Borgions Paul MsC Podiatry
Developer of the "BorgInsole®" Functional Foot Orthotic
Biomechanist for Belgian Football club KRC Genk (Champion 2010-2011)



Introduction

Paul Borgoins has been a Biomechanist for more than 25 years and is also the developer of the BorgInsole®, a functional foot orthotic. BorgInsole® is a patent pending insole which is based on the Root functional foot orthotic. Paul is using the dynamic axes of the subtalaar joint to design the BorgInsole® Functional Foot orthotic. (based on a 3D scan of a loaded subtalar joint neutral footprint.) Therefore Paul has spent a lot of time observing the subtalar joint and has learnt that the more you can see, the more you can measure, and the better you can understand and treat problems.

Within his state of the art indoor gait lab he uses 4 synchronized Dalsa GigE High-Speed cameras', which can record at up to 350 fps. The cameras are set up to capture both aspects of the sagital and frontal planes (sagital left, sagital right, frontal anterior and frontal posterior) around the treadmill. A 5th camera is positioned directly above the treadmill to capture videos in the transverse plane during walking and running. As well as the hi-tech gait lab set up, Paul also has an artificial grass area and running lane, equipped with a Casio Exilim high-speed camera, which can capture at 300fps,600fps and 1200fps

Paul's aim was to observe in a clinical setting the subtalar joint aixis, therefore contacted Quintic Consultancy with hopes to collaborate on the existing software and produce something specific to measure the subtalar joint. Quintic have been able to optimize the Quintic Biomechanics 9.03 v17 Video analysis Software by integrating a novel method to measure the subtalar joint angle by using a 4 point calculation which measures the moving angle between two lines. In the case of the subtalar joint, the bisection of the calcaneum and of the tibia.

The difficulty in this observation is the changing angle between the bisection and the camera, in comparison with a sagitale plane analyzing video (cfr sagitale knee or ankle flexion-extension).

Case Study:

Tom is a young football player with a history of left ankle instability and ankle inversion trauma.

With literature showing that the highest incidence of injury occurs during ankle inversion at the initial contact phase of gait within football players, this area needs to be thoroughly analysed.

Methodology

The subjects subtalar joint is put into a neutral position and measured, reflective markers that can be automatically tracked by Quintic Biomechanics V17 video analysis software are then applied to the subject . A two marker cluster is positioned on the tibia and another two marker positioned on the posterior aspect of the calcaneum fixed on the bisection of the tibia and calcaneum with the subtalaar joint in his neutral position.

For the data analysis, High Speed Dalsa Gig E cameras were configured to capture at 100fps focused horizontally on the sagital and transversal plane. The camera was positioned 1.5 m behind the treadmill. For the walking trial the treadmill was set at a speed of 4 km/h and for running (11 km/h). For each walking and running trial seven complete gait cycles were recorded for statistical analysis.

Illustration 1a: Marker position set-up for the barefoot trial.

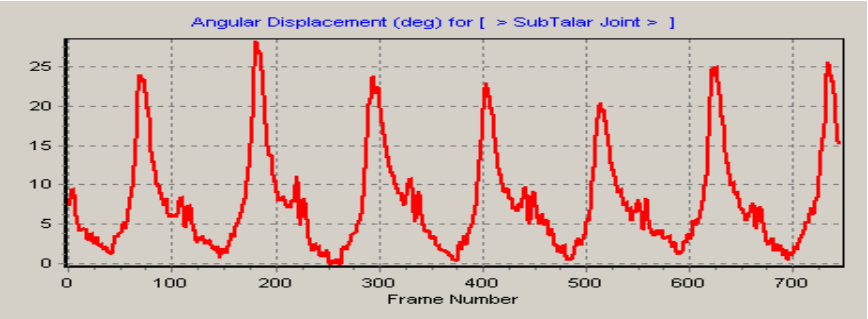
Statistical Analysis

Kinematic data was collected using a High Speed Dalsa Gig E camera filming the subject from a rear view. Filming was conducted at 100fps and a shutter speed of 1/1000. Reflective markers were attached to the subject at the subtalar joint. Marker placements were determined by joint palpation and identification of anatomical land marks.

