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Research Article

Changes of Equilibrium during Gestation

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Abstract: Aim of the authors was to evaluate the effects of physical activity on body balance during gestation. Balance testing was performed in 80 normal pregnancies, where pregnancy exercises were regularly performed, in 80 pregnancies where bed rest was suggested and in 80 matched control volunteers (n=240). Dynamic balance was measured with five different tasks of the stabilometer (D1-D5). Data of balance testing of the groups were compared with *t*-test. Average results of static balance (eyes closed- and eyes opened) tests were significant worse in groups of healthy and pathologically pregnant women compared to non-pregnant women. Concerning the subgroups: those who had previously been involved in professional sports and were healthy and physically active during pregnancy performed better on the open–eye test compared to pathologically pregnant patients. Examining healthy pregnant women's dynamic balance resulted in significantly worse performed D1-D5 exercises compared to non-pregnant women. Pathologically pregnant women were compared to non-pregnant women results of 4 tasks (D1, D3, D4, D5) showed a significant difference. Healthy pregnant women performed significantly better in exercises D1 and D4 than pathologically pregnant women. Between the second and third trimesters of healthy pregnancies a significant difference was detected in the movement of central point of body mass (D5). 21% of healthy pregnant women and 43.1% of women with gestational pathology reported an episode balance loss. Physical activity has positive effect on balance during pregnancy.

Keywords: Balance, physical activity, inactivity, pregnancy.

INTRODUCTION

Good static posture is known to be characterized by small sways [1]. While the postural control mechanism seems to be unaffected during pregnancy, the increased and asymmetric distribution of body mass, and the posterior tilt observed during pregnancy could play an important role in modulating body sway amplitude and frequency [2]. Butler et al. established that posture becomes unstable during pregnancy and remains diminished for 6 to 8 weeks after delivery [3]. In addition, the data of eyes closed and eyes opened tests suggest that there is an increased importance of vision on maintaining balance. Jang et al. found that pregnant women displayed increased sway comparing to non-pregnant individuals, especially in the anterior-posterior direction [4]. According to the findings of Oliveira, moreover, the elliptical area encompassing the centre of pressure significantly increases over the course of pregnancy during straddle position and eyes closed test protocols [5]. According to Nagai et al. high anxiety during pregnancy may also destabilize the posture during eyes open test [6]. Postural instability changes throughout pregnancy may lead to an increased incidence of falls. Nearly 25% of employed women sustain a fall during pregnancy, a rate that is comparable to the rate in elderly persons over 65 years of age [7]. Research data of this age group prove that physical training improves balance and reduces body oscillations during static and dynamic equilibrium tests and current exercise activity reduces the risk of falls [8]. Little is known about the connection between changes in equilibrium and physical activity and their effects over the course of pregnancy.

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The purpose of our study was to determine both static and dynamic postural equilibrium changes during pregnancy especially during the 2nd and 3rd trimesters. Besides, to reveal how equilibrium changes are influenced by lack of physical activity in pregnant patients with bed rest, and also the effects of regular physical training before and during pregnancy. With the help of a questionnaire the other aim of the study was to access the rate of loss of equilibrium in surveyed women during the examination period.

EXPERIMENTAL SECTION

Participants

Stabilometer balancing tests were performed in 80 primipara women with normal singleton pregnancies (normal pregnancy), in 80 primipara pregnant women with suggested bed rest (pregnancy pathology) while 80 healthy young non-pregnant women formed the control group (non-pregnant women, CG). Pregnancies were allocated into two groups: 2nd and 3rd trimesters of pregnancy, at 13 to 24 and 28 to 40 weeks of gestation. Pregnancy complications included threatened abortion or preterm delivery, as well as bleeding complications due to low-lying placenta. Patients with twin gestation, known disease or conditions that may affect postural stability (if they had a history of gestational diabetes, pre-eclampsia, toxaemia, gestational hypertension), and also those who were over 35 years were ineligible for this study. Potential control or pregnant participants were excluded from enrolment if they had a history of type I or type II diabetes or any other condition which could affect their sensation, a lower extremity fracture within the last five years or a sprain during the last year, current back or knee pain, or a history of ruptured ankle or knee ligaments. Subjects were also excluded if they were current smokers, if they currently took any medication that would affect their ability to balance, or if they consumed more than one alcoholic drink a day.

