


# The study of vertical ground reaction during walk of Czech women

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## ABSTRACT

Korvas P, Musil R, Došla J, Kolářová K, Pavlík J, Šenkýř J. The study of vertical ground reaction during walk of Czech women. *J. Hum. Sport Exerc.* Vol. 8, No. Proc2, pp. S54-S60, 2013. The aim of this study was to find whether it is possible to explain different plantar loading during absorption and propulsive stages of stance in the observed persons by means of basic body indicators or time characteristics of gait. Fifty-one healthy women participated in the study; their age range was between 30 and 60 years of age. The women were divided into two groups according to whether they reached higher values of vertical ground reaction during absorption (group A, 8 women, 16 %) or propulsive (group B, 43 women, 84 %) stage of stance. Capacitive pressure insoles in the shoe were used (PedarX, Novel Munich). During laboratory survey each woman performed monitored natural walk. Three stances of each leg were assessed, always from between the third and eighth steps. Five parameters had been chosen for monitoring, three recording force characteristics of gait and two time parameters. Group A reached relative value of 121 % of BW during the first stage and 110 % of BW during the second one. Group B reached 105 % in the initial stage, and 117 % of BW in the other stage. A significant difference was found for  $F_1$  parameter between groups A and B, not for the second part of stage. Group A manifested shorter duration of both stages of stance (not significantly different from group B). The level of relationship between stance duration as well as its stages and force manifestations in both groups of women was very low (from  $r = 0.010$  to  $0.015$ ). Only in group A, the weight of the women correlated with relative values of both  $F_1$  and  $F_2$  ( $r = -0.795$ ,  $r = -0.625$  resp.). **Key words:** GROUND REACTION, STANCE, WALK, WOMEN.

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## INTRODUCTION

Since the mid-20th Century, modern humans have gradually started to neglect the need of physical activity. If we take physical load manifested by a human in the early 20<sup>th</sup> century as 100 %, then at the end of the century the load was 1 % (Frollis, 1988). At present, up to 70 % of the inhabitants of advanced countries suffer from physical inactivity as a result of a sedentary way of life (Dobry, 2007). Decreasing the level of physical fitness as well as decreasing time of active sporting during leisure time have a secondary effect on work capacity, work performance and, most of all, health (e.g. Blair et al., 1989, 2001; Blahutková et al., 2005; Dobry, 2008).

Up to the present time, walking has been one of the most important physical activities of Czech population. The share of walking in total motor activity remains still big and walking is most often reported as usual physical activity which is used by more than 75 % of the population of the Czech Republic during the week. Frömel (2005, 2006) states that the average time that teenagers spent by walking per day is 50-80 minutes. Neuls (2007) found out that the average time in adult population of the Czech Republic is about 60-80 minutes and this amount of time is also influenced by environmental factors. If compared with other advanced countries, the Czech Republic is still a country of walkers; e.g. in the USA, Berkey et al. (2003) found only 24 minutes of walking per day and only for 15-30 % of adults in the USA walking presents the most often used motor activity (McArdle et al., 1986). Walking is always considered a modest cheap physical activity with simple movement structure, which is very suitable for elderly people to maintain optimum fitness, but at the present time it can be very important for younger generation too because they don't want to take part in regular sports or games.

Research in the area of health and physical activity and inactivity of humans increases the amount of knowledge about walking and its kinetic and kinematic characteristics. Great individual variability in gait has been proved which is based on the quality of the locomotive and support systems, the quality of controlling and regulatory mechanisms and on motor activity in childhood and youth. Gait variability is an issue both biomechanical and orthopaedic. Many studies have been carried out to describe some variables which contribute to the gait variability mainly from the point of view of age or illness (Brach et al., 2008). According to Gabell and Nayak (1984), the characteristics of gait such as length and the duration of a step represent the automatic stepping mechanisms of gait (i.e. pattern generator for gait) and gait width and the duration of double-support posture represent the checking of balance. Therefore, worsened activity of such controlling mechanisms increases gait variability. Scientists who study the differences in gait of different adult age categories have proved a number of changes in elder population such as decrease in velocity (Hageman & Blanke, 1986; Waters et al., 1988; Winter et al., 1990; Ostrosky et al., 1994; Perry & Burnfield, 2010), smaller extension in hip and knee joints, smaller range during dorsal leg flexing (Winter et al., 1990; Ostrosky et al., 1994; Kerrigan, 2001; McGibbon, 2003), decrease in stride length, changes in stride width or reductions in performance during the take-off stage of a stride (Blake, Hageman, and Blanke, 1989; Ostrosky et al., 1994; McGibbon, 2003). Further increase in gait variability has been proved with the influence of diseases such as Parkinson, Alzheimer diseases or peripheral neuropathy (e.g. Hausdorff et al., 1997, 2000; Richardson et al., 2004).

