3D ANALYSIS AND DETERMINATION OF STRIDE PARAMETERS FOR DIFFERENT TYPE OF FOOT STRIKE IN RUNNING.

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Introduction

In running, the analysis of the stride has been investigated in different studies. There are a lot of kinematics and kinetics differences between runners (Dicharry, 2010; Larson et al, 2011). In this context, different numerical parameters such as flight time, contact time, or reactivity can be some important indicators for the coaches. To provide information on the biomechanical characteristics of the athlete and how to improve its stride, a critical component is the accurate estimation of event times such as foot strike and toe-off. To give us these informations, 3D analysis represents a good way to analyse the running movement. It provides the exact position in space at any time of each segment studied.

Objectives

The aim of the study was to compare methods (M1 → M6) for the calculation of various parameters of the stride (focusing primarily on the contact time) for runners with different foot strike patterns. A 3D optoelectronic system usually used in motion laboratories was compared with tools commonly used on the field: an optical based detection system (Optogait) and an accelerometer based system (Myotest).

Materials & Methods

Twenty healthy males (33±10 years) were recruited, all practicing jogging or athletics at least four hours per week. The population was divided into two groups, heel strikers (n=12) or forefoot strikers (n=8)..

The developed test included two parts: the first part analyzed the runner stride with the 3D system; the second part analyzed the same parameters with two other systems, the Myotest Run and OptoGait. Following a five minutes warm up at 8 km/h, each participant was asked to perform, for each of the two parts, one trial of 60 seconds at 8km/h, followed one trial of 60 seconds at 16km/h. Recovery between each trial was three minutes to allow full recovery. Inside the 60 seconds trials, a 30 seconds 3D recording was performed.

Four optoelectronic cameras (Codamotion, Charnwood Dynamics Limited, UK) and eight active markers (four on each foot) were used. Markers used for the 3D analysis (first part) were disposed and held in position on both shoes of the participants at the center of the heel (marker 1), the head of the fifth metatarsal (marker 2), the head of the first metatarsal (marker 3) and the big toe (marker 4) (Fig1). For the second part, the Myotest Run was placed on the belt of the participant, while parallel bars of the Optogait system were placed on the side edges of the treadmill, up to the contact surface (Fig2). Myotest Run was under the control of the participant, while the Optogait bars were connected to a computer under the control of the experimenter.

Six gait event detection algorithms were applied to the raw data. They are based on the time difference between minimal displacements points or between peak velocities in the curves of different markers.. To determine toe off, the minimal vertical displacement of the big toe marker was used. To determine foot strike, method M1 uses the minimal vertical displacement of the heel marker. Method M2 uses the peak velocity of the heel marker to determine foot strike. Method M3 uses only the toe marker to determine both foot strike (peak velocity) and toe off (minimum vertical position). Method M4 is a new method using the minimal vertical position of the 5th metatarsal marker. Method M5 is also new and uses the peak velocity of the 5th metatarsal marker. Method M6 uses the peak velocity that would come first, of either the heel marker or the 5th metatarsal marker. In a sense, it combines method M2 and method M5 together. Contact time for each of the six methods was simply assessed by calculating the time difference between toe off and foot strike.