The surveyed pregnant women were reorganized into four new groups based on duration and frequency of exercise prior to and during pregnancy. First group: those pregnant women who were engaged in sports competitively both in their childhood and during the years prior to their pregnancies with 4-5 trainings weekly for 1.5-2 hours, when endurance and sports specific training were involved and sports activity continued even during pregnancy (professional athletes; n=25). Second group: those who did leisure sports devoting max 1 hour to exercises 2-3 times weekly and doing exercise continued even during pregnancy (non-professional athletes; n=25). Third group: healthy pregnant women took part in pregnancy exercises from the 12th week, where each session lasted one hour (non-athletes, exercising during pregnancy; n=25). Fourth group: During the stay in the ward they performed exercises once a day for 5-10 minutes under the direction of a physiotherapist. Healthy pregnant women performed other exercises than those which were performed in hospital wards to prevent complications as a result of inactivity. Women with suggested bed rest due to a low-lying placenta or threatened preterm delivery. Exercises performed in the hospital ward significantly differed from pregnancy exercises out of hospital. The program involved exercises in a prone position to improve venous circulation, respiration and to move joints (not exercising during pregnancy; n=25).

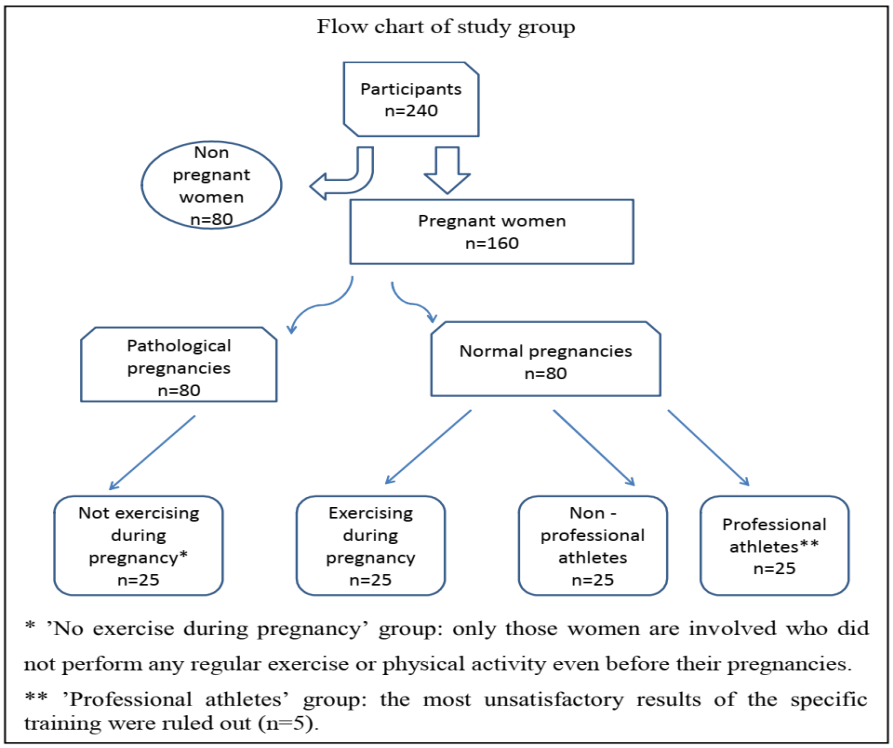

Fig-1: Flow chart of study group

Measures

Measurements were performed with stabilometer (Bretz Mérnökiroda, 1987. Budapest, Hungary). The equipment consists of two pieces of force plate, size: 10cm×50cm×50cm, 3 amplifiers per force plate, one microcontroller, and one PC. The plate measures the position of the centre of pressure; output stress depends on deformation and it is proportional to it. The output stress attunes to the amplifiers, and the microcontroller transforms the amplified analogue stress signals into digital signs to be interpretable by the computer. The computer performs the calculation with the help of these signals and the results in the form of result diagrams, where the moving and the time function graphs are displayed on the monitor or are numerically provided.

