Communication brève

Science & Sports 2002 ; 17 : 92-4

S0765-1597(02)00122-3/SCO

Runner's stride analysis: comparison of kinematic and kinetic analyses under field conditions

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(Received 10 October 2001; accepted 10 January 2002)

Summary

Introduction – The purpose of this study was to identify the specific events in the gait cycle of a runner on the cranial–caudal, anterior–posterior and median–lateral acceleration curves obtained with an accelerometer system (Locométrix).

Synthesis of facts – The strides of seven middle distance runners were analysed by using the 3D lumbar acceleration recordings synchronised with a video recording. Specific events, such as initial contact, mid stance and toe-off, were readily identified on the acceleration curves. The median–lateral acceleration curve enabled the right and left steps to be identified.

Conclusion – Practical biomechanics information on an athlete's running style could be provided to the trainer by this new apparatus. © 2002 Éditions scientifiques et médicales Elsevier SAS

kinematics / kinetics / running / stride

Résumé – Analyse comparative, cinématique et cinétique, de la foulée de l'athlète à la course à pied.

Introduction – *L'objectif de cette étude était d'établir la correspondance entre le signal d'accélération enregistré en région lombaire médiane par un nouveau système d'analyse de la locomotion humaine (Locométrix), et l'enregistrement cinématographique des déplacements chez l'athlète à la course.*

Synthèse des faits – *La correspondance établie chez sept athlètes de demi-fond permet d'identifier à partir du signal d'accélération les événements caractéristiques de la foulée tels que : l'attaque du talon, les milieu et fin d'appui, pour les pas droits et gauches.*

Conclusion – *L'enregistrement des accélérations en région lombaire médiane apporte des informations utiles à l'entraîneur sur l'analyse biomécanique de la foulée de l'athlète à la course. © 2002 Éditions scientifiques et médicales Elsevier SAS*

cinématique / course à pied / dynamique / foulée

Despite the great interest in the biomechanics of runners' gaits, few methods are available for obtaining relevant information under field and track conditions. Trainers evaluate the characteristics of an athlete's stride in daily practice using their experience and their knowledge of previous kinematic studies. Thus it is possible presently to identify rear, mid and forefoot initial contact and to evaluate leg motion with reference to kinogram shapes that describe the running style of each athlete [2]. A new apparatus, using accelerometric measurements, has recently been designed for analysing human locomotion (Locométrix™) under track and field conditions [1]. This

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study compares the kinetic data recorded by this new gait analysis system with the kinematic data from video image analysis. Specific events in the running stride cycle were identified simultaneously on both the acceleration curves (kinetics) and the images (kinematics).

1. MATERIALS AND METHODS

The study was carried out on 7 top level male middle distance runners (age: 29 ± 5 years, weight: 64 ± 5 kg, height: 173 ± 4 cm). The exercise was a track running test over 30 m at a constant speed close to the athlete’s anaerobic threshold. Speed was measured with an electronic synchronized stopwatch. All subjects were rear foot strikers and each wore his normal running shoes during the test. All the athletes gave their informed consent.

The tests were filmed with a digital camera (Memocam C25, Sony) at 200 field/s, shutter speed 1/2000 s. The camera was mounted on a 1 m high stand and placed orthogonally 30 m inside the track. A black linen sheet was used as a background to provide contrast between the subject and the environment.

The gait analysis system used (Locométrix, Fig. 1) includes an accelerometric sensor, a recording device, and a computer program for processing the accelerometric signals. The sensor is composed of three transducers placed perpendicularly to each other. The sensor is fixed into a semi-elastic belt, which is fastened around the subject’s waist, so that the sensor is pressed onto the medial lumbar region of the runner, close to his centre of gravity (Fig. 1). Three axial accelerations recorded at this point provided information about the kinetics of the body. The kinetic variables of gait were recorded continuously according to the cranial–caudal, median–lateral and anterior–posterior axes of the athlete. The data were recorded at a sampling rate of 100 Hz. A filter with a cut-off frequency of 50 Hz was applied to avoid aliasing and to filter high frequencies. Recorded signals were transferred to a laptop computer and specific software displayed the acceleration curves. The video camera and acceleration recorder were synchronized with an event marker device (a flash triggered when the subject crossed the first photoelectric bar) with a precision of 0.01 s.

Figure 1. The 3D accelerometers housed in a box are fixed over the middle of the lower back by a semi-elastic belt fastened around the subject’s waist.

2. RESULTS AND DISCUSSION

All the athletes ran at about the same speed (5.16 ± 0.06 m/s). The initial contact, mid-stance and toe-off points were readily identified by the video pictures and the acceleration curves, and were in agreement for all subjects. Initial contact corresponded to the beginning of the loading phase from the cranial–caudal acceleration curve, and to the deep deceleration peak of the antero-posterior acceleration curve; mid-stance was associated with the second peak of the cranial–caudal acceleration curve; toe-off occurred at the end of the loading phase (Fig. 2). The median–lateral acceleration curve allowed us to identify the right and left steps from the sharp ipsilateral acceleration at the initial contact.

