

Epidemiological studies in Poland on effect of physical activity of pregnant women on the health of offspring and future generations – adaptation of the hypothesis Development Origin of Health and Diseases

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Abstract

It is recognized that the levels of women's physical activity during pregnancy has a direct bearing on the method of delivery and health of the newborn. The main objective of the study was investigation the level of physical activity of women during pregnancy according to the Pregnancy Physical Activity Questionnaire (PPAQ). The subjects of this study were n=2852 post-partum women surveyed together with their newborns, representing all obstetric hospital departments throughout Poland. The questionnaires were completed on a single day during the second week of November 2011. The women were also asked about the amount, range and type of physical activity they performed before becoming pregnant. The Pregnancy Physical Activity Questionnaire was used for precisely measuring physical activity according to the standard metabolically equivalent (MET). In addition, comparisons were made between the weight of the infant and newborn status using the APGAR scale with the amount of physical activity performed by the mothers. There were decidedly low physical activity levels observed in pregnant women compared to those before becoming pregnant. Appropriate interventions can therefore now be targeted through remedial action in Poland. It is important to perform intervention studies intended to test this hypothesis and attempt to identify the most appropriate levels for intensity, duration and frequency of physical exercise during pregnancy. The studies should consider the four domains of daily physical activity and utilize tools that reliably measure exposure variables. Such studies would provide valuable information for recommendations about physical activity during pregnancy.

Key-words

newborn health, physical activity, pregnancy

INTRODUCTION

Regular physical activity in pregnancy is the precondition of the normal course of pregnancy [1]. This is the recommendation by the responsible institutions, both in the countries of the American continent and in Europe [2, 3, 4, 5, 6, 7]. Physical activity during this period, similar to the time before becoming pregnant, is a basis for maintaining the cardiovascular and musculoskeletal systems on a proper level, and prevents the development of many disorders, such as varicose veins of the lower extremities, deep venous thrombosis or low back pain. Physical exercises are the key

element in the strategy for the prevention and treatment of diabetes, arterial hypertension, cardiovascular diseases or obesity [8, 9, 10]. Gestational Diabetes Mellitus (GDM) is defined as glucose intolerance with onset or first recognition during pregnancy [11]. Insulin resistance within muscle cells decreases glucose uptake and leads to an increase in the level of glucose in the blood of the mother, resulting in an excessive weight gain of the foetus [12]. Uncontrolled hyperglycaemia in the mother often results in delivery by Caesarean section, and may lead to hypoglycaemic coma, or even to disorders in the development of extremities [13]. Risk factors of this type of gestational diabetes are overweight, obesity, or insulin resistance diagnosed before pregnancy [14, 15, 16]. These are also causes resulting from a sedentary mode of life and lack of physical activity of women at reproductive age. In babies born by women with gestational diabetes, there more often occurs macrosomia (birth weight of over 4,000g), which is

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the cause of obesity in childhood, with all its consequences [17, 18]. Physical exercises are commonly considered as supportive treatment for women with gestational diabetes [11, 14]. There is evidence that women who are physically active before pregnancy, more rarely contract gestational diabetes in pregnancy, and the frequency of this disorder decreases with an increase in the physical activity of women [19, 20, 21].

Epidemiological studies show that regular physical exercises in the early period of pregnancy reduce the risk of occurrence of preeclampsia [22, 23]. Women who perform exercises in the early period of pregnancy show a greater pace of placental growth, its larger size, and an increase in the amount of placental villi [24, 25]. This results in an increased blood flow to the placenta, enhances its transport capabilities, especially of oxygen, and as a consequence, affects the normal growth and development of the foetus [24].

The results of the studies indicate that systematic physical exercises increase the antioxidative abilities of the mother's organism in response to oxidative stress associated with pregnancy, thus preventing the dysfunction of the placental endothelium which leads to preeclamptic toxemia [26]. The majority of evidence available indicate a positive anti-inflammatory role of regular physical exercises in coronary heart disease in patients with circulatory failure [27, 28, 29]. These effects are weakened in individuals with an increased amount of fatty tissue [30]. Physical exercise in pregnant women has a similar anti-inflammatory effect, which prevents or alleviates the systemic inflammatory response accompanying preeclamptic toxemia [31]. Regular physical exercises improve the function of the body's endothelium, also in type 2 diabetes [32, 33]. It is indicated that similar mechanisms act in pregnancy to prevent preeclamptic toxemia [34, 35]. In the USA, nearly 50% of Caucasian women at reproductive age, and 70% of black women are overweight or obese [36]. Women who are physically inactive, overweight or obese before conception are characterised by an increased risk of such complications as polycystic ovary syndrome [37], menstrual abnormalities and infertility, which considerably reduce the probability of conceiving [38].