Procedures

Prior to the stabilometry testing a questionnaire was completed which focused on the following issues: range of motion, quality of physical activity, the existence of associated diseases, use of medication, and the course of pregnancy and possible complaints of pregnant women.

Both the questionnaire and examination were administered by the same individual researcher under controlled conditions. At the beginning of each session pregnant women were asked whether they had lost their balance or sustained a fall during the pregnancy.

The first trial of static equilibrium examination was the Romberg test with the eyes open. The pregnant woman stands barefoot, legs together on the platform with straight alignment of posture, arms are extended into the anterior supinated position and fingers are closed. Pregnant women were asked to stand still for 20 sec. In the same position the trial was performed with the eyes closed. During stabilometer measurements dynamic balance was examined with 5 programs on a stabilometer. First trial: retention of centre of pressure within a given range. (retention of centre of gravity, D1) Second trial: effective and quick movement of centre of gravity (CoG) according to six predetermined points (quick moving of centre of gravity, D2). Third trial: the subject has to move her centre of gravity as quickly as possible towards a point (centre of gravity moves into the stationary point, D3). Fourth trial: centre of gravity has to be forwarded into points along a stationary circle in 20 seconds as many times as possible (moving of centre of gravity on the counter-line, D4). Fifth trial: The possible largest area of the 2x2 cm area has to be covered on the monitor by moving the central point of body mass, using a cursor configuration feedback within 20 seconds (moving of the central point of body mass within the square, D5). During the trial the subject stands on a platform approximately 1.2 m from the monitor.

All subjects of the study were volunteers, and provided informed consent. Examinations were performed during a 24-month period at the Department of Obstetrics and Gynecology, Faculty of Medicine, and Institute of Physiotherapy and Sport Sciences, Faculty of Health Sciences, University of Pécs.

Statistical analysis

The study was a prospective, observational and a controlled trial with non-random sampling. Variables are described by frequencies and mean and standard deviation, mean and range or mean with prevalence (%). Statistical data (inter-group differences) were analyzed by *t*-test or nonparametric Mann-Whiney *U*-test was used to compare the difference between groups. Differences between nonmetric variables were analyzed using Fisher's exact test. A p value <0.05 was interpreted as statistically significant. Statistical analysis was performed using SPSS 15.0.1 for Windows (SPSS Inc, 1989–2006).

RESULTS

Statistical Characteristics of the Participants

Demographic parameters of surveyed women were as follows: mean age 28.4±2.3 years (19-35 years), mean value of BMI: 25.62±3.1 kg/m^2, which is 4.26 kg/m^2 higher compared to the control group, average of gestational weeks was 29±3.1 (13-40 weeks).

Table-1: Demographic Characteristics of Women Participating in the Study (n = 240)

	Age (years)	BMI (kg/m^2)
Normal Pregnancy	29.03±3.08	24.93±7.05
Pregnancy Pathology	27.77±4.01	26.31±8.33
Control Group	22.34±3.86	21.36±5.01

Static Equilibrium Test

Group mean values of Romberg test with eyes closed and eyes open performance in the pregnant group were significantly worse compared to control subjects.

Table-2: Results of the Romberg test (n = 240)

	Romberg test (open eyes)	Romberg test (closed eyes)	p value
Normal Pregnancy	12.36±4.28 mm	17.7±6.35 mm	p=0.034
Pregnancy Pathology	13.14±4.59 mm	18.22±7.93 mm	p=0.042
Control Group	10.42±3.07 mm	14.32±5.32 mm	

Amongst the efficiency of pregnant groups there was a decline (13%) in pregnant women with gestational pathology but no significant variation was found. Results of 2nd and 3rd trimesters of normal pregnancy were neither significant.

Table-3: Romberg test results during 2nd and 3rd trimesters of normal pregnancy (n = 40)

	Romberg test (open eyes)	Romberg test (closed eyes)	p value
2nd Trimester Of Pregnancy	12.56±3.8 mm	18.47±6.45 mm	p=0.33
3rd Trimester Of Pregnancy	12.14±4.75 mm	18.38±7.93 mm	

Romberg test with eyes closed among the sub-groups (developed on the basis of physical activity): 'exercising during pregnancy' subgroup (state category) achieved better results (p=0.022), which is significantly higher compared to the 'not exercising during pregnancy' subgroup The 'professional athletes' subgroup in the trial with eyes open showed considerably (p=0.038) better results compared with the 'not exercising during pregnancy' subgroup.

