THE INFLUENCE OF THE RANGE OF OSCILLATIONS OF THE CENTER OF GRAVITY OF THE BODY AND THE ENERGY RECOVERY MECHANISM ON THE VALUE OF EXTERNAL WORK DURING WALKING OF PREGNANT WOMEN

Abstract

During pregnancy, all changes occurring in the female body interact with each other, to some extent changing the biomechanics of the pregnant woman's movement. This is largely due to the increase in body mass and the associated position of the center of mass (COM). The author's intention was to explore the issue of mechanical adaptation of the future mother's body to the changes brought about by the development of pregnancy.

For this purpose, the Vicon system was used and free gait, as the basic form of locomotion, was examined in a group of 26 women in the early stages of pregnancy (T1, first trimester of pregnancy), and then compared with the gait results of the same women in advanced pregnancy (T3, third trimester of pregnancy). Additionally, in accordance with the available literature, an original modification of the mathematical model for determining the position of the COM (Mod-1) was made, taking into account changes in the distribution of the mass of individual body segments in women in advanced pregnancy. In order to determine the usefulness of the applied modification of the model, the gait of the group of women in the third trimester of pregnancy was subjected to repeated analysis using Mod-1 (group GP3) and compared with the gait results of the T3 group for the basic model of determining the COM position (GolemCOM).

All obtained results were compared with the results of free gait of an appropriately selected control group of 26 non-pregnant women (GK). It is also worth emphasizing that the obtained values of biomechanical variables were subjected to standardization taking into account the somatic structure of the women and the length of the gait cycle in order to normalize the obtained results.

Five categories of variables were compared: the structure of the experimental group and anthropometric variables, time-space parameters, lateral and vertical COM oscillations, mechanical energy components of COM and the energy recovery index during walking.

In order to realize the first of the set goals of the work, it was observed that between the first and third trimester of pregnancy the body mass of the examined women increased by

11.31 kg, and the BMI by 3.97 kgm^{-2} ($p < 0.001$, ANOVA; $p = 0.0000$, Student's t-score). The third indicator showing a difference in the course of pregnancy was the range of lateral oscillation of the general body center of gravity Δ COM(X)_std, which increased by 0.3% in the T3 group compared to the T1 group ($p = 0.0091$N, ANOVA; $p = 0.0000$, Student's t-score). Additionally, the variables STT, STRT, SSUP and RECOV_1 showed differences only in one of the statistical tests. During pregnancy (T1-T3), the step time (STT) and cycle time (STRT) were shortened by 0.01 s and 0.02 s, respectively. In the case of the RECOV_1 variable, women in the initial period of pregnancy, despite the lack of significant morphological changes, moved with the least energetically advantageous gait. In each gait cycle, they had to provide 56% additional energy. The development of pregnancy influenced the increase in the efficiency of the energy recovery mechanism by 3.5% in the T3 group compared to the T1 group.

In the comparison of the results of the pregnant women groups with the results of the control group, the most significant differences were observed between the gait parameters of the GK and T1 groups. The most significant changes occurred in: Δ COM(X)_std (decrease by 0.6% in T1), RECOV_1 (decrease by approx. 10% in T1) and SSUP. The temporal-spatial parameters (FO, OFO, STL and STRL, WS) as well as ΔEp_std, also showed lower values in the T1 group than in the GK group.

The second aim of the study was to assess the usefulness of the modified model of determining the COM position (Mod-1) for the analysis of the gait of pregnant women. In terms of all the analyzed variables, only the kinetic energy of the lateral component of the COM (GP3_ΔEkx_std) showed a statistically significant difference (in both tests) with all other groups, and the greatest difference was noted in comparison with the T1 group. The statistical difference was shown by the ranges of changes in oscillations COM(X)_std ($p < 0.05$) and COM(Z)_std ($p < 0.005$), in both groups (T3 and GP3), as well as changes in the potential and total energy of the COM. It was noted that the modification of the COM position determination model (Mod-1) additionally showed statistically significant differences ($p < 0.05$) compared to the control group (GK, GolemCOM) also for the ΔEkx_std variable.

The results obtained based on the use of the modified Mod-1 model remain difficult to interpret due to the small number of reports and analyses on this subject. The influence of changes in the position of the SC of the trunk and the distribution of masses of individual segments on the position of the COM among pregnant women also remains not fully understood. The modification made by the author of the work, based on the literature, is an innovative approach to gait analysis, which requires further research in this area. The

differences between the models found in our own studies (especially for COM oscillations in the lateral direction) and the conclusions of other authors suggest the need for further work on determining changes in the COM position for pregnant women, using models better suited to the realities of the phenomenon being studied. Additionally, the influence of the model modification (Mod 1) on other kinetic and kinematic parameters that can be determined during gait of pregnant women and were not analyzed in this study remains unknown.