Gait technique and its quality is affected by foot architecture, anthropometric and biomechanical properties of an individual and other factors such as body weight, muscle fatigue, the location of the centre of gravity of the body etc. Individual gait technique affects movement economy or causes problems with the support or locomotive systems. The range of normality of gait motor pattern determination is a matter of selecting appropriate criteria for evaluating its quality with respect to the uniqueness of every individual. At present, it

is possible to make use of a number of modern technologies and methodologies which help to examine and solve this topic (e.g. Ayyappa, 1997a, 1997b; Kirtley, 2006; Zvonař & Lutonska, 2009; Perry & Burnfield, 2010).

From the results of our contemporary studies it follows that we can divide our population into two kinds of walkers. Each of our walkers showed usual course of vertical ground reaction force during stance with two peaks and one decline between the peaks. But one group reached higher size of vertical ground reaction during opening stage of stance (Loading Response) and the second group reached higher size during the second stage of stance (Terminal Stance) (unpublished study of authors).

The aim of our study was to try to explain the different course of vertical ground reaction during stance of observed women with the help of body parameters or time characteristics.

## MATERIAL AND METHODS

We have carried out a preliminary descriptive study. The research group was composed of Czech women adult population with normal physical activity. The number of subjects was 51; the age range was from 30 to 60. The observed women were divided into two groups along the size of vertical ground reaction. Group A reached higher vertical ground reaction during first peak of stance and group B during the second peak of stance. Group A consisted of 8 women (16 %) and in group B there were 43 women (84 %).

**Table 1.** Basic characteristics of subjects.

Group	n.		Age(years)	Height (cm)	Weight (kg)	BMI
A	8	M	38.5	167.0	61.7	22.0
		SD	8.0	4.3	7.6	2.0
B	43	M	45.5	167.9	69.5	24.6
		SD	10.6	7.7	14.6	4.0

The vertical ground reaction (force) during stance was recorded by PedarX mobile system (Novel Company, Munich, Germany) through two pressure insoles (in shoes) which contain 99 pressure sensors equally spread all over their surface. It was recorded with the frequency of 100 Hz.

We completed laboratory survey, each woman performed three attempts of natural walking (speed, frequency, length of step) two of them were performed for training and the final attempt was monitored. The observed variables created during stances were recorded for a minimum of 12 - 15 strides. Three stances of each leg were evaluated, always after the fifth step. The observed persons during the initial 5 - 6 strides reached natural stable individual gait technique and speed. All observed persons wore the same type of footwear with flat sole.

We monitored five representative force and time parameters, three parameters recorded force characteristics during stance and two time parameters of stance:

F<sub>1</sub> - maximal force during absorption stage of stance, force peak during Loading Response (LR) and Midstance (MSt), F<sub>2</sub> - maximal force during propulsive stage of stance, force peak during Terminal Stance (TSt) and Preswing (PSw), t<sub>1</sub> - time of absorption stage of stance, time from Initial Contact (IC) to the end of MSt, t<sub>2</sub> - time of propulsive stage of stance, time from the start of TSt to Terminal Contact (TC), t - total time of stance. To compare ground force reaction among different persons, percentage of body weight (% BW) was used. The observed persons were further inquired about their body weight, height, age, their BMI was calculated.

We used descriptive statistics, correlation, t-test. Statistical level of significance was set at α = 0.1.

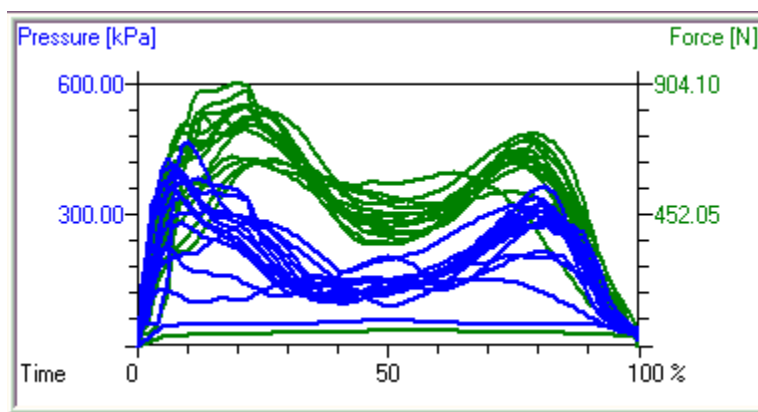
**RESULTS**

Women in our research proved different relative size of vertical ground reaction at both peaks of stance. Usual course of vertical ground reaction force during stance with two peaks and one decline between the peaks was found for all subjects. Most of our subjects produced higher size of vertical ground reaction during the second stage of stance (propulsive stage), which is probably more economical (group B).