Table-4: Static balance measurements in subgroups

	Romberg test (open eyes)	Romberg test (closed eyes)	p value
Not Exercising During Pregnancy	12,5±3,61 mm	17,4±6,17 mm	
Exercising During Pregnancy	12,43±4,30 mm	17,07±6,3 mm	p=0.022
Non-Professional Athletes	11,6±5,08 mm	17,12±8,44 mm	p=0.45
Professional Athletes	11,09±3,96 mm	17,38±7,27 mm	p=0.038

Dynamic Equilibrium Test

Every dynamic equilibrium test evaluation between normal singleton pregnancy and CG showed a significant difference. The control group performed better both in tasks D1 (p=0.031) and D5 (p=0.029), and faster in D2 (p=0.042), and more successfully in D3 (p=0.032) and in D4 (p=0.008), compared to pregnant women.

Pregnant women with a gestational pathology performed tasks D1 (p=0.038), D3 (p=0.003), D4 (p=0.002) and D5 (p=0.001) with a significantly worse result compared to CG.

Normal pregnancies compared to pathological pregnancies during D1 (p=0.028) and D4 (p=0.042) tasks of stabilometer measurements achieved a significantly better result.

Between the second and third trimesters the D5 of dynamic balance test's (p=0.041) results did show significantly different results. Pregnant women in the third trimesters performed tasks a significantly worse compared to second trimesters.

The 'non-professional athletes' subgroup performed D3 significantly (p=0.033) better while the 'professional athletes' subgroup performed D5 significantly (p=0.003) better result compared to hospitalized passive pregnant women's performance. The 'exercising during pregnancy' subgroup achieved a (p=0.043) better result compared to hospitalized pregnant women doing less exercise during the performance of the second dynamic balance measuring test (D2).

Table-5: Dynamic balance measurements in the 2nd and 3rd trimesters and in subgroups

	D1 (%)	D2(sec)	D3(sec)	D4(piece)	D5 (%)
2nd Trimester Of Pregnancy	93,25±3,14	8,29±1,73	4,21±2,17	8,96±2,12	69,96±5,13*
3rd Trimester Of Pregnancy	93,13±5,01	8,5±3,01	3,79±1,44	8,5±2,32	66,58±7,86
Not Exercising During Pregnancy	91,2±4,93	9,73±3,29	3,29±1,37	7,8±2,51	67,64±8,32
Exercising During Pregnancy	92,9±3,47	7,19±1,97*	3,26±2,62	8,36±2,06	69,1±4,67
Non-Professional Athletes	95,46±3,45	8,47±2,3	3,18±1,17	8,67±2,68	66,6±6,74
Professional Athletes	93,85±3,39	7,2±1,61	3,19±1,52*	8,54±1,9	67,9±5,88
* Significant difference between groups (p≤0.05)					

By means of the questionnaire we investigated whether pregnant women experienced a period of balance loss during their pregnancies. Twenty one per cent of healthy pregnant women and 43.1% of women

with gestational pathology reported an episode balance loss. There were no personal injuries during the examination period. Static and dynamic balance measurements in subgroups with loss of balance did not show significant difference (p=0.069).

DISCUSSION

Equilibrium involves the coordination of sensorimotor strategies to stabilize the centre of body mass during both self-initiated and externally triggered disturbances in postural stability [9]. Balance requires a contribution from three areas i.e. information provided by balance sensors (visual, vestibular, and somatosensory), central integration in the nervous system. It is widely recognized that pregnant women suffer from multiple physiological changes, namely decreased nerve conduction velocity [10], the increase of relaxin concentration during pregnancy affects the ligamentous laxity and cause instable peripheral joints [11, 12]. The standard view is that there is an increase in both lumbar lordosis and thoracic kyphosis [13]. These physiological changes can cause impaired function in maintaining balance during pregnancy. In the recent study, results of groups prove that in cases of control group are better than pregnant women. Moccellin's results also demonstrate that the pregnant woman's body seems to already change postural control and during the trimesters, there is a trend to reduction in postural stability [14].