Low physical activity of women at reproductive age and during pregnancy also exerts an effect on the state of newborns after delivery and their birth weight, as well as the health of the offspring in later life. According to the hypothesis Developmental Origin of Health and Diseases (DOHaD), low birth weight, as well as macrosomia in newborns, creates the risk of occurrence of many chronic diseases in adulthood, mainly obesity, type 2 diabetes, cardiovascular diseases, including arterial hypertension, cerebral stroke and dyslipidaemia which, in consequence, is manifested by the occurrence of metabolic syndrome [39, 40, 41, 42]. Observations made in studies on animals, and some epidemiological observations in humans, show that human physical activity is also of prenatal origin [43, 44, 45, 46, 47]. At present, it is commonly assumed that both low and high birth weights are associated with the low level of physical activity in the offspring at the age of adulthood [45]. In addition, some studies confirm that low birth weight results in the occurrence of metabolic syndrome in adulthood among the offspring, leading a sedentary life style, except for those who are slim and lead an active mode of life. It is also assumed that from the aspect of prevention of metabolic syndrome, physical activity brings about greater health benefits to adults who were born with low birth weight than

those who possessed a normal body weight at birth. A similar relationship was also noted concerning the risk of falling ill with type 2 diabetes [46, 47, 48]. Some studies also show that the level of physical activity during leisure time is clearly lower in adults born with a low or high birth weight, whereas it is clearly higher in individuals who had a normal weight at birth [45]. Low physical activity among the offspring born with a low or high body weight often results in an increase in body weight as early as in childhood and adolescence, which causes the occurrence of the phenomenon of so-called catch-up growth which, according to the hypothesis of Developmental Origin of Health and Diseases, creates the probability of occurrence of the above-mentioned chronic diseases in later life [49, 50]. According to this hypothesis, the ratio between fat-free mass of the newborn to fatty tissue mass is also important. The lower the percentage of fatty tissue within the body of a newborn, the lower the susceptibility to the occurrence of chronic diseases in the offspring (type 2 diabetes, cardiovascular diseases, or metabolic syndrome). The phenomenon of catch-up growth, i.e. compensatory weight gain, mainly by an increase in the percentage of fatty tissue may occur during the foetal period with a rapid change of diet by the mother. This often takes place in the first trimester of pregnancy in dieting women who, after confirming pregnancy, rapidly calorifically enrich their everyday diet. According to the above-quoted theory, the periods of developmental plasticity in humans, when there occur epigenetic changes and proliferation, differentiation and growth of cells and tissues, are the developmental periods from conception to puberty [51]. Physical activity of pregnant women results in a beneficial increase in the percentage of fat-free mass, with relation to the total body weight of the foetus and the newborn, which reduces the risk of chronic diseases in later life [52].

A high percentage of fatty tissue in newborns with a normal body weight is observed mainly in Indian babies, called the thin-fat baby syndrome [53, 54, 55], by which is explained by the high morbidity among the societies of the developing countries due to civilization diseases, which has been recently observed in association with urbanization [56]. According to the results of studies, physical activity on a moderate level results in a slightly lower body weight of the offspring, and smaller contents of fatty tissue in the newborns (lighter 3.39 kg vs. 3.81 kg) and thinner (8.3% fat vs. 12.1% fat). Babies of mothers who led a sedentary life style had 12.1% of fat and weighed 3.81 kg, on average, whereas the babies of active mothers were born, after week 20 of pregnancy, with 8.3% of fat and weighed 3.39 kg [57, 58].

Both the lack of physical activity and excessive physical activity of pregnant women exerts a negative effect on the development of the foetus. For example, during the first two trimesters of pregnancy, long-lasting climbing stairs (as an example of vigorous activities), as well as long-lasting watching television, are risk factors of premature delivery [59, 60]. Intense physical activity leads to the reduction of birth weight of the foetus, while the levels of physical activity from low to moderate prevent low birth weight [61, 62]. Similar observations concern premature births [63]. Physical activity of high intensity increases the risk of premature delivery, whereas low and moderate physical activity prevents it. The mechanism of the negative effect of physical activity of high intensity on the foetus consists in the fact that, as a result of this activity, there occurs a reduction in placental blood flow



and flow to the foetus, a decrease in the partial pressure in placental blood, and a decrease in blood pH in the placenta and the blood of the foetus [64].

