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EXPERIMENTAL STUDY OF THE FOOTWEAR INFLUENCE ON THE HUMAN'S LOCOMOTOR SYSTEM

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Abstract

The content of this article highlights the importance and insignificant influences of wearing high and no high heel shoes, as well as the significance of wearing the right footwear as a way to improve and maintain the functional and healthy condition of the locomotor system in such a way as to comply with the rules and standards.

Introduction

Doctors are concerned, because fashion trends with a constant increase in high and no high heel shoes are detrimental to people's health.

According to the Journal of the American Academy of Orthopedic Surgeons, the frequency of back pain in adolescents and youth is steadily increasing. A study cited by futura-sciences.com claims that the incidence of back pain in adolescents has increased from 11% to 33%. For almost 60% of adolescent patients, clinical examination and imaging investigations do not reveal a clear cause of back pain.

According to the study's leading author, Suken Shah, an orthopedic surgeon at Children's Hospital in Wilmington (USA), "it could be of muscular origin, due to incorrect posture, intense training in one or more sports or, on the contrary, too much little physical activity "[10].

In fact, 80% of people can have significant back pain at some point. Between them, 50 percent will have more than one episode in a year. In 90% of all cases, pain relief is better without surgery [5].

The main reason for our research is that, from an early age, girls try to follow fashion, they strive to look attractive by wearing high heels, without imagining how badly they cause to their locomotor system.

The skeleton is formed by the age of 20-25, and if a teenager manages to influence it negatively with wearing the wrong footwear, it will be almost impossible to recover. The topic we selected in our research is based on the connection between the science of measurement, the laws of physics and biology, medicine and mathematics [9].

Thus, the purpose of the shoe heel has historically changed according to the state, era, time. Basically, they were used to highlight the height and stature of the given person. At present, the high heel of the shoes is an ornament and is especially characteristic for women's shoes. Since then, ladies have deliberately broken their legs for fashion [6,7].

Human - is the only representative of the living world whose legs are specially designed for vertical walking. We daily move in space: we run, walk, jump, crawl, swim, making thousands of bending, actions and movements. A feature of the leg structure is the presence of the so-called foot arch, which performs a very important function - it compensates for the pressure on the limbs. This amazing mechanism of 26 bones, 33 joints, 107 ligaments, 31 tendons, as well as meters of nerves and blood vessels is the foundation of health, as it performs extremely important functions for its formation and preservation. The human organism is a complex mechanism that presents by itself a summation of the organ systems that keep this body alive [12].

All these are provided by the musculoskeletal system. It includes bones that connect the connective tissues and muscles. A solid skeleton (the bones of the skull, limbs and trunk or the skeleton as a whole) performs different functions, the main one being balance (support): it holds all the organs in a certain position, and the whole body weight. And together with a flexible skeleton (cartilage, ligaments, tendons) it gives us the ability to move. If the animals are sustained by all four limbs, then the man is held in the upright position only standing vertically. In relation to the vertical position, the human foot has acquired an arched structure, which has made it more durable. And this is vital. [3]

According to the law of physics, the subject has a stable balance if a vertical line drawn from the center of gravity passes inside the base. The standing human does not fall only as long as a vertical line in the center of gravity is inside the platform, bounded by the edges of his sole. Moreover, the support surface with high heels is much smaller than the low one, which makes it more difficult to maintain balance when we walk, because, according to the laws of physics (static section), an object does not lean only when, a vertical line drawn from the center of gravity, passes inside the base. Properly maintaining balance on one foot and high heeled shoes is much more difficult.

The author M., Constantinescu consider "The musculoskeletal system, due to minimal induced requests, will enter into a process of slow deconditioning but with visible repercussions on the structures: bone osteoporosis; on the muscles,

hypotony; cartilage, arthrosis, and also regarding the functionality a significant reduction of the effort capacity" [1].

Material-method

The object of research. Human locomotor system.

Research topic. The study of the footwear importance on the locomotor system.

The purpose of the research. Research of the footwear influence on the locomotor system.

Research methods. Analysis of the scientific literature; questionnaire method; observation, reporting of research results, experiment; statistical - mathematical methods for processing the results of measurements; the method of tabular and graphical interpretation of data.

Research organization.In the research were included 133 respondents aged 14-79 (women), random people.