A Hedler (1000w) lamp was positioned behind the camera to ensure the markers were clearly visible.

The videos were opened in the Quintic Biomechanics Software and heel strike and toe off were identified. After calibration, the videos were then automatically digitized, due to Quintic's accurate and quick automatic tracking system 700 frames (7 gait complete gait cycles) could be easily and accurately tracked.

Results: Barefoot Condition



Graph 1 : Quintic Biomechanics Graph Export of Subtalar Angular Displacement During 7 Complete Gait Cycles

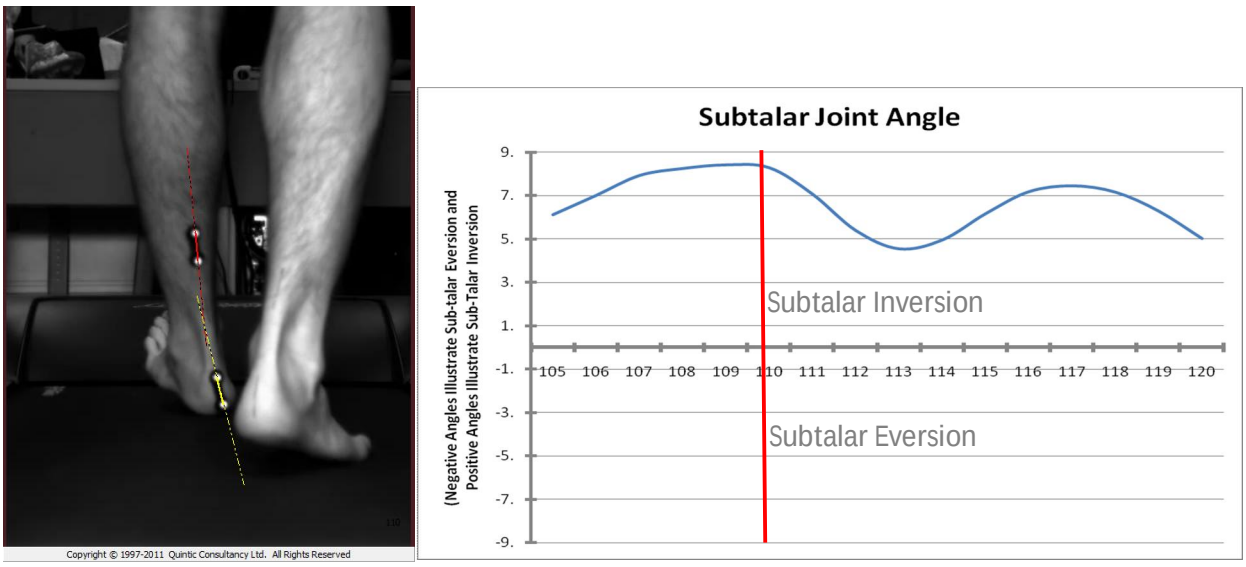


Illustration 1 and Graph 2: Subtalar angle at point of contact (heel strike) from one gait cycle.

(Red line on graph indicates point of heel contact)

