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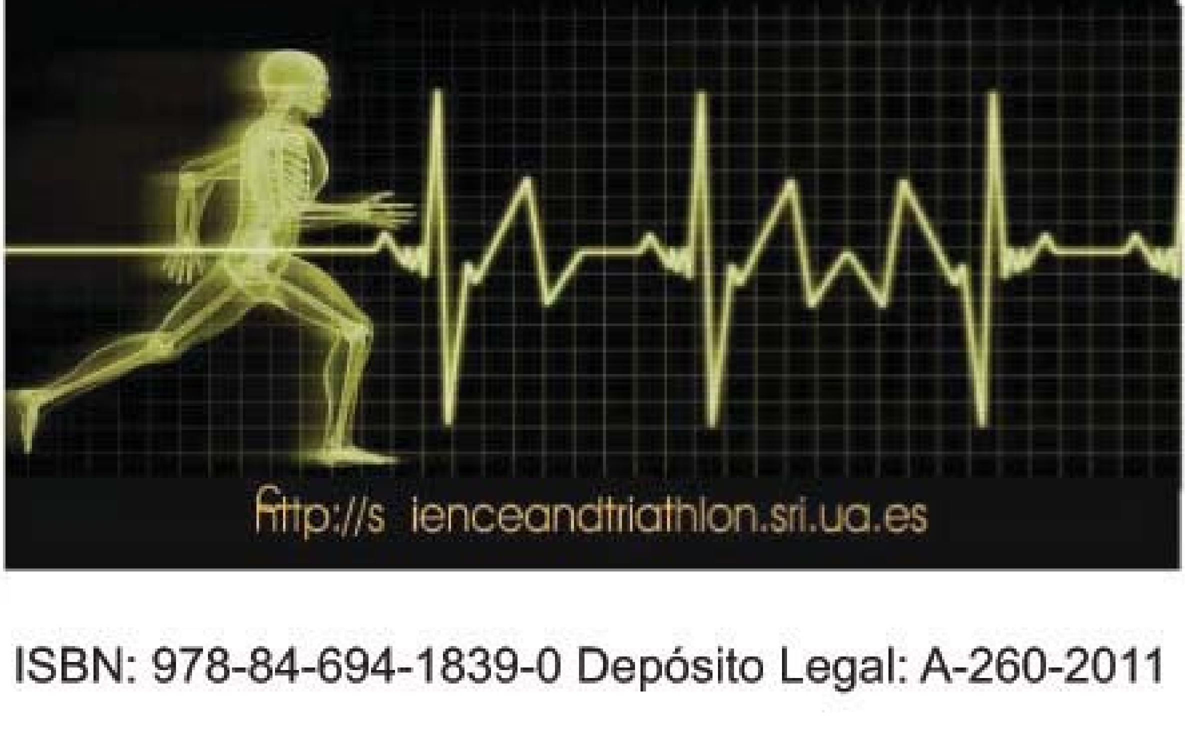

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THE VALIDATION OF A NEW METHOD THAT MEASURES CONTACT AND FLIGHT TIMES DURING TREADMILL RUNNING

Ana Ogueta Alday. Bachelor's degree in Sciences of Physical Activity and Sports. Faculty of Sciences of Physical Activity and Sports. Department of Physical Education and Sports. University of León

Juan Carlos Morante. PhD in Sciences of Physical Activity and Sports. Faculty of Physical Activity and Sports. Department of Physical Education and Sports. University of León

Raúl Lazo Vales. Master's degree in Sciences of Physical Activity and Sports. Faculty of Physical Activity and Sports. Department of Physical Education and Sports. University of León

Jose Antonio Rodriguez-Marroyo. PhD in Sciences of Physical Activity and Sports. Faculty of Physical Activity and Sports. Department of Physical Education and Sports. University of León

José Gerardo Villa. PhD in Sciences of Physical Activity and Sports. Faculty of Physical Activity and Sports. Department of Physical Education and Sports. University of León

Juan García López. PhD in Sciences of Physical Activity and Sports. Faculty of Physical Activity and Sports. Department of Physical Education and Sports. University of León

Corresponding author:

Ana Ogueta Alday

C/Madre Vedruna 18 6º I, 01008 Vitoria-Gasteiz (Spain)

aogueta@gmail.com

+34649355787

Summary

This study aims to adapt and validate a new low cost method that measures contact and flight times during treadmill running. 15 well-trained distance runners participated (25±1 years, 69.5±1.4 kg, 1.77±0.02 m). They completed 7 running trials (10-22 km/h) in a treadmill where the new method was installed (1.5 m laser contact mat, SportRunning). Stride parameters (contact and flight times, stride length and rate) were registered simultaneously with a high speed video camera (reference method) and with the new method (laser contact mat + software). Additionally, runners were classified at 18 km/h according to their foot stride pattern (Hasegawa et al., 2007): rearfoot and midfoot/forefoot strike. Contact time was longer ($F=249$ y $p<0.001$) and the flight time smaller ($F=105$ y $p<0.001$) with the new method comparing to the reference method. Correlation between both methods was very high ($r>0.994$ y $p<0.001$). The differences depended on treadmill velocity ($F=8.9$ y $p<0.001$) but not on runners foot stride pattern ($F=0.2$ y $p=0.64$), so an equation was obtained to correct values. Runners' foot stride pattern affected contact time ($F=5.13$ y $p<0.05$) and flight time ($F=19.42$ y $p<0.001$), as other studies have shown. Therefore, the new low cost method has been validated with great accuracy and sensitivity. Further studies could use it to clarify the influence of these biomechanical variables on running economy and performance.

Keywords: running biomechanics, sports technology, photoelectric mat

Resumen

El objetivo del trabajo es adaptar y validar un sistema optoeléctrico de bajo coste, capaz de registrar y analizar los parámetros biomecánicos básicos de la carrera en tapiz rodante. Participaron 15 corredores de fondo-medio fondo de nivel nacional (25±1 años, 69.5±1.4 kg, 1.77±0.02 m). Realizaron una prueba en tapiz rodante donde se registraron las variables biomecánicas básicas de la carrera (tiempos de apoyo y de vuelo, frecuencia y amplitud de zancada) a 7 velocidades diferentes

(10-22 km/h). Se tomaron simultáneamente registros mediante el software Sport-Bio-Running®, conectado a la plataforma de contacto láser y un sistema de vídeo de alta velocidad (método de referencia). Los corredores fueron clasificados a 18 km/h como talonadores o de planta entera-antepié (Hasegawa et al., 2007). El tiempo de contacto fue mayor ($F=249$ y $p<0.001$) y el de vuelo menor ($F=105$ y $p<0.001$) en la plataforma láser respecto al vídeo de alta velocidad, con correlación muy alta ($r>0.994$ y $p<0.001$) entre sistemas. Estas diferencias dependieron de la velocidad del ensayo ($F=8.9$ y $p<0.001$) y no del tipo de corredor ($F=0.2$ y $p=0.64$), por lo que se obtuvo una ecuación para corregir los valores. El tipo de corredor afectó al tiempo de contacto ($F=5.13$ y $p<0.05$) y de vuelo ($F=19.42$ y $p<0.001$), en consonancia con estudios previos. La nueva herramienta es válida y sensible, por lo que futuros estudios podrían utilizarla para el análisis biomecánico de la carrera y su relación con la economía.

Palabras clave: biomecánica de la carrera, innovación tecnológica, plataforma láser

Introduction

Running economy is an important factor in middle and long distance running performance and therefore in triathlon. Several researches have shown that after the second transition (cycle to run), running economy is modified compared to a control run (Millet and Vleck, 2000). However, running economy is influenced by different factors: physiology, training, environment, anthropometry and biomechanics (Saunders et al. 2004). The influence of running biomechanics (contact and flight times, stride length and stride rate) on running economy and performance is still unclear not only in running (Saunders et al. 2004) but also in triathlon (Millet and Vleck, 2000). This may be due to several problems: a-insufficient number of analyzed strides, b-the use of expensive methods, c-too time-expensive analysis, which difficult the feedback, etc. To solve these problems Viitasalo et al.

(1997) designed and validated the "Photocell Contact Mat" (track running). However, this system should be installed in a short testing area (insufficient number of strides) and requires adjusting the running velocity (no natural stride pattern). Recently, Gullstrand and Nilsson (2009) designed and validated the "IR40mat" (treadmill), solving some problems previously described. However, it has some disadvantages too (only one foot was registered, assuming bilateral symmetry, etc). This study aims to validate a new low cost method that measures for a long period of time contact and flight times during treadmill running.