The shape of the cranial–caudal acceleration curve agreed with the published shapes of the vertical component of ground reaction force [3, 4]. The peak corresponding to the maximum loading for each of the seven subjects was identified as the first peak on the vertical acceleration curve; the second peak corresponded to the maximum thrust. The interval between these two peaks corresponded to the trainer’s so-called lightening period during the stance phase. The shape of the anterior–posterior acceleration curve was also similar to that of the anterior–posterior component of the ground reaction force with the successive braking and propulsive phases. The shape of the median–lateral acceleration was more complex and less periodic; but the right and left steps were still readily identified from the deep ipsilateral acceleration at initial contact.

3. CONCLUSION

The Locométrix system is a portable, non-invasive system that requires no specific tehnical environmemt. It provides relevant information about the spatial-temporal characteristics of an athlete’s stride that agree well with the video recordings. This ambulatory gait analysis system provides trainers with practical information on an athlete’s running style under field conditions. Further studies are now needed to analyse the variations in running style and their relationship with running distance.

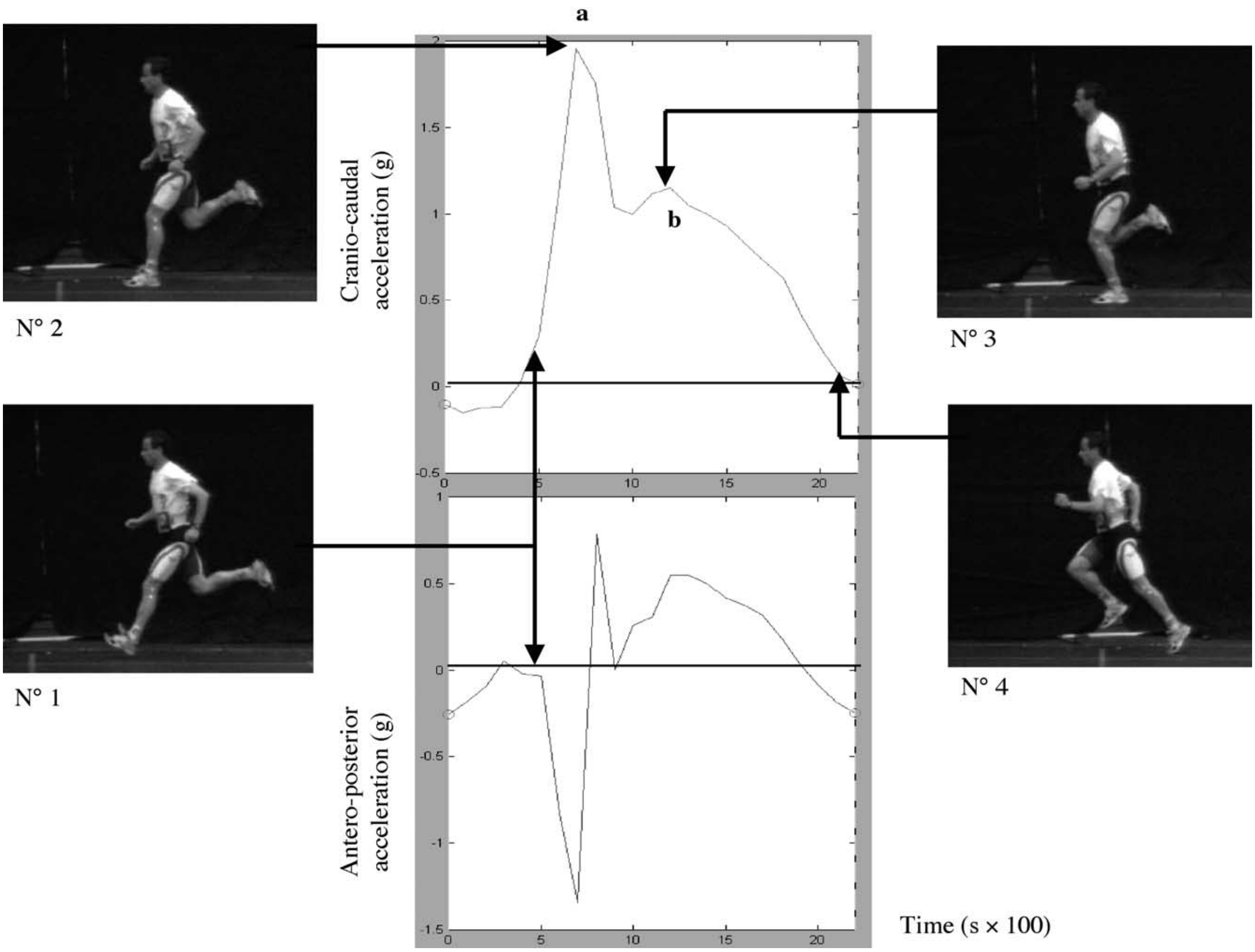

Figure 2. Cranial–caudal and anterior–posterior acceleration curves and synchronised images at specific stages of the gait cycle: initial contact (n° 1), foot flat (n° 2), mid-stance (n° 3), and toe-off (n° 4), identification of maximum loading impact (a) and thrust (b).

ACKNOWLEDGEMENTS

We thank the trainer and athletes for their contributions. This project was funded by the Minister of youth and sports, the local councils (communauté de communes de Laval, conseil général de la Mayenne) and the regional council of Pays de la Loire.

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