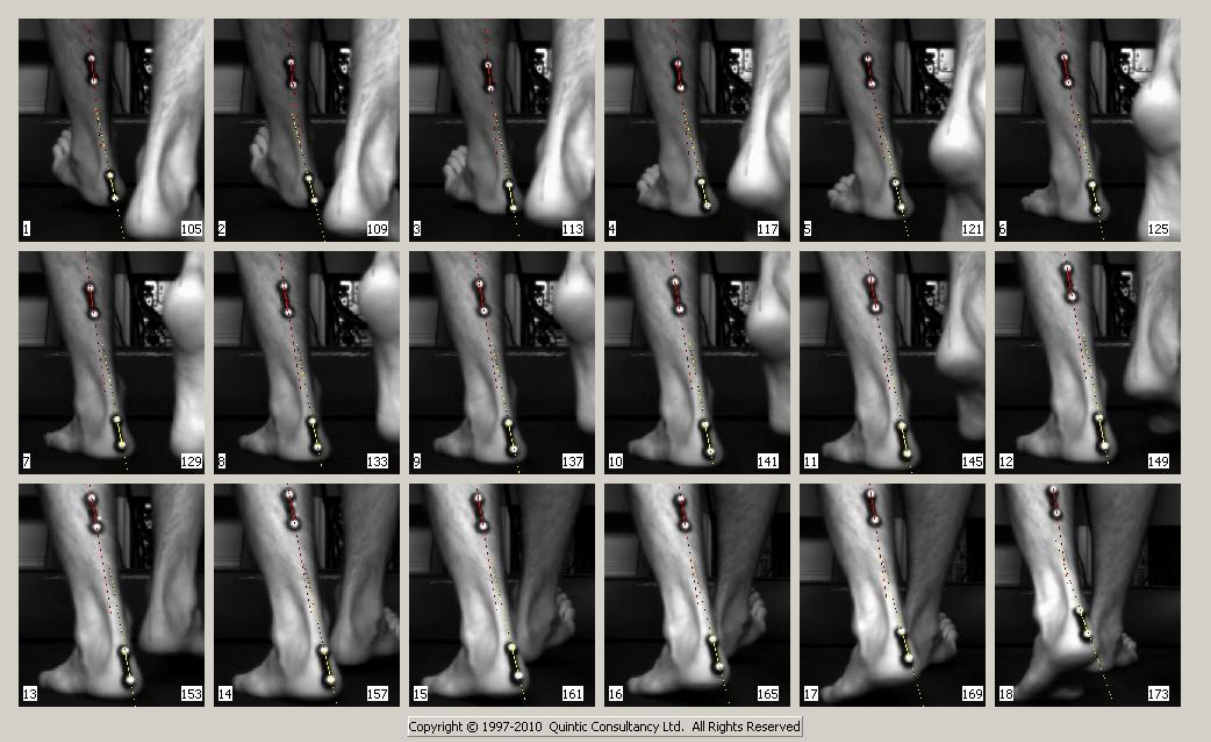
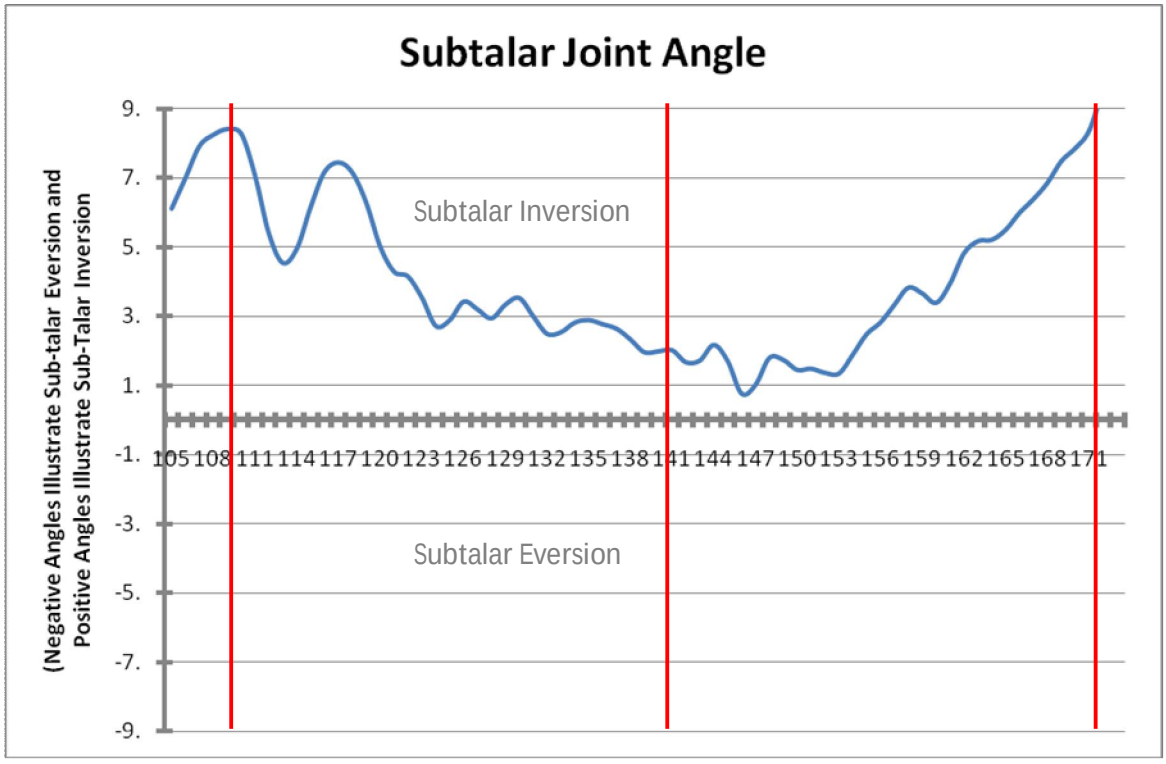


