DURATION OF PRONATION PERIOD DURING GROUND CONTACT IN HEEL-TO-TOE RUNNING

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INTRODUCTION

Pronation may be considerably influenced by footwear (Bates et al. 1979). Therefore, different shoe constructions are built to control rearfoot motion and protect against excessive pronation and high pronation velocities. Hintermann et al. (1994) reported that excessive pronation and induced tibial rotation might lead to overuse injuries. However, duration times of maximum pronation were not yet in the focus of investigations. Longer duration may result in prolonged loading of the achilles and the patella tendon and might therefore be the cause of running-related overuse injuries. Thus, the goal of the study was to investigate duration times of peak pronation in different shoe conditions.

METHODS AND PROCEDURES

Twenty male and injury-free recreational runners (age: 24.8 ± 2.5 years, height: 177.7 ± 5.8 cm, weight: 72.2 ± 6.9 kg) participated in this study. Running speed was set to 3.5 m/s (±0.1). Data of each subject was collected for a total of five trials over a Kistler force platform. Three running shoes of the categories cushioning (CU), motion control (MC), and low profile (LP) were used. Pronation and supination was measured with an electrogoniometer (Milani et al. 1995) during ground contact time (GCT).
A digital filter was applied to the rearfoot motion (RF-motion) data before traditional parameters were calculated, such as total pronation (TPR), maximum supination angle at foot strike (MSA), maximum pronation (MPA) as well as maximum pronation velocity (MPV).

To determine pronation duration a new parameter was defined describing subjects' individual total pronation (Fig.1). Two relative levels, 80% (DTP80) and 90% (DTP90) of total pronation were analyzed. Finally, the analyzed parameters were normalized to individual ground contact time to get the relative pronation duration in percentage of ground contact time: RDTP80 and RDTP90, respectively.

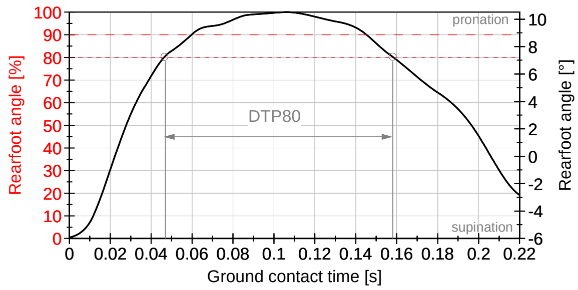

Figure 1: Definition of pronation duration during stance phase

To compare the effect of different shoe conditions, means of five repetitive trials were calculated and analyzed by using repeated measures ANOVA and Post-Hoc tests according to Fisher's LSD. Cluster analysis was performed to identify different pronation duration groups among subjects.

RESULTS

shoe	MSA [°]	MPA [°]	TPR [°]	DTP80 [ms]	DTP90 [ms]
CU	-4.6 (2.6)	8.5 (2.8)	13.1 (2.9)	108 (27)	66 (32)
MC	-4.0 (2.5)	7.5 (2.6)	11.5 (2.7)	116 (37)	73 (36)
LP	-5.8 (2.3)	7.1 (2.5)	12.9 (3.1)	99 (32)	68 (33)
p	<0.01	<0.01	<0.01	=0.10	=0.52

Table 2: mean (SD) of RF-motion parameters

Regarding the traditional rearfoot parameters in running highly significant differences between shoe conditions could be observed.

For all shoe conditions no significant differences were found for RDTP80 as well as RTDP90 (Fig. 2). Furthermore, positive correlation coefficients were found for these parameters (MC: r=0.74, LP: r=0.97, CU: r=0.66).

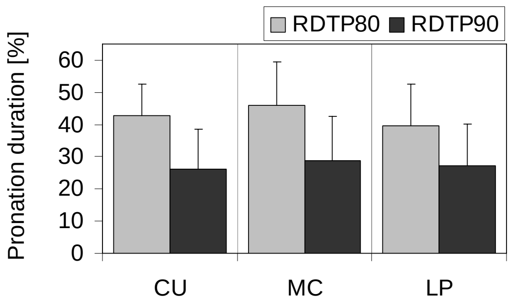

Figure 2: Pronation duration at 80% (90%) of subject's individual total pronation rate

Since the general pattern of pronation duration is not different for RDTP80 and RDTP90 only RDTP80 values are dicussed in further analysis. High interindividual variability is present for the duration time. RDTP80 ranges from 13% up to 71% of ground contact time. Across all shoe conditions subjects reached DTP80 after 42(±11.5) ms and stayed for a mean period of 108(±32.5) ms in this position. Cluster analysis with average linkage between groups results in three clusters (Tab. 1).

cluster	1	2	3
range	< 35%	35 - 50%	> 50%
n	3	15	2
Ø (SD)	23.9 (4.4)	44.7 (4.1)	57.4 (3.0)

Table 1: cluster analysis for RDTP80 across subjects for mean of shoes (n=20)

The majority of the cases (n=15) is grouped in Cluster 2 in a range of 35% to 50% of RDTP80.
No correlations were found between RDTP80 (RDTP90) and traditional rearfoot motion parameters.

DISCUSSION

The average duration pronation period (>80%) starts directly after impact peak and is present until the middle of take off phase after active peak of the vertical ground reaction force during heel-to-toe running.
Traditional rearfoot motion parameters were analyzed to be highly significant different between shoe conditions. No significant difference was found between shoe conditions comparing the parameters relative duration of total pronation (80% and 90%). Therefore, these parameters seem to be independent from shoe construction and traditional rearfoot motion parameters. As pronation duration also considers pronation when the heel has already left the ground, modifications of the heel area between shoe conditions most likely have only minor effects on this parameter.
Positive correlations between RDTP80 and RDTP90 show that one parameter is sufficient for a general discussion.

SUMMARY

Pronation duration of 80% and 90% was analyzed as a new distance running parameter. For complete assessment of pronation behaviour it seems to be important to discuss also the duration next to the maximum pronation angle and total pronation. In further studies, the relationship between pronation duration and running-related injuries should be investigated. Also, anthropometrical data like foot type and lower extremity alignment should be considered with respect to pronation duration.

REFERENCES

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