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ORIGINAL ARTICLE

Rapid diagnostic method for the detection of longitudinal flat feet in mass health examination of beginner athletes

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ABSTRACT

The design of FizioStep Examination System, rapid diagnostic method for the detection of flat feet, is described. Detection is performed with the help of a specially-developed "diagnostic" insole and an adjustment unit that allows the assessment of the loaded and relaxed longitudinal foot arch height. Arch height is measured by the means of specific software that uses a web camera to take a photograph of the arch for further assessment and comparison of loaded and relaxed arch parameters. The system was tested on 8-9-year-old football players (N.=25). The findings showed that three subjects had bilateral pes planus, and nine had unilateral pes planus (one case of the left foot deformity, and 8 cases of the right foot deformity, which apparently was sport-specific).

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KEY WORDS: Flatfoot - Diagnosis - Mass screening - Athletes - Football.

The incidence of flat feet (foot arch flattening or pes planovalgus deformity) in children and adults is currently high and keeps on growing, which proves both medical and social significance of this problem. It is estimated that flat feet are diagnosed in 15-25% of population.[1]

Athletes have a special place among people with detected signs of flat feet — mainly, due to extreme physical loads during training and competitions, inappropriate footwear and equipment, violation of rest schedule and dietary regime, and exaggeration of qualifying standards.[2]

If flat feet are not diagnosed at the basic stage of training, and, hence, correction has not been started, then later on young athletes will likely begin complaining of headaches, be nervous and inattentive, and tire quickly. If this happens, the young athlete is hardly going to become a junior professional athlete, due to quick fatigue with walking and running, static load intolerance, and inability to take part in sports games or competitions.[3]

Traditional methods for diagnosing fallen arches include "wet footprint" test, podometry, plantography, podography, electromyography, and X-ray study. Many of these methods require special equipment; some of them may be implemented only by a qualified specialist; and some are very expensive.[4, 5]

The aim of this research was to design a method that would allow the simple and rapid detection of flat feet.

Materials and methods

The development of a rapid diagnostic method involved two stages:

- designing of the "diagnostic" insole and adjustment unit: 3D modeling, 3D prototyping, and silicone casting;
- diagnostic software creation: C# and SQL programming.

Results

Stage 1

At the first stage we used CIMCORE Stinger II measuring machine to obtain the 2D model of the insole contour (sizes 34, 39, and 45). Then the 3D model of the prototype insole was created in SolidWorks, and the original casting mold was manufactured (Figure 1). The final variant was fabricated after eight prototypes had been designed.[6, 7] The diagnostic silicone insole and adjustment unit (grid) were manufactured (Figure 2).

Stage 2

At the second stage we developed FizioStep Examination System software providing the following functions:

- storing the initial information about customers in the unified data repository;
- obtaining and processing the image from the web camera to assess the foot arch height and to save the results in the unified data repository;
- analyzing the user's information to calculate the results of investigation of the foot arch height;
- composing e-mailable reports on examinations.

FizioStep Examination System design data:

- programming language: C#, SQL.
- type of computer for running: IBM-PC-compatible.
- operating system: Windows 7 (XP, 8, 10).
- distribution package size: 50 Mb.

FizioStep Examination System requirements:

- Microsoft .NET Framework 4;
- Microsoft Office Word;
- Adobe Acrobat Reader;
- 1.3 MP web camera.

In its final variant, the method for diagnosing longitudinal flat feet comprises the following steps:

- input of the athlete's data (Figure 3);
- loaded pronation assessment (adjustment grid is placed on the floor, and the insole blank is put into the grid) (Figure 4);
- photography of the loaded longitudinal arch (Figure 5, 6);
- adjustment of lamellae height for the foot arch under examination (lamellae are pushed out from the adjustment grid until they touch the plantar surface) (Figure 7);
- photography of the unloaded longitudinal arch (Figure 8);
- estimation of the loaded and relaxed longitudinal arch height, comparison of differences between the left and right feet;
- photography of the ankle joint with assessment of the foot-ankle angle (Figure 9).

Figure 1.—A) Prototype insole model: B) original casting mold.

