the construction of wearable instrumentation have become available. Such transducers have been used to measure the distributed GRF at the foot-shoe interface (in-shoe pressure) and measure acceleration in three orthogonal components from a site approximating the subject's centre of mass (CoM acceleration). However, there are a number of difficulties in relating measurements from these transducers to anterior-posterior (AP) GRF as their output is not directly related to this component of GRF and the transducers themselves are mediated by the subjective conditions in which they are applied.

To circumvent the individual disadvantages of both GRF and wearable instrumentation a method based on the application of artificial neural networks (ANN) in conjunction with both forms of instrumentation has been

proposed (Savelberg, & de Lange, 1999). An ANN can be likened to a flexible mathematical function, which has many configurable internal parameters (Chau, 2001). To accurately represent complicated relationships between wearable instrumentation and the AP component of GRF, these internal parameters are adjusted through an optimization or learning algorithm.

The purpose of this research is to investigate the accuracy of this proposed method using different forms of wearable instrumentation: In-shoe pressure (4 inputs), CoM acceleration (3 inputs) and a combination of the two (In-shoe pressure & CoM acceleration). The development of such a technique would enable the assessment of braking and propulsive forces from wearable instrumentation in a training and competition environment, which is currently not possible.

## METHODS

Data was collected from four elite middle distance runners, running at an average velocity of  $6.13\text{ms}^{-1}$  along a runway with embedded Kistler force plates. Running velocity was measured instantaneously as the subject crossed the force plates using a laser system. Force plates were separated by an appropriate distance in order to obtain consecutive foot-falls from each foot.

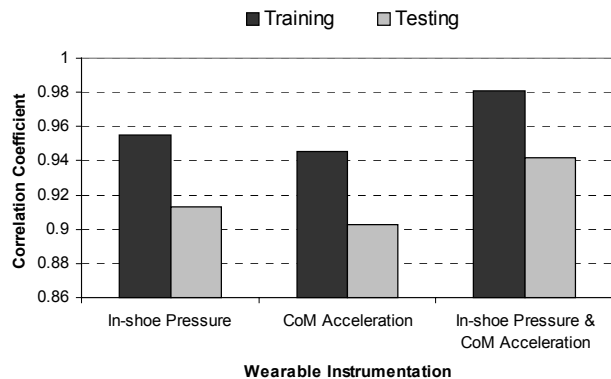
Custom microprocessor based wearable instrumentation has been developed to sample eight channels of in-shoe pressure and three channels of CoM acceleration simultaneously at 500Hz per channel. Discrete in-shoe pressure sensors were positioned at the heel, first metatarsal head, third metatarsal head and hallux of the subjects left and right foot. A three orthogonal component CoM acceleration system was incorporated into a semi-elastic belt and fastened around the subject's waist so that the sensor system is pressed onto the medial lumbar region.

Matching AP GRF and wearable instrumentation data sets were aligned and trained by an optimized three layer feed-forward back propagation ANN. Upon completion of the training process the network is presented with new data from the wearable instrumentation with which it attempts to predict (testing) AP GRF. The application of the ANN technique described herein has been tested on an intra-subject level only. That is training and testing files were from the same subject. To evaluate the accuracy of the ANN predicted AP GRF by each form of wearable instrumentation and the actual GRF measured by a force plate a correlation coefficient (CC) was calculated. Correlation coefficients above 0.90 were considered to be good.

## RESULTS AND DISCUSSION

Figure 1 illustrates the correlation coefficients achieved in training and testing using different forms of wearable instrumentation. In-shoe pressure & CoM acceleration provided the most accurate prediction of AP GRF (CC 0.94). The correlation coefficients for in-shoe pressure (CC 0.91) and CoM acceleration (CC 0.90) alone were above 0.90.

The results from this study indicate that AP GRF can be predicted from wearable instrumentation. The improved prediction accuracy seen for In-shoe pressure & CoM acceleration is likely to be due to the increase in input parameters to the ANN.



**Figure 1:** Wearable instrumentation correlation coefficient for the prediction of AP GRF

## SUMMARY

These findings indicate that the AP component of GRF can be predicted from wearable instrumentation and provides the possibility of determining braking and propulsive forces in a competition and training environment, which is currently not possible.

## REFERENCES

- Savelberg, H.H.C.M. & de Lange, A.L.H. (1999). *Clinical Biomechanics*, **14**, 585-592.  
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## ACKNOWLEDGEMENTS

The authors would like to thank the Cooperative Research Centre for microTechnology and the Australian Institute of Sport for funding this research.