According the Butler's results there is an increased reliance on vision to maintain balance [3]. The same result has been reported in the aging population and in cerebral palsy and other neurologic conditions too [1, 15]. Findings of subgroups where physical activity was taken into consideration prove that in cases of eyes open test the results of professional athletes who are physically active during pregnancy are better than pregnant women in the inactive subgroup. In eyes closed test the results of active during pregnancy are better than in the subgroup of inactive during pregnancy. According to recent results static balance can be improved with intense physical activity or by doing sports, but it is not exactly known what kind of physical activity can be the best without doing any harm to the body during the pregnancy.

Various populations at risk of falling, such as lower-limb amputees, diabetic patients and elderly individuals, have shown impaired dynamic stability, but only McCrory *et al.*, and Moccellin have assessed dynamic postural stability in pregnant women [14, 16-20]. In the recent study, data of dynamic equilibrium changes are compared in healthy pregnant women, in pregnant women with gestational pathology and in the subjects of the control group. The findings of the control group are significantly better compared to the other pregnant groups. The impaired ability of maintaining dynamic balance can cause difficulties in retaining balance, which may lead to falls. It is known, that nearly 25% of employed women sustain a fall during pregnancy, a rate that is comparable to the rate in elderly persons over 65 years of age [7]. In the previous study it can see, that elderly people performing exercises can maintain or improve balance which may reduce the risk of falls and related injuries [21]. Perrin et al. found no difference between those who had begun physical and sporting activities late in their lives and those who had either never stopped or practiced physical and sporting activities a long time ago [22]. Current measurements show that balance retaining ability can be improved by doing exercises before and during pregnancy. McCrory found that participation in regular exercises at some point during the pregnancy was associated with a reduced number of falls [16]. Current findings also show that physical activity performed only during the pregnancy can also develop dynamic balance.

In the first and second trimesters, maternal tissues such as blood volume, protein and fat predominate the bodyweight of the mother, and in the third trimester, the fetus, the amniotic fluid and placenta prevail [23]. Pelvic segment flexion motion may be limited due to the gravid uterus [24]. Data of trimesters are studied in healthy pregnant women, the findings of dynamic equilibrium tests in the 2^{nd} and 3^{rd} trimesters partly confirm the assumption of Fries, namely that the higher rate of weight gain in the 2^{nd} and 3^{rd} trimesters may explain a decrease in the balance retaining ability [25]. Body mass is increased by adipose tissue and during pregnancy the development of the fetus causes changes to the instability of the pregnant woman [26]. A decreased weight normalized hip joint flexion movement with reduced joint excursion has been reported in late pregnancy, indicating the biomechanical changes were not all due to gravitational components [27]. According to the Butler et al. postural stability declines during pregnancy and remains diminished at 6 to 8 weeks after delivery [3]. Moccellin's results demonstrate that not only in late pregnancy but in the beginning of the pregnancy, the woman's body seems to already change postural control [14]. Only the weight change can not be explained instability during pregnancy. Further studies are needed.

It is considered, that examination of changes in retaining dynamic balance ability is extremely important because injurious falls may account for 17-39% of maternal trauma cases [7]. In addition, serious falls after loss of balance can result in maternal and/or fetus complications leading to 3-7% fetus mortality [28, 29]. Butler et al. found that 25% of women suffered falls during pregnancy, while none of their control subjects during the investigated period [3]. Similar fall rates (26.6%) during the pregnancy were reported by Dunning in 2003 after the analysis of a surveyed group of a large number of active, employed pregnant women [7]. Jang *et al.*, determined the fall rate among pregnant women to be 13% [4]. In this survey 21% of healthy

pregnant women and an extra 22.1% with a gestational pathology (43.1%) reported episodes of balance loss. In subgroups with loss of balance, static and dynamic balance measurements did not show significant difference. Although the results may diminish our study's findings, the merit of their consideration remains relevant. More investigation is needed to determine the effects of exercise on postural sway during pregnancy.

CONCLUSION

In conclusion, physical activities prior to becoming pregnant and physical activity during pregnancy have positive effects on maintaining balance. Introduction of special preventive exercise program may be recommended during pregnancy.

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