Results

I conducted the survey as a questionnaire. During the conduct of the questionnaires, the degree of knowledge of the respondents about the correct footwear was highlighted, as follows: 81.95% of the respondents mentioned that they know how high or no high heel hurt when forming the bones of the foot, 11.27 % considered that high or no high heel do not hurt when forming the bones of the foot, and 7.51% mentioned that they do not know how high or no high heel hurt when forming the bones of the foot. Table 1.

And, when asked how you feel in high-heeled shoes, the respondents stated the following: 51.12% of the respondents said that they feel comfortable, 32.33% of the respondents mentioned that when they are very barefoot they are happy, and only 17.29% said they felt uncomfortable. Table 1.

When asking the surveyed ones, if the different types of shoes are to be alternated, the respondents stated the following: 85.71% of the respondents mentioned that yes the different types of shoes need to be alternated, 11.27% mentioned that they do not know if the different types of footwear should be alternated, and only 11.27% of respondents mentioned that there is no need to alternate different types of footwear.

Table 1. Knowledge about wearing the correct footwear

Sample	Do the high heel or no-hell hurt when forming the bones of the foot			How do you feel in high-heeled shoes?			Shoulddifferent types of shoes be alternated?		
Years	Yes	Not	Do not know	Comfortable	uncomfortable	Very happy when I take my shoes off	Yes	Not	Do Not Know

Total	109 81.95%	15 11.27%	10 7.51%	68 51.12%	23 17, 29%	43 32.33%	114 85.71%	5 3.75%	15 11.27%

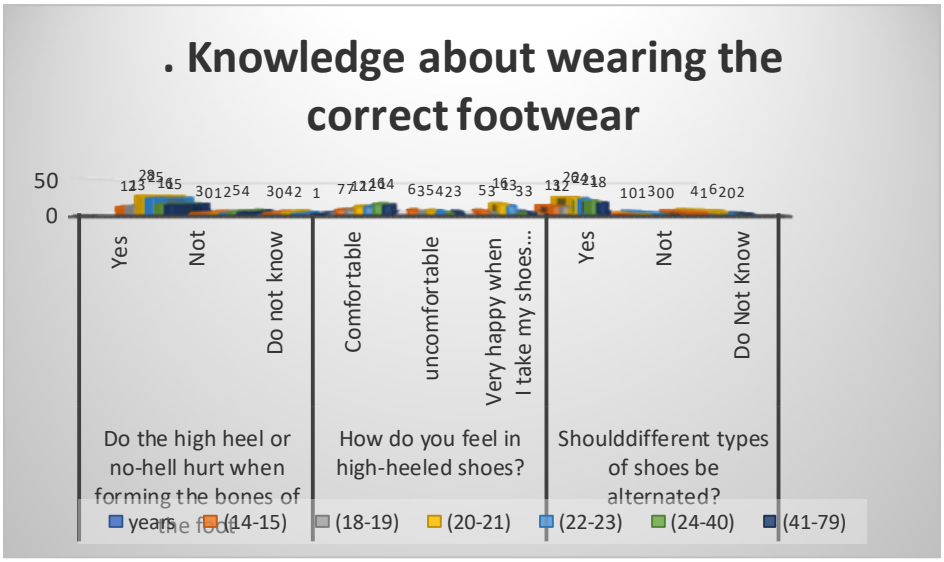

Fig.1 Knowledge about wearing the correct footwear

In conducting the questionnaires of the respondents regarding the data on the high-heeled shoes, we obtained the following results: 81.05% of women prefer to wear heels, 18.93% prefer not to wear heels, and approximately 114 respondents mentioned that they wear high heels starting from the average age of 16.24.

Table 2. Data on the high-heeled footwear

No.	High - heeled shoes		
	Not wearing	wearing	Wearing from the age of
1.	11 (61.11%)	7 (38.88%)	13.42 years
2.	3 (23.07%)	10 (76.92%)	16.8 years
3.	3 (9.37%)	29 (90.62%)	15.89 years
4.	3 (10.34%)	29 (89.65%)	14.58 years
5.	1 (4.72%)	20 (95.23%)	18.3 years
6.	1 (5.00%)	19 (95.00%)	18.5years
Total	X = ± 22 (18.93%)	114 (81.05)	16.24 years

