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FOOT DYNAMICS ANALYSIS WITH COMPARISON TO OTHER PARAMETERS

[1,2] Barbora Pankova, [1]Petr Kubovy and [1]Karel Jelen
[1]Charles University in Prague, Czech rep., Faculty of Physical Education and Sport, Dep. of Anatomy and Biomechanics
[2]Corresponding author; email: bapanka@seznam.cz

SUMMARY

With the present lifestyle loss of natural functions of the foot occurs by decreasing of the dynamics and activity of the foot in daily movements. The purpose of this study was to clarify individual strategies of the foot dynamics and it‘s shape characteristics and to compare direct and indirect methods to determine the height of the foot arch and other parameters in 2D and 3D view.

INTRODUCTION

The foot shape is adapted to vertical locomotion, the foot creates hard and variable contact with terrain [1]. The foot dynamics changes during locomotion in accordance with the motion character. In vertical jump first comes the subtalar joint pronation to absorb the shock after the impact, when the maximum of the arch flexibility is used. After that the foot supinates to stabilize the medial arch to prepare for take off [2], load transfers to the first metatarsal head and the hallux [3].
In the present study we captured the individual strategy of the foot dynamics during extreme load in 3D view and we compared it with other available methods – with static parameters obtained from 2D footprint.

METHODS

10 healthy people (20 feet) 23±7 years old, 75±11kg were asked to jump on one foot to maximal height, in the time of 30s.
The 6 camera motion capture system Qualisys was used to capture longitudinal arch angle (D1MT-NAV-MCAL) as used in the study of Ferber et al. [4] and forefoot width (D1MT-D5MT). The markers were applied in accordance with the Oxford model on anatomic points of the foot (Fig. 1) [5]. The dynamic parameters were taken as the difference of the value (forefoot width or angle size) in maximal loaded and unloaded foot. The tensometric plate Kistler was used to capture the force impulse during the jump.
As objective method for capture the foot parameters from the 2D the footprint imaging through a glass plate was used. The Chipaux-Smirak index (the ratio of the narrowest and the widest dimension of the footprint) and the Clarke´s footprint angle (between medial line of the footprint and the line from medial forefoot to the apex of the concavity of the arch of the footprint) were used [6]. The dynamic parameters were compared with the static parameters in the quasi-static stand.

RESULTS AND DISCUSSION

After the correlation analysis the results from both 2D footprint methods were similar. But this two methods didn´t correlate with the height of the foot arch angle in 3D. Probably it could illustrate, that the methods obtained from 2D footprint don´t capture the shape of higher segments correct.
Higher force impulse correlates with higher body weight and lower medial arch dynamics. The lower medial arch dynamics correlates with lower medial arch. Lower medial arch also correlates with higher forefoot width dynamics (tab1). Probably it is due to higher ligamentous laxity in lower medial arch and also in forefoot width changes.

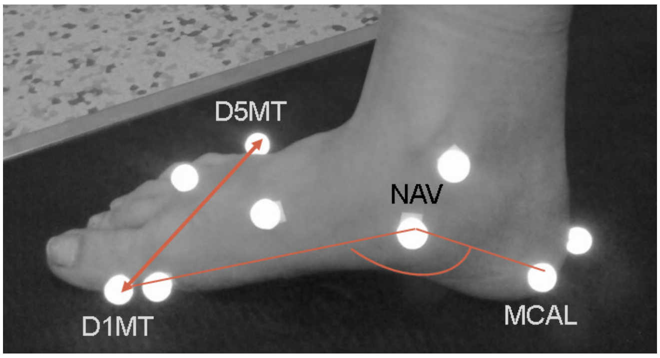

Figure 1: Positions of markers used in the foot model.
D1MT – head of first metatarsal
D5MT – head of fifth metatarsal
NAV – os naviculare
MCAL – medial part of calcaneus

CONCLUSIONS

Individual strategy of foot dynamics during extreme load can be captured and compared with available methods in some parameters. The results from present study can lead to improvement of understanding the foot dynamics or the sport performance.

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	Force impulse	Body weight	No. of jumps	Chipaux-Smirak	Clarke's angle	Dynamics of forefoot	Dynamics of med. arch	D1MT-NAV-CAL2
Force impulse	1,00	**0,91**	**-0,95**	0,41	-0,25	0,22	**-0,60**	-0,29
Body weight	**0,91**	1,00	**-0,75**	**0,52**	-0,25	0,26	**-0,53**	-0,22
No. of jumps	**-0,95**	**-0,75**	1,00	-0,39	0,25	-0,27	**0,56**	0,15
Chipaux-Smirak	0,41	**0,52**	-0,39	1,00	**-0,63**	**0,68**	-0,12	0,24
Clarke's angle	-0,21	-0,25	0,25	**-0,63**	1,00	-0,41	0,01	-0,35
Dynamics of forefoot	0,22	0,26	-0,27	**0,68**	-0,41	1,00	-0,03	0,19
Dynamics of med. arch	**-0,60**	**-0,53**	**0,56**	-0,12	0,01	-0,03	1,00	0,40
D1MT-NAV-CAL2	-0,29	-0,22	0,15	0,24	-0,35	0,19	0,40	1,00

Table 1: The results – correlation analysis between measured parameters, $p<0,05$.
Measured parameters: average force impulse during jumping, body weight, number of jumps in the time of 30s, Chipaux-Smirak index, Clarke's angle of the footprint, dynamics of forefoot = the difference between the distance D1MT-D2MT in maximal loaded and unloaded foot, dynamics of medial arch = the difference between the size of angle D1MT-NAV-CAL2 in maximal loaded and unloaded foot, the size of the angle D1MT-NAV-CAL2.