The mechanism of the protective effect of physical activity of low and moderate intensity on the foetus is that as a result of this activity there occurs the concentration of maternal and foetal haemoglobin, thus improving the transport and diffusion of haemoglobin from the mother's body to the foetus through the placenta. A high level of physical activity increases body temperature and, in this way, inhibits the above-described mechanism [61, 65, 66, 67]. The above-presented studies show that the effect of physical activity on the course of pregnancy, the foetus, type of delivery, and the state of the newborn may be represented by a U-shaped curve, where both excessively intensive and long-lasting activity of the mother, and sedentary mode of life deprived of physical activity, exert a negative effect on the pregnant woman, development of the foetus, term and type of delivery, as well as the state of the baby after birth.

While summing up the above-presented information from the aspect of the hypothesis of of Developmental Origin of Health and Diseases it should be emphasized that both situations lead to an increased risk of delivering an offspring susceptible to chronic diseases. The risk of contracting chronic diseases in later life is due to both:

- an insufficient amount of fatty tissue (intrauterine dystrophy and prematurity),
- an excessive amount of fatty tissue in the case of macrosomic newborns (mainly from mothers with diabetes), and babies with a normal body weight with a high percentage of fat (thin-fat baby syndrome).

When foetal growth is inhibited in the initial periods of foetal development there occurs the phenomenon of thrifty phenotype, consisting in the distribution of nutrients or oxygen to the organs which are important for survival (brain, lungs, heart), at the expense of others (muscles, kidneys, pancreas).

If, during further development, the conditions change and become more beneficial, a rapid compensatory growth of body weight may occur (catch-up phenomenon). This, however, will be the growth of fatty tissue, which increases the risk of chronic diseases in later life.

A similar relationship is observed while comparing health risk related with the physical activity of the mother. The highest risk is noted in the case of sedentary mode of life and very intensive physical activity of the pregnant woman. In both cases, the relationships are in the form of a U-shaped curve (Fig. 1). According to the above-mentioned hypothesis,

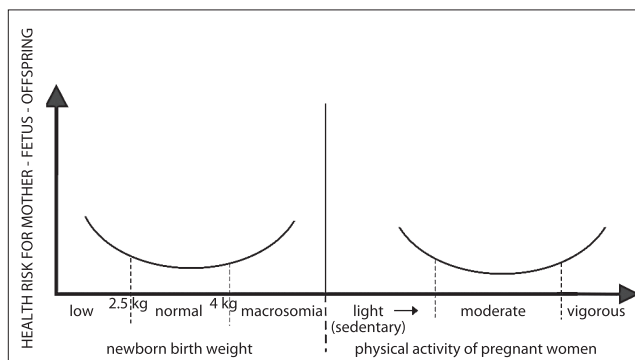


Figure 1. Physical activity of a pregnant woman and its consequences with relation to the hypothesis Developmental Origin of Health and Diseases at the age of adulthood

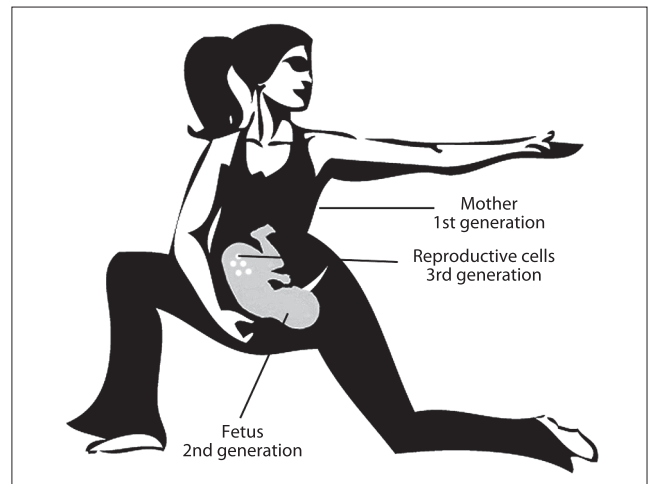


Figure 2. Physical activity of a pregnant woman may exert a positive effect on the health of the mother, offspring, and future generations, according to Developmental Origin of Health and Diseases

the physical activity of the mother may also exert an effect on the health of future generations [68] (Fig. 2).

OBJECTIVE

The main objective of the study was investigation of the level