Illustration 2: Quintic multi image capture highlighting 18 specific points of the left foot stance phase of one gait cycle.



Graph 3: Angular Displacement of the Subtalar angle during the stance phase of the left foot. (First red line indicates heel strike (foot contact) frame 109 in illustration 2, second red line indicates midstance, frame 141 in illustration 2 and the third red line indicates toe off (last contact) frame 173 in illustration 2

The data analysis as well illustration 1 and graph 2 reinforce that there is significant subtalar inversion at heel strike, for each step. When looking at the complete stance phase graph 3 and illustration 2 illustrate that during the stance phase of the gait cycle the subtalar joint remains in an inverted position.

Borginsole Condition

By recording the subjects walking and running gait using the Dalsa Gig E cameras at 100fps in both sagital and coronal planes and executing a full biomechanical analysis, (joint angles, stride lengths, stride frequencies, limb alignments etc, BorgInsole® Insoles were prescribed.

Once the BorgInsole® insoles were fit into the subject's daily footwear the same walking and running trials conditions were repeated from the barefoot condition (Walking at a speed of 4 km/h and running at a speed 11 km/h on the treadmill). The markers on the tibia stayed on the same place as the test before, and the markers placed on the rear heel of the shoe in the same position as the calcaneum markers has been placed in the barefoot trials.

Illustration 3a: Marker position set-up for the Borginsole condition.