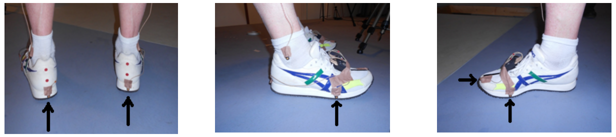


Fig 1: disposition respectively of markers 1, marker 2, marker 3 and 4

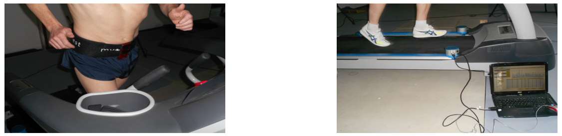
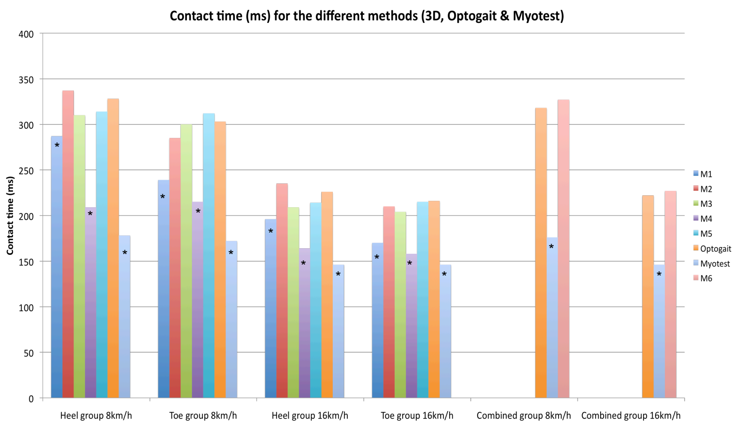


Fig 2:disposition of the Myotest Run ans the Optogait.



Graph 1. contact time (ms) of to the different methods, for the two groups, at 8km/h and 16km/h

Results & Discussion

✓ For both the Heel group (n=12) and Toe group (n=8) at 8 km/h and 16 km/h, we observed a significant difference between the values calculated by method M1 and method M4 compared to the OptoGait values. However, there is no significant difference between the values of methods M2, M3, M5 compared to the OptoGait values for both Heel group and Toe Group.

✓ To detect foot strike, the use of the first peak velocity between two different 3D markers provided the best results. For the Heel Group, the closest statistical value comes from methods M2 (marker placed at the center of the heel) (235 ms (± 13) for M2 versus 226 ms (± 12) for the Optogait at 16 km/h). This was expected considering that the marker detecting foot strike is actually located at the heel and is the first of the four markers to record a peak velocity. Methods M5 (marker facing the fifth metatarsal head) provides the closest for the Toe group (215 ms (± 15) for the M5 versus 216 ms (± 17) for OptoGait at 16 km/h). When the runner arrives with the middle or forefoot on the ground, the 5th metatarsal marker records the first peak velocity related to the foot strike. Therefore method M5 seems to be the most valid for the toe group.

✓ To detect de toe off, the minimum vertical position of a 3D marker placed in line with the big toe gives the most satisfactory results for both groups. Using these peak velocity and these markers, there were no significant difference with the Optogait values (P>0,05).

✓ For both groups, we observed a significant difference between the values supported by the Myotest Run and the values from the OptoGait and the 3D methods (method M1 to M5). Significant differences between all methods and OptoGait with Myotest values can be explained by the fact that the Myotest determines the support time and not the contact time.

✓ With the combined group (n=20), we observed no significant difference between the values of the 3D methods M2, M5 and M6 and the values of the Optogait, at either 8 or 16km/h. The method taking the first peak velocity between the heel marker and the fifth metatarsal marker (M6) to detect foot strike seemed the most convenient. This method is statically equivalent (p>0,05) to the results of the Optogait (eg: contact time=227±16ms for 3D vs 222±14 for Optogait at 16km/h) for the combined group, whatever type of foot strike a runner has.

✓ These results lead us to believe that whatever type of foot strike a runner has (Toe strike or Heel strike), the sixth method (method M6) taking the first peak velocities between the heel marker and the 5th metatarsal marker to detect foot strike seemed the most convenient. After analyzing the results, method M6 is statically equivalent to the results of the Optogait for the combined group (n=20) and therefore seems the most valid for any type of foot strike.

Conclusions

The main objective of this study was to validate a 3D method of calculating the different strides parameters, focusing primarily on the contact time. In conclusion, 3D analysis provides interesting opportunities for calculation of the stride analysis, allowing to give precise numerical feedback on athletes running strides.

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