Dynamic postural control via smartphone

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There are about 265 million active football players around the world [1]. As a sport that requires good dynamic postural stability, there is an increased risk of anterior cruciate ligament injuries. The TTS App wants to help individuals monitor their dynamic postural stability for better primary and secondary prevention.

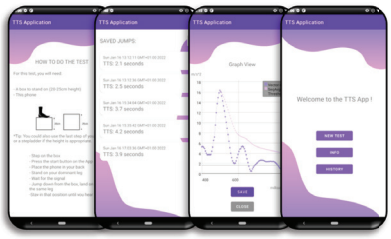
Background

A good dynamic postural stability (DPS) is key to the safe practice of many sports. A lack thereof can quickly lead to injury. One way to measure dynamic postural stability is to perform a Time To Stabilization (TTS) test, which involves jumping and stabilizing on one leg.
TTS tests are typically performed in laboratories, with expensive force plates. This reduces the accessibility to such tests and limits their widespread use. A recent master thesis explored the possibility of using inertial measurement units (IMUs) instead of force plates, paving the way for TTS testing in a lighter and more affordable setting [2]. It is still unknown whether sensors of a smartphone are sufficient to calculate reliable TTS test results. To address this question, we implemented a prototype that calculates the TTS using the integrated accelerometer of a smartphone. In this work, we investigated the validity and usability of our prototype.

Method

Our prototype calculates the TTS in three steps:

- When a test is started, the prototype records data from the phone's accelerometer for 15 seconds and computes the vector norms (VN) of the x, y and z components.
- The data is cropped to only retain 0.5 seconds before and 12 seconds after landing.
- The sequential average (SA) of the VN series is computed and a threshold is set at 18 times the standard deviation of the VNs in the last 5 seconds. The TTS corresponds to the time needed for the SA curve to fall below that threshold. When this happens, the person is considered stable.



Extracts of the TTS prototype

TTS tests were performed in a comparative study in the Bern Movement Lab using simultaneously a force plate, an IMU and smartphones with our app prototype. R and RStudio were used for analyzing the generated data. The TTS obtained with the various sensors were compared to one another by means of Bland-Altman plots. A visual inspection of the acceleration curves was also performed for results that stood out, to ensure the data was not erroneous. Finally, a usability test was carried out with the participation of ten test subjects.

Results and outlook

According to the usability test, the prototype is clear and easy to use. The appearance of the prototype was also discussed, and the feedback was used to reconsider the general design.
The comparison of our prototype's results to the ones produced by the force plate and the IMU showed that small variations in the algorithm had a strong impact on the results. It follows that a TTS measure is only really meaningful in comparison to other TTS values generated in the same way. Using the same device each time would ensure that the differences observed are indeed due to a change in DPS.
This is exactly what could become possible if our prototype were to be further developed: Allowing for anybody to monitor their DPS over time, with a simple test protocol and their smartphone.

References

[1] Alentorn-Geli et al., Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 1: Mechanisms of injury and underlying risk factors. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. Juli 2009;17(7):705–29.
[2] Rohrer, Eichelberger, Intraday and Interday Reliability and Validity of an Accelerometry-Based Assessment of Dynamic Postural Stability, Bern University of Applied Sciences, Department of Health Professions

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