

Temperature Changes on the Foot during Pregnancy Affected by Wearing Biomechanical Shoes

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ABSTRACT

Introduction: Everyone needs to walk; however, many people have problems with walking caused by non-standard condition or function of their feet, which in some cases can be easily recognized by thermography methods. The question is which internal actors can influence plantar temperature. 20 pregnant women from Czech and Slovak Republic in early stage of pregnancy, aged from 24 to 38 years old were included in the research. In this research, we followed the course of temperature-rested feet and feet after exercise for pregnant mothers in the different trimesters of pregnancy. Our task during the experimental research was to verify the functionality of special shoes. When we examined the temperatures of left and right sole in pregnant women, we noticed significant differences between right and left leg on 1 % level of statistical significance. Body weight gain is directly proportional with increased pressure on future mother's sole. Increased body weight and pressure on the sole connected with it increases blood flow of the tissue. More blood flowing increases the friction and the temperature of the sole. Surprisingly, from second to third trimester we noticed decrease in temperature after walking.

Key words: Orthopaedic insoles, biomechanical shoes, pregnancy, thermography

Introduction

In plantography, the most studied movement is the basic type of human locomotion - gait. Many people have various problems caused by an abnormal state or functions of their feet, in some cases easily identifiable by podobarographic methods. The question is which factors may influence plantar pressure (Perry, 1995; Praet, 2004).

The most important factors that are interconnected are arrangement shape of the foot, way of gait, the distribution of body mass and body weight, or shape of the foot during pregnancy is primarily genetically determined, but it is also influenced by other factors, such as wearing shoes, injury, disease, pathological states of legs, which may occur in connection with the operated physical activity, occupation, or weight gain. Gait is usually completely individual characteristic manifestation of every human being. It depends on the physical parameters, posture, body mass distribution, musculoskeletal conditions and the like. The distribution of body mass is also influenced in women by pregnancy. Body weight is a factor that is affected by a number of phenomena such as heredity, lifestyle, metabolism, pregnancy.

Aim of this work is to measure the impact of special shoes and dynamics of temperature changes in pregnant women in each trimester with the use of thermography.

We expect that special insoles and shoes using through increasing pregnancy will result in a significant increase in the temperature of the feet on any details of the thermal imager in all terms.

Use of Thermography in medicine

In this study we observed pregnant women whose body weight returned to its original state after giving birth to clarify the tem-

perature changes during the pregnancy. This fact enables us to explore how plantar pressure changes with increasing body weight for interacting pregnancy changes, as well as weight loss after childbirth, which also offers the opportunity to compare the original and final state and the question of whether the study of temperature has widespread applications across science and industry. Thermal image is able to give us real time two-dimensional temperature measurement (Ring & Ammer, 2011). With a new technology, a single image contains several thousands of temperature points, captured in one second. Average speed rates were 1 to 16 frames per second, temperature resolution was 0.5°C and spatial resolution was about 5 mm at a target size of 50 cm² (Ring, 1984). Thermal imaging has been used mainly for research over the last 50 years. It has been used to study a number of diseases where skin temperature can reflect the presence of inflammation in underlying tissues, or where blood flow is increased or decreased due to a clinical abnormality (Ring & Ammer, 2011).

Thermography gives us very useful information if the process of change in the pressure load of legs in pregnant women is reversible.

Results of other studies suggest that pregnancy actually causes change in the formula of plantar pressure distribution. It is also necessary to consider whether these changes can somehow alleviate and prevent overloading areas for which such a burden is not usual. In this sense, it offers use of orthopedic aids or special orthopedic shoes, the effect of which should be experimentally tested. One factor related with the degree of blood perfusion of the foot is also temperature as one of the very important indicators.

Pregnancy is usually 38-42 weeks long period in which the woman - expectant mother - is preparing for childbirth and motherhood. This period is characterized by plenty of not only

body changes (see. Fig. 1) but also mental changes (Behinová & Kaiser, 2012). In this chapter, we describe briefly the most important physical changes associated with pregnancy, which

directly or indirectly affect gait parameters. These changes include changes in body weight, change in the position of the center of gravity and musculoskeletal changes.