Also here, the respondents stated that 70.67% - prefer to wear high -heeled shoes from 5-10 cm, 20.30% - prefer to wear shoes with 3-4 cm heel and 0.9% - from the respondents prefer to wear shoes with 1-2 cm heel (Table 3), the standard being 3-4 cm, according to the evaluative estimations carried out about us (Table 8.9). We emphasize that, when asked about the number of hours of wearing high heeled shoes, 31 (23.30%) of the respondents stated that they wear high heeled shoes 1-2 hours a day, 37 (27.81%) of the respondents stated that they wear shoes half a day, 20 (15.03%) of the respondents stated that they wear high heels all day and 46 (34.58%) of the respondents stated that they do not wear high heels. Table 3. Likewise, we wanted to highlight the reason for wearing high-heeled shoes, as follows, 11 (0.82%) of the respondents stated that they wear high-heeled shoes because it is fashionable, 104 (78.19%) of the respondents stated that they wear high heels for the reason that it is beautiful, 10 (0.75%) of the respondents stated that they wear high heels for the reason that it is comfortable and only 8 (0.60%) respondents stated that they wear high heels for the reason that it is useful.

Table 3. Responses of respondents

No.	Age of respondents	Nr.ofRespondents	Height of heel			Number of hours of wearing high-heeled shoes				Assessment of foot comfort	What is the reason for wearing high-heeled shoes?			
			1-2 cm	3-4 cm	5-10 ... cm	1-2 hours	Half day	all day	I do not wear	On the scale of 5 scores	Fashionable	It is beautiful	Comfortable	useful
Total	27.20 years	133	12 (0.9%)	27 (20.30%)	94 (70.67%)	31 (23.30%)	37 (27.81%)	20 (15.03%)	46 (34.58%)	I	11 (0.82%)	104 (78.19%)	10 (0.75%)	8 (0.60%)

Each of respondents, regarding the wearing of sports footwear and which are the preferred models, the following stated:35.33% of the respondents mentioned that they prefer the footwear manufactured by Nike company representatives, 25.56% of the respondents mentioned that they prefer the footwear manufactured by Adidas company, 17.29% of the respondents mentioned that they prefer the footwear manufactured by Puma company , 13.53% of the respondents mentioned that they prefer the footwear manufactured by Asicis company , and only 9.02% of the respondents mentioned that they prefer the footwear manufactured by the representatives of the company Reebok.

Table 4. Preferred models. [8].

No.	What are your favorite models?				
Age	Adidas	Nike	Puma	Reebok	Asics

(14-15 years)	4	6	6	1	1
(18-19 years)	1	7	2	2	1
(20-21 years)	5	15	3	4	6
(22- 23 years)	7	11	3	3	5
(24-40 years)	8	5	4	1	3
(41-79 years)	9	3	5	1	2
Total	34 (25.56%)	47 (35.33%)	23 (17.29%)	12 (9.02%)	18 (13.53%)

In the second stage of the research, we measured the indices (Average age, Height, Weight, Foot size, Flat sole) in Table no.5 6.7.

Table 5. Anthropometric indices

No.	**No. of subjects**	**Average age (years)**	**Height (cm)**	**Foot size**	**Average weight (kg)**
1.	18	X = 14.88 years	167.61	37.94	55.27
3.	32	X = 20.00 years	165.40	37.78	57.09
4.	29	X = 22.34 years	168.06	38.12	62.79
5.	21	X = 35.09 years	165.09	37.42	61.61
6.	20	X = 52.10 years	163, 45	37.87	68.50
Total	**133**	X = 27.20 years	166.06	37.91	60.91

Table 6. Data on the flat sole%

No.	No. of subjects	Average age (years)	Flat sole%	Level
1.	18	X = 14.88 years	4 (22.22%)	1
3.	32	X = 20.00 years	3 (9.37%)	1
4.	29	X = 22, 34 years	3 (10.34%)	1
5.	21	X = 35.09 years	1 (4.72%)	1
6.	20	X = 52.10 years	1 (5.00%)	1
Total	133	X = 27 , 20 years	12 (11.08%)	1

Fig. 2. Visual method [4,8].

Then, we calculated the pressure on a solid surface of different types of shoes: with the heel height of 5-10 cm, 3-4 cm and 1-2 cm.

The results of the study of the distribution of weight on the plantar surface of the foot showed that 20.5% of the weight falls on the anteroposterior side of the foot, 18.4% - on the anteroinferior side of the foot, 5.1% in the arch area and 55.1% in the heel . When you walk, the pressure is distributed as follows: 33.2% falls on the heel, 5% on the middle, 26% on the top of the foot and 35.8% of the total load on the inside front .