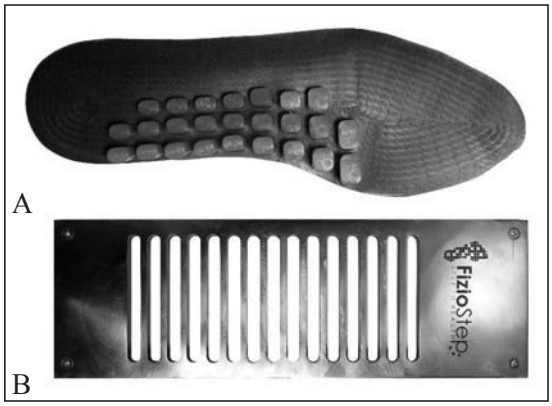

Figure 2.—A) Diagnostic insole (size 39); B) adjustment unit.

Figure 3.—FizioStep software database.

Discussion

The designed method allows a 5-minute assessment of the longitudinal arch whose state in 80% indicates the presence or absence of flat foot. Based on the findings, the report and recommendations for coach are formed (Figure 10).

As illustrated in Figure 10, the longitudinal arch height at the stance phase is 5 mm for the left and 4 mm for the right foot. The relaxed arch height is 11 mm for both feet. Thus, if the relaxed arch height is an individual normal value then its standing deformity is 6 mm for the left and 7 mm for the right foot, which, in accordance with our preliminary data, corresponds to 2-degree flat feet (deformity over 50% of the initial state). This condition leads to changes in

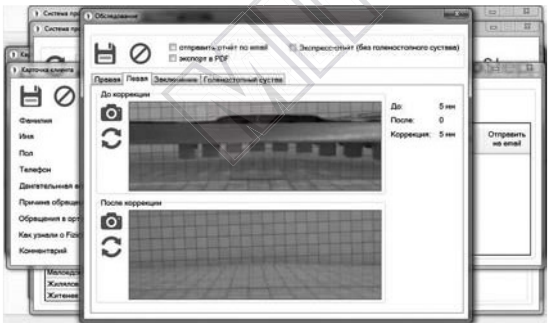

Figure 6.—Results of photo assessment of the longitudinal arch height (loaded pronation) in FizioStep software (left foot).

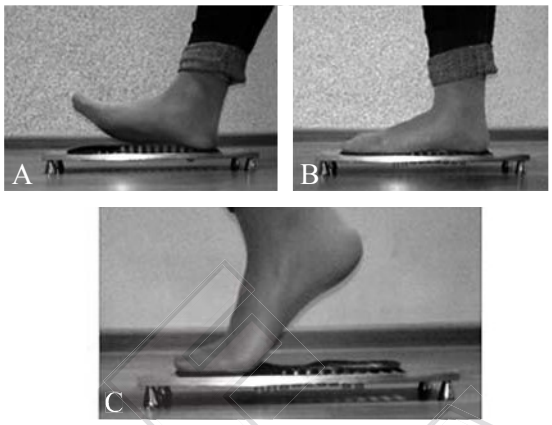

Figure 4.—Algorithm of the foot pronation assessment (right foot): A) phase 1; B) phase 2; C) phase 3.

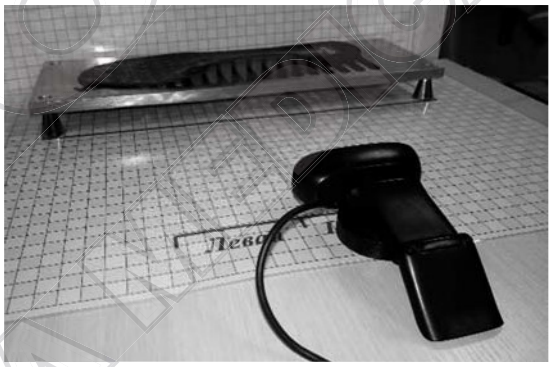

Figure 5.—Position of the adjustment grid with the insole and web camera for photo assessment of the longitudinal arch height (length: 0.15 m, left foot).