Results: Comparing Barefoot and Borginsole conditions

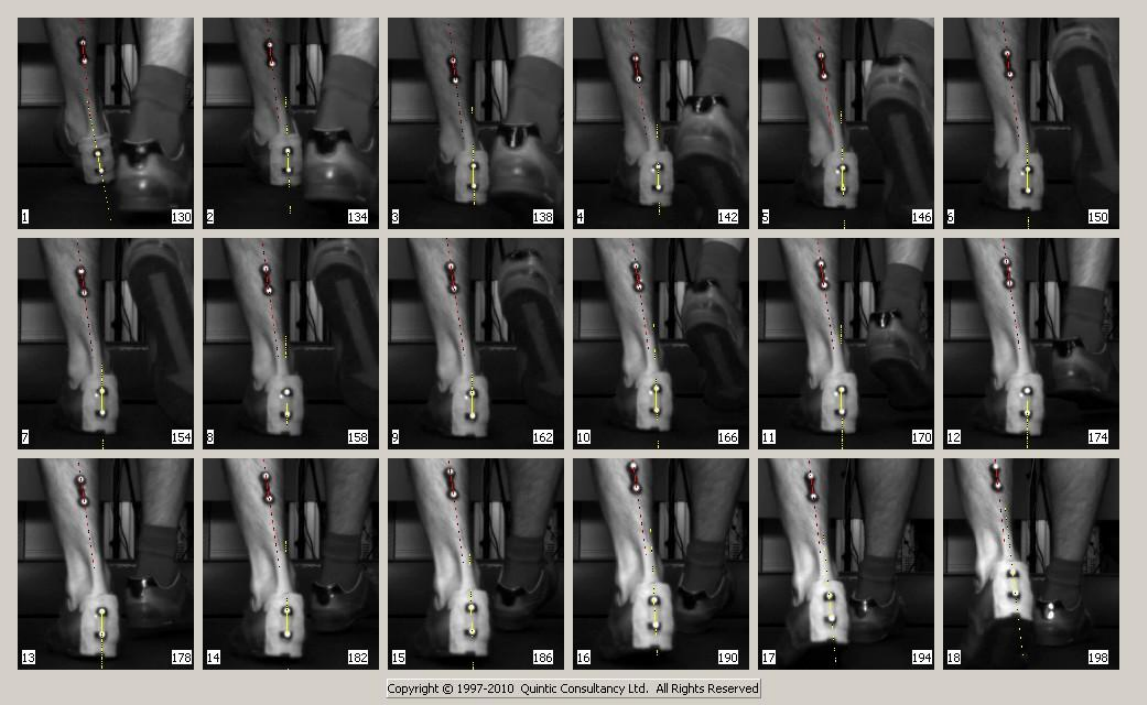
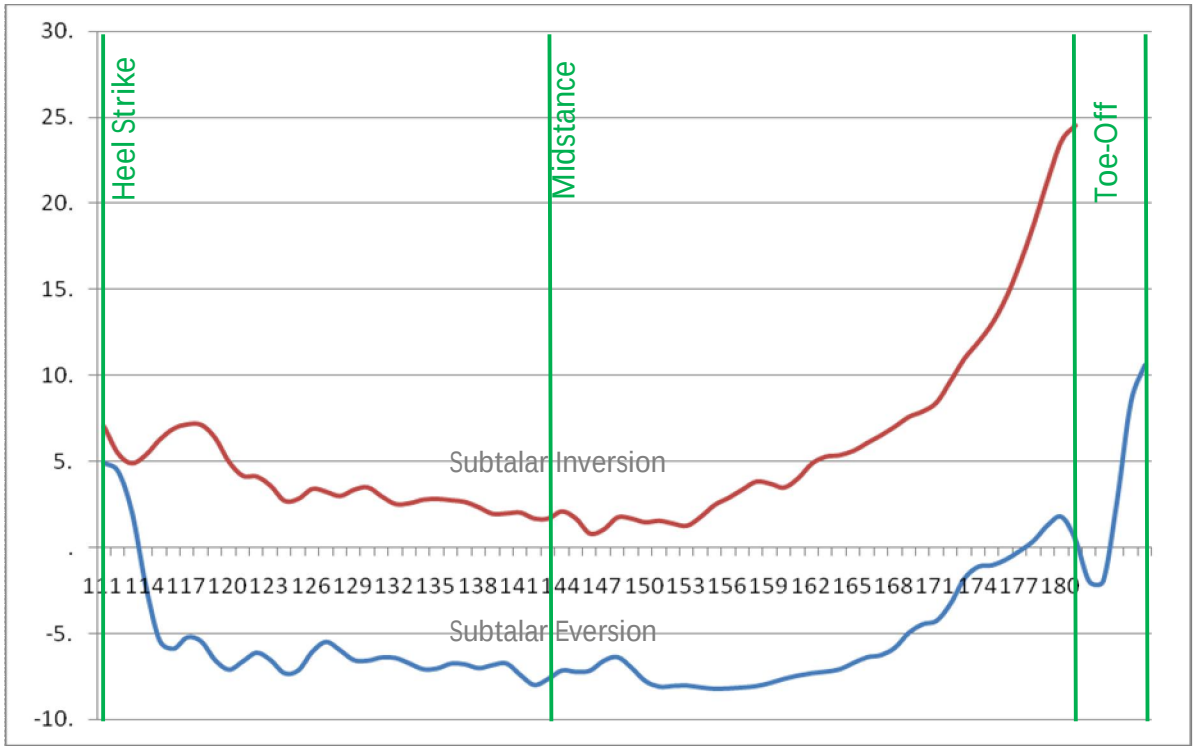
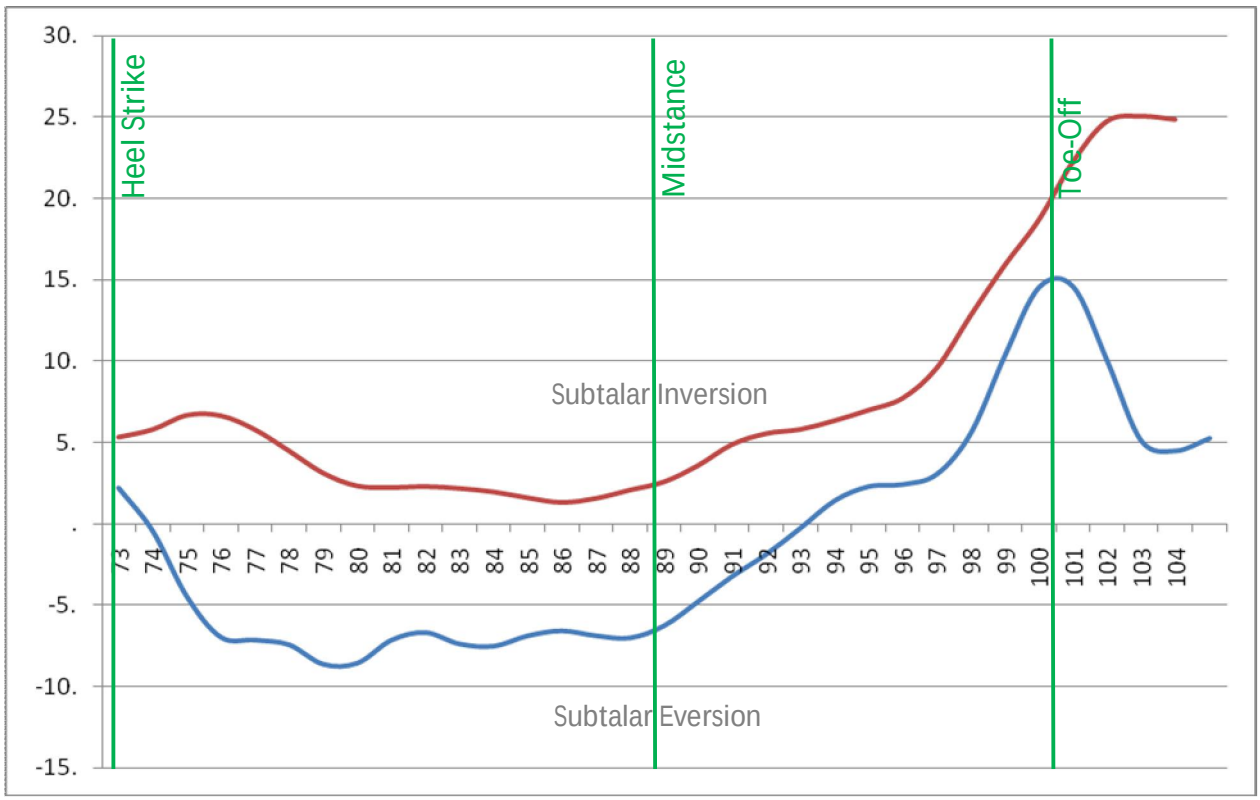


Illustration 3: Quintic multi image capture highlighting 18 specific points of the left foot stance phase of the gait cycle during the Borginsole condition.



Graph 4: Comparison of walking subtalar angles, Red line illustrates barefoot condition and Blue line illustrates Borginsole condition.



Graph 5: Comparison of running subtalar angles, Red line illustrates barefoot condition and Blue line illustrates Borginsole condition.

Graphs 4 and 5 illustrate that when the subject uses the BorgInsole® insoles we can conclude that:

- The subject experiences a normal inversion (functional varus) before heel strike (up to 6°)
- An initial pronation through the subtalar neutral movement up to 7° (in a real pronation moment).

Conclusion:

The new subtalar analysis function which is only available with Quintic Biomechanics v17 video analysis software allows the clinician to accurately and quickly identify and diagnose subtalar joint problems, while also enabling detailed observation and control of an intervention/treatment in an objective way. With many anatomical joints not having a fixed axis of rotation, Quintic's new angular analysis method is a more accurate method of analysing body motion and is more accurate than fixing an artificial axis of rotation.