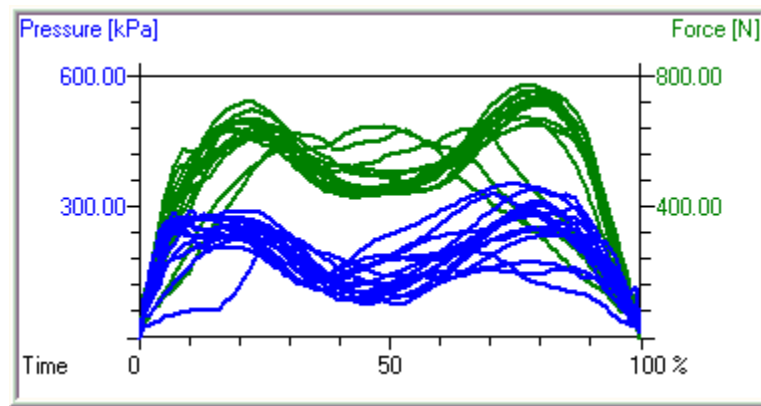
**Table 2.** The results of vertical ground reaction during standard walk for both group.

Group	n.		F <sub>1</sub> (N)	F <sub>2</sub> (N)	t <sub>1</sub> (sec)	t <sub>2</sub> (sec)	t (sec)	t <sub>1</sub> /t <sub>2</sub>	F <sub>1</sub> in % BW	F <sub>2</sub> in % BW
A	8	M	726	658	0.30	0.33	0.63	1.12	120	109
		SD	56	78	0.01	0.03	0.2	0.15	15	16
B	43	M	709	788	0.31	0.35	0.66	1.16	104	116
		SD	164	157	0.04	0.04	0.4	0.16	15	13

For F<sub>1</sub>, women of group A reached relative value of 120 % of BW during the first stage of stance and 109 % of BW during the second one. Women of group B reached 104 % in the initial stage, and 116 % of BW in the propulsive stage. A significant difference was found for F<sub>1</sub> parameter between groups A and B, which illustrates basic differences in plantar loading during stance in the observed groups of women. The difference for F<sub>2</sub> between groups was not significant.



**Figure 1.** Course of vertical ground reaction for group A.



**Figure 2.** Course of vertical ground reaction for group B.

We have found only few interesting relationships among the selected parameters. In group A, a relationship on the mid level of significance was found between  $F_2$  and BMI ( $r=0.536$ ) and relatively strong relationship between weight and of both relative  $F_1$  and  $F_2$  expressed in % of BW ( $r=-0.795$ ;  $r=-0.625$  resp.).

Further, interesting correlations in group B were found between body height and absolute vertical ground reaction for both  $F_1$  and  $F_2$  ( $r=0.623$ ;  $r=0.632$  resp.).

#### *Time characteristics*

Both groups showed longer time of propulsive stages, for group A by 52 % and for group B by 53 % of the whole time of stance. Time of propulsive stage was significantly longer than absorption stage for both groups ( $p_A=0.082$ ;  $p_B=0.000$ ).

Women with higher  $F_1$  during absorption stage manifested, on average, shorter duration of both stages of stance, however, such difference was not significant when compared to group B. Also the level of relationship between stance duration as well as its stages to the absolute or relative vertical ground reaction in both groups was very low (from  $r=0.010$  to  $0.015$ ).

## **DISCUSSION**

Relative values of force ground reaction were only partially comparable with other studies in which e.g. Kirtley (2006) presents an average of 117% at  $F_1$  and 109% of BW at  $F_2$  which is comparable with the result of our group A. Perry and Burnfield (2010) states 110% of BW for both peaks. And this is not comparable with our groups who showed different size of  $F_1$  and  $F_2$ . The results in our groups were within a relatively wide range between 104% and 120% of BW for both peaks.

During propulsive stage (Terminal stance, Preswing) the size of vertical ground reaction was similar for both groups (without significant difference) because each woman needed to produce sufficient propulsive force for maintaining natural speed and rhythm of walk.

On the average, during the absorption stage, women with higher F1 reached shorter duration in both phases of stance; however, this difference was not significant if compared with group B. The second phase in which propulsive force for maintaining speed of walk is generated is longer than the initial stage in both groups. It depends on the force and technical skills of the subjects how fast it is performed.

The portion of time of the absorptive and propulsive parts of stance was similar in both groups, which means that time characteristics are similar for both groups.

## CONCLUSIONS

It can be stated that for the selected parameters, a certain relationship can be considered in group A of plantar load to the BMI of the subjects and relative weight. In group B, there was only a relationship between the height and the absolute vertical ground reaction for both peaks. And this is an insufficient proof of any influence of body dimension and time characteristic on the course of vertical ground reaction for our subjects.

We found out some interesting results, but for more relevant results which could better explain the substance of the differences of plantar load during stance a kinematic analysis and a follow-up survey are necessary.

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