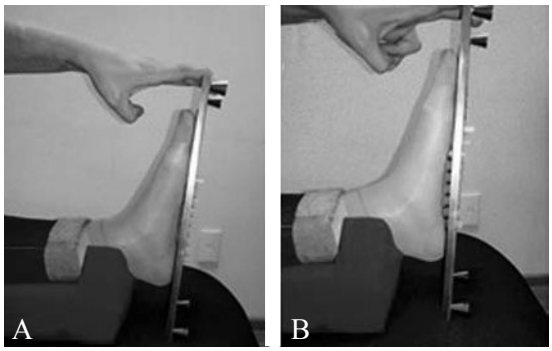

Figure 7.—Lamellae pushed out from the adjustment grid (left foot, relaxed, until plantar surface is touched): A) initial lamellae position; B) final lamellae position.

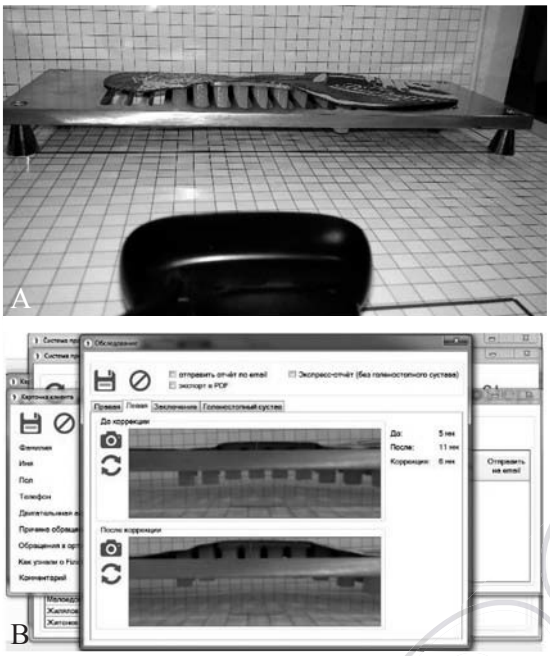

Figure 8.—Result of assessment of the longitudinal arch of the left foot: A) position of the adjustment grid with the insole and web camera for photo assessment of the unloaded longitudinal arch height; B) result of photo assessment of loaded and unloaded pronation.

the foot-ankle angle which, in our case, is 168° for the left and 163° for the right foot. Running, jumping, or other exercising may apparently cause even worse deformity, which might result in diseases and injury. Further, if flat feet are not treated then, according to the literature,[8-20] it may eventually lead to deformities of superjacent joints (Figure 11).

To test the designed method, we conducted the examination of the longitudinal foot arch in 8-9-year-old football players (N.=25).

Based on Table I, it is possible to rapidly assess the longitudinal arch height and ankle joint value (angle). According to the analysis, most athletes under examination tend to have flat feet, mainly on the right foot, which is probably associated with the specifics of football training. In three young athletes, we observed pronounced deformities of the longitudinal arch of both feet (bilateral pes planus), while in 9 subjects unilateral pes planus was found (one case of the left foot deformity and eight cases of the right foot deformity).

Figure 9.—Photography of the ankle joint: A) position of the web camera and the athlete (length: 0.8 m); B) estimation of the foot-ankle angle.

Figure 10.—Example of report (A) and recommendations (B).

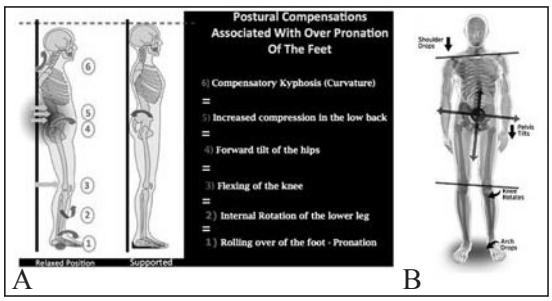

Figure 11.—Disorders caused by flat feet: A) sagittal plane; B) frontal plane.

TABLE I.—*FizioStep Examination System in young football players*.