It is interesting the moment of deviation of the gravity center from the normal. The man standing barefoot, if we draw a vertical line through him, forms a perpendicular angle of 90 °. On 5 cm heels, the body inclines, and the angle drops to 70 °, and on 8 cm heels, it drops to 55 °. Also, in a barefoot woman, the pelvic displacement is 25 °, on heels of 2.5 cm increases to 30 °, on 5 cm to 45 °, on 8 cm to 60 °.

As we know from the course of physics the pressure (P) is called the cash dimension equal to the force (F) acting perpendicular on a surface, for the calculation of pressure it is important to use the formula p =F/S, where F- is the force where the man presses on a solid surface. The force is equal (F = mg), where m - body mass, g - free fall acceleration (9.8m / s). To calculate the surface S, we make the outline on millimeter paper and find the size of the surface as an arithmetic mean of the complete and incomplete squares, multiplied by the surface of a square (0.25 cm2), where S =(PC + PI)/2* 0.25 cm2 where CS - complete squares, IS - incomplete squares. The data obtained are shown in

Table 7. Calculation of the heel height, the force, pressure

Heel height, cm	S cm^2	F, H,		P, Pa
5-10cm	94	550		585 106
3-4cm	27	550		203 703
1-2cm	12	550		458 333

Analyzing the obtained results we can conclude that the 5-10 cm heel shoe has a smaller support surface and creates maximum pressure on the solid surface that is influenced by the weight of the body, and the thickness of the heel. Such

footwear influences negatively, causing different types of disease of the locomotor system. It should be noted that the shoe with 1-2 cm heel is also dangerous.

Thus, in order to maintain a vertical position, the body must make a number of changes to the joints. The center of gravity moves forward, the back is folded back to maintain balance, the lumbar bending increases, and this leads to a curvature and increased pressure on the spine and possible displacement of the internal organs. The load in the lower lumbar regions increases significantly in this position of the pelvis. Effect - the muscles of the calf will contract, and the circulation of blood in the thigh will also be disrupted. The increased muscle tension in the legs, pelvis and lumbar spine as well.

Then I imagined what would happen if a woman weighing 70 kg accidentally steps on someone's foot, with her narrow heels. The area where the woman is leaning, in this case will be equal to the thickness of the heel as in the above examples Sк = 4 cm2 = 0.0004 m2 and for the heel with the thickness that Sm = 1 cm2 = 0.0001 m2. As a result of the measurements, we concluded that the pressure exerted by a narrow heel is approximately equal to the pressure of a towing vehicle.

It is given: NarrowHeel - h-10 cm. m = 70 кg, S1= 0.0073 м2, g = 9.8 H / кg.

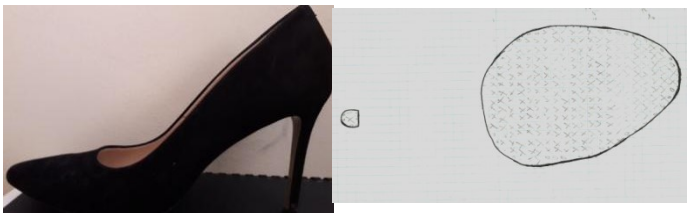

Fig. 3 Estimation:

$p_1 = \frac{mg}{S_1}$ - the pressure exerted on a solid support by only one foot,

$p_2 = \frac{p_1}{2}$ - the pressure exerted on a solid support by both feet.

$$p1 = \frac{70kg\ x\ 9.8\ /\ kg}{0.0073m2} \approx 94000Pa \approx 94kPa$$

$$p2 = \frac{94000Pa}{2} = 47000Pa = 47kPa$$

Result: p_1 ≈94 кPa and p_2 =47 кPa.

For comparison:

The pressure exerted by a ДТ-75M towing vehicle with a mass of 6610 kg, with a supporting ground surface on both sides 1.4 m2.

$$p = \frac{mg}{S} = \frac{6610kgx\ 9.8H/kg}{1.4m2} \approx 47kPa$$

It is given: Broad heel with - 10 cm. m = 70 кg, S1= 0.0099 м2, g = 9.8 H / кg,

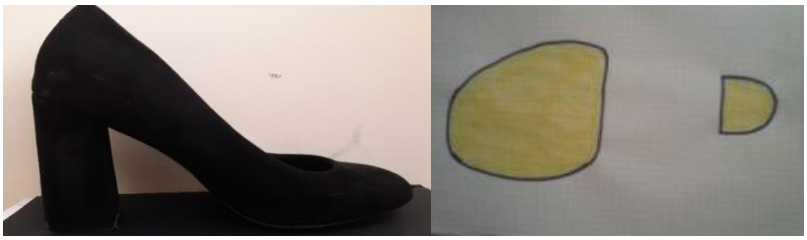

Fig. 4 Estimation:

$p_1 = \frac{mg}{S_1}$ - the pressure exerted on a solid support only by one foot

$p_2 = \frac{p_1}{2}$ - thepressure exerted on a solid support by both feet

P1 $= \frac{70kgx\ 9.8H/kg}{0.0099m2} \approx$ 70000 Pa ≈**70 кPa,**

P2 $= \frac{70000Pa}{2}$ 35000 Pa =**35 кPa**

Solution: ≈70 кPa and =35 кPa.

The third stage of the experiment consists in determining the optimal heel height. There are two approaches to determine the optimal heel height.

The first method we calculated the arithmetic mean of the optimal height of the heel footwear. For this it was necessary to divide the height of the body (cm) by the length of the lower limbs (cm), which was measured from the waist line to the ground. And then we calculated the difference between the obtained variable and the coefficient of the ideal correlation between the height and the length of the lower limbs. The data obtained must be multiplied by 10.

$$H = \left(\frac{L}{d} - K\right) * 10$$

L - the height in cm

d - the length of the lower limbs, measured from the waist to the ground.

K - thecoefficient of the ideal correlation between the height and the length of the lower limbs (k = 1.61).

Table 8. Determination of the ideal heel height

No.	Ideal heel height according to the theory of arithmetic mean in centimeters (cm)						Ideal heel height from orthopedics point of view in centimeters (cm)	
	L	d	Foot size	Average age (years)	k	H	l - sole length (cm)	h

1.	167.61	88	37.94	14.88	1.61	2	25	3.5
2.	165.40	86	37.78	20.00	1.61	2	25	3.5
3.	168.06	89	38.12	22.34	1.61	1	25	3.5
4.	165.09	85	37.42	35.09	1.61	1	24	3.4
5.	163.45	84	37.87	52.10	1.61	1	25	3, 5
6.	166.06	87	37.91	27.20	1.61	1	25	3.5

The second method We calculated the physiological height of the heel from orthopedic point of view: $H = \frac{l}{7}$, l - the length of the sole in centimeters. But scientists have proposed an alternative, that in order to determine the ideal height of the heel, the size of the foot must be divided by 7. For example, if the size of the shoe is 36, then 36: 7 = 5 cm, so the ideal height of the heel is 5 cm for the given subject.

Practical and Methodological Indications

Therefore, it is necessary to comply with the basic rules for purchasing the right footwear as follows: to wear shoes not less than 3 cm heel and not more than 4 cm heel; it is necessary to alternate different types of footwear; high-heeled shoes should be worn no more than 3 hours a day twice a week; periodically, we have to go barefoot and do foot massage; shoes with heels of more than 4 centimeters should not be worn by those whose work involves a long-standing position, as well as adolescent girls during the active growth period.

Conclusions

In the opinion of the orthopedists, the choice of heel footwear according to these formulas is the most optimal one; this heel provides the soles to movement during walking and protects them from fatigue.

The data in Table 8 and 9 clearly show that the optimal heel height calculation by the first and second methods is ideally suited.

It should be noted that according to our evaluative estimations, the optimal height of the shoe heel should be 3-4 centimeters.

Some of the foot problems can also be caused by wearing the wrong size footwear, and it should be noted that the footwear must match the season. Choosing and purchasing the correct footwear is most welcome in the second half of the day, giving preference to natural and soft materials that "breathe", making sure that the toes are evenly seated, and the footwear does not cause inconveniences, the sole is elastic and anatomically well made .

The authors D., Pasăre, E., Raţă consider that "The purpose of recovery is to avoid or reduce any infirmity in reducing disability and incapacity for work and,

especially, the creation of a new state of equilibrium, based on the physical and functional outstanding through which the patient must be taught and trained to adapt active life" [2]. The authors M., Constantinescu, E., Vizitiu consider that " The constant physical activity involves the consumption of carbohydrates, useful for the formation and storage of muscle glycogen. The development of healthy eating and physical activity behaviors in childhood and adolescence are very important for adult life" [11].

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