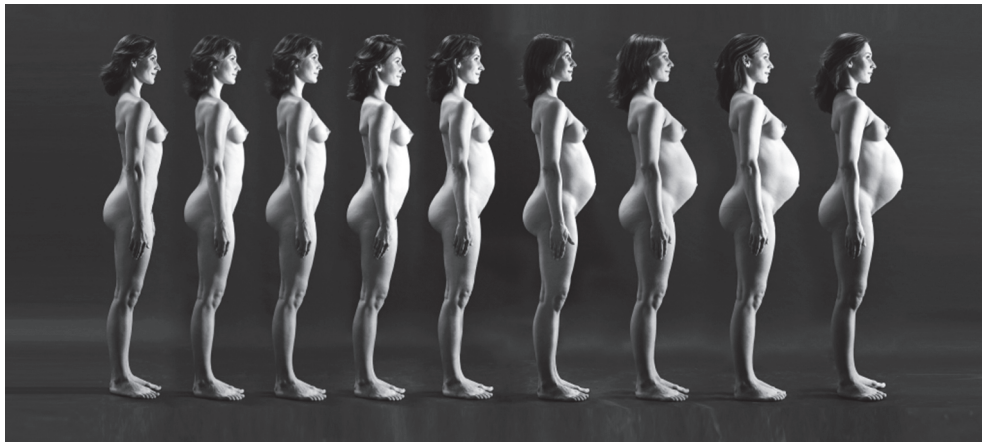


Figure 1. Physical changes during pregnancy

Body weight

Although pregnancy is generally associated with weight gain, in early pregnancy some women may paradoxically experience weight loss. The reason is generally pregnancy-induced nausea caused by high concentration of the hormone hCG. The growth of the uterus, placenta and fetus, enlargement of breast volume, blood and extravascular extracellular fluid sooner or later results in a distinct increase in body weight (Hops, 2004). To a lesser extent, the increase in body weight also contributes to increased volume of intracellular water, fat and protein (lekari.porodnice.cz, 2013).

Concerning the size of the ideal weight gain during pregnancy, the experts are not unanimous. Usually a distinction is made for different BMI in early pregnancy and moves in various sources in the interval from 5 kg for high BMI to 18 kg for low BMI. In women expecting twins the ideal weight gain is 16 - 20.5 kg. (Brázdová, 1999) For illustration, we calculated expected weight gain composition of the woman who gives birth to a child weighing 3300 g:

- placenta weight by approximately 500 g
- uterine weight increases by approximately 1000 g
- amniotic fluid weight 1000 g
- fetal weight 3300 g
- mass volume increased blood of pregnant women 500 g
- weight multiplied fluid in body tissues 2000 g
- breast mass is increased by about 500 g

Methods

Characteristics intervention factors: "Biomechanical shoes" and "biomechanical insert"

The most specific feature of the shoe is a depression below the first metatarsal head, which should lighten this area while supporting the longitudinal and transverse arch of the foot, which is exactly what is particularly needed in pregnancy (Fig. 2 and Fig. 3).



Figure 2. Tested orthopaedic insoles

The characteristics of the reference file

In the research were included 20 pregnant women from the Czech Republic and Slovakia in late stage of pregnancy at age 24-38 years. None of participants wore any special health shoes to correct arch before the research. All women were monitored without serious health problems of musculoskeletal system.

In our case, we conducted single arm, two-factor, time-pha-



Figure 3. Tested biomechanical shoes

sed research. The study group of pregnant women was repeatedly measured in the laboratory of the Department of Sports Kinesiology at the Faculty of Sports Studies in Brno.

Research situation

After their arrival, each participant was asked to lie down on a recliner without shoes and socks, and thus remained 5

minutes in the supine position or on their side, without contact with the foot pad. Then we took three pictures of rested feet with a thermal camera. There were 40 second intervals between each photo. Figure 4. Then the volunteer put on socks and shoes and walked on a treadmill for five minutes at a constant speed of 3km/h. Subsequently, they returned to lie down on the recliner and identical photographing with a thermo camera took place, with the same number of photographs in 40 second gaps. Immediately, the volunteers stood on prepared platform made



Figure 4. Photo after exercise

of 2cm thick play plasticine. They remained on this platform for 30 seconds. The last photographing was done on thermal imprint left by the volunteer on the platform with the number of 1 photograph. Figure 5. We repeated the same process in the collection of data at the beginning of each trimester of pregnancy. Every tested pregnant woman was wearing our special insole and biomechanical shoes while walking on treadmill to keep standard conditions for each observed person.