Subject #	Left longitudinal arch			Right longitudinal arch			Left ankle		Right ankle	
	Before	After	Correction	Before	After	Correction	Value	Deviation	Value	Deviation
1	8	10	2	7	10	3	165	15	168	12
2	8	11	3	6	9	3	156	24	161	19
3	10	11	1	6	9	3	167	13	166	14
4	8	9	1	3	7	4*	164	16	165	15
5	7	10	3	8	10	2	166	14	169	11
6	6	7	1	6	9	3	166	14	168	12
7	7	10	3	1	9	8*	167	13	171	9
8	8	10	2	8	10	2	170	10	169	11
9	6	9	3	3	7	4*	161	19	166	14
10	8	10	2	7	10	3	164	16	168	12
11	5	11	6*	3	9	6*	167	13	169	11
12	8	9	1	5	11	6*	151	29	156	24
13	9	10	1	5	9	4	171	9	170	10
14	5	10	5*	5	11	6*	171	9	168	12
15	9	10	1	8	11	3	171	9	172	8
16	11	12	1	6	10	4	166	14	167	13
17	5	11	6*	5	11	6*	167	13	166	14
18	7	10	3	10	11	1	170	10	172	8
19	10	11	1	5	10	5*	162	18	165	15
20	7	11	4	5	10	5*	162	18	165	15
21	9	12	3	6	9	3	167	13	166	14
22	5	10	5*	6	10	4	165	15	165	15
23	8	10	2	6	10	4	162	18	162	18
24	7	10	3	4	8	4*	164	16	167	13
25	9	11	2	5	10	5*	162	18	164	16
Mean	7.6±0.31	10.2±0.26	2.6±0.26	5.56±0.47	9.6±0.21	4.04±0.36	164.96±1.04	15.04±1.04	166.6±0.83	13.4±0.83

*Longitudinal arch correction ≥100% of its loaded height.

Conclusions

To sustain the effective training process and low injury rate we think it rational to perform the timely and prompt control of the longitudinal arch with the help of FizioStep Examination System. The designed system is mobile; it can be installed on any PC or laptop and allows the assessment and diagnosis without pausing the training process.

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Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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ORIGINAL ARTICLE

Influence of different types of circuit training on the functional status and anthropometric parameters in young women with obesity

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ABSTRACT

BACKGROUND: Today, obesity is one of the most serious public health problems in economically advanced countries. Strength training increasing energy expenditure of the body may enhance adaptive capability of the woman's body and improve woman's anthropometric parameters. The aim of this study was to compare the influence of different types of circuit training on adaptive potential of the cardiovascular system and anthropometric parameters in young women with class I obesity.

METHODS: Thirty women with class I obesity, aged 31-36, were divided into 2 equal groups and started training. The first group (the endurance group) focused on muscular endurance development, and the second group (the resistance group) was developing muscular strength. The progress was estimated based on Body Mass Index (BMI), body fat percentage (BFP), and adaptive potential values.

RESULTS: Positive changes of BMI, BFP, and adaptive potential were observed in both groups, but the endurance group had a better progress than the resistance group ($P<0.02$ and $P\leq0.04$, respectively).

CONCLUSIONS: Young women's body shaping is more effective if it is based on endurance training. Adaptive potential of the cardiovascular system in the examined women has increased equally in both groups ($P<0.02$).

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KEY WORDS: Exercise tolerance - Resistance training - Women - Obesity.

Today, obesity is not only a social problem in economically advanced countries, but also one of the major public health problems.[1] According to the World Health Organization (WHO) experts, if the obesity incidence rate remains the same then up to 2025 there will be over 300 million obese people worldwide.[2]

High incidence of obesity, the associated risk of disability and early mortality as well as low effectiveness of existing methods of managing excessive weight and obesity impel scientists to search for new methods of early diagnosis and treatment for overweight and excessive weight.[3-5] In women, obesity is often associated with the reproductive system disorders, high-risk pregnancy and/or delivery including increased risks of caesarean section, preeclampsia, gestational diabetes, and also a significantly higher risk of congenital anomalies (Branca *et al.*, 2009).[2]

In Russia the rate of overweight people grows by 10% every ten years.[6]

Obesity is a health condition caused by many different factors. The observed incidence growth is explained by the following reasons:

— excessive food energy intake;