Materials and methodology

15 well-trained distance runners participated in this study (25±1 years, 69.5 ± 1.4 kg and 1.77 ± 0.02 m). They completed 2 minutes trials (with 2-3 minutes recovery) at 7 different running velocities: 10, 12, 14, 16, 18, 20, 22 km/h in a treadmill (HP Cosmos Pulsar), where the new method was installed (SportRunning). It consists in 1.5 m laser contact mat, with an emitter and a receiver bar placed on both sides of the treadmill and laser beams 20mm separated from each other. Treadmill inclination was kept constant at 1% (instead of 0%) in an attempt to mimic the effects of air resistance on metabolic cost of flat outdoor running (Jones and Doust, 1996). Stride parameters (mean register of both feet) were registered during the last 10 s of each trial, enough time to get a steady-state in running velocity (Rodríguez-Marroyo et al., 2009). Records were performed simultaneously with a high speed video camera (reference method, 1200 Hz, Casio Exilim Pro EX-F1) and with the new method (laser contact mat, SportRunning + software, Sport-Bio-Running®). The software registered contact and flight times of both legs (although the representative value of the average of both legs was selected for analysis), and the coefficient of variation (CV). Stride time (ST) was obtained adding contact and flight times, and since it stride rate (SR) was calculated by the equation:

SR(Hz)=1·ST(s)$^{-1}$. In addition, introducing treadmill velocity in the equation: v(m·s^{-1})=SF(Hz)·SL(m), stride length (SL) is obtained. Images from high speed video camera were analyzed manually in Kinovea® software, analyzing a total of 10 supports (5 with each leg). As it has been explained before, stride time, stride rate and stride length were achieved from contact and flight times. Additionally, runners were classified at 18 km/h according to their foot stride pattern (Hasegawa et al., 2007): rearfoot strike (n=10) and midfoot/forefoot strike (n=5). ANOVA repeated measures were performed to compare both systems (reference method and photocell mat). One-way ANOVA was used to compare different running stride patterns. Post-hoc analysis was performed by using Kolmogorov-Smirnov test. Pearson coefficient of correlation was applied to analyze relationship between variables.

Results

Contact time was longer (IC95%=0.0040-0.0051 s, F=249 and p<0.001) and the flight time smaller (IC95%=0.0034-0.0051 s, F=105 and p<0.001) with the new method when comparing to the reference method, with no significant differences in stride length and stride rate. Correlation between both methods was very high (r>0.994 and p<0.001). These differences depended on treadmill velocity (F=8.9 y p<0.001), but not on runners' foot stride pattern (F=0.2 and p=0.64), so an equation was obtained to correct values. Applying the equation, the differences between contact and flight time disappear. Interval of confidence of the differences between systems at 95% (IC95%) was approximately 1 ms (contact time=between -0.0003 and 0.0006 s; flight time=between -0.0007 and 0.0009 s). Correlation between both methods in contact and flight times still very high once values have been corrected. Contact time decreased (F=513 and p<0.001) and flight time increased (F=29.4 and p<0.001) as treadmill velocity was higher. Contact time was longer (F=5.13 and $p<0.05$) and flight time shorter (F=19.42 y $p<0.001$) in rearfoot strike runners than midfoot/forefoot strike runners (F=5.13 and $p<0.05$).

Discussion and conclusions

The differences in both contact and flight times agree with those obtained by Viitasalo et al. (1997), but contrary to Gullstrand and Nilsson (2009). An equation was obtained to correct them according to treadmill velocity, and they disappear (IC95% ~1ms). Probably runners' foot strike pattern did not affect contact and flight time due to the low height of the laser beams (0,7 cm) (Viitasalo et al., 1997). Gullstrand and Nilsson's (2009) study showed more variability (IC95% ~33ms, between -0.028 and 0.005 s), possibly due to the mechanical sensor which was used to validate "IR40 mat". Differences between the two groups of runners (rearfoot vs midfoot/forefoot) are coincident with Hasegawa's et al. (2007) study. Therefore, the new low cost method that measures contact and flight times during treadmill running has been validated. Its accuracy and sensitivity are greater than those obtained in previous studies. It allows recording a sufficient number of steps with both feet, during a long period of time. Runners should not adjust the running velocity, so the movement pattern is more natural. Further studies could use it to clarify the influence of these biomechanical variables on running economy and performance, clarify what happens with stride parameters after cycle to run transition in triathlon and to study the symmetry during running.

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