Figure 5. Photo of the fingerprint plasticine

Results

First we compared the temperature of the right and left foot on each image and in each trimester. Using a paired t-test we did not find statistically significant differences in temperature between the right and left foot in one frame. Therefore, the project further used the average of the right and left foot for evaluation. We evaluated the significance of differences in mean values of individual measurements in the second and third

trimesters. We found statistically significant changes between measurements within one quarter.

In the second trimester women had an average temperature of $28.26 (\pm 1.79) ^\circ\text{C}$ (± 1.79) and after the load was increased to $29.54 (\pm 1.97) ^\circ\text{C}$ ($p \leq 0.01$) and $29.17 (\pm 2.68) ^\circ\text{C}$ to $30.03 (\pm 2.32) ^\circ\text{C}$ ($p \leq 0.01$) in the third trimester. When the women were pushing the plasticine, the temperature of the feet changed back to the original temperature of $26.12 (+1.69) ^\circ\text{C}$ and $26.13 (1.96) ^\circ\text{C}$ in the third trimester. Between trimesters we have recorded significant differences.

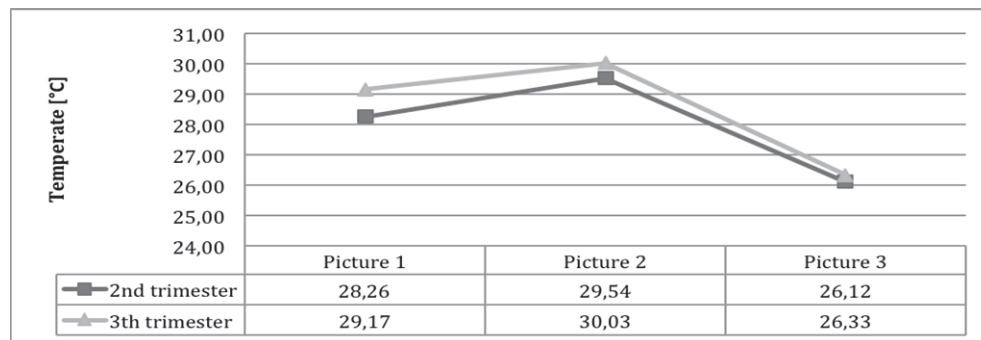


Figure 6. Course average foot temperatures in each trimester of pregnancy

Figure 6 shows that the temperature of the foot on a treadmill increased from the second to the third trimester. This temperature rise is natural, due to increasing demands on the body in response to the load. With the increasing weight of the body is directly connected proportional increase of pressure applied to the sole of the mother, resulting in an increase in perfusion. A greater amount of perfusion in the foot increases the friction and thus the temperature of the foot. However, we did not show statistically significant increases.

Throughout the study, we observed various temperatures in each trimester. Every pregnancy is unique and female body can react to changes caused by pregnancy differently. Other factors that may affect the course of pregnancy, the mother and research results related to the measurement of the temperature of

the foot of the reference file may be psychological mood of the mother, work, other physical activity, physical condition, age, and birth order.

Discussion

Results of work indicate that the temperature of the foot during pregnancy is changing. The temperature increases with progressing pregnancy. Analysis of variance did not confirm a statistically significant increase in the temperature of the feet on the camera images in all trimesters. This might be caused by the fact that the organism of each pregnant woman responds differently to the changes during gravidity. In our case, we might also face the situation where special

insoles and special construction of the shoes used in this research were influencing perfusion and of course feet temperature differs during scanned trimesters. It was observed that the temperature of the foot increased from $28.26 (\pm 1.79) ^\circ\text{C}$ (± 1.79) to $29.54 (\pm 1.97) ^\circ\text{C}$ ($p \leq 0.01$) in the second trimester and from $29.17 (\pm 2.68) ^\circ\text{C}$ to $30.03 (\pm 2.32) ^\circ\text{C}$ ($p \leq 0.01$) in the third trimester. In the future we plan to compare our tested group of pregnant women with another group of pregnant women in order to capture differences caused by special insoles and shoes used in research more easily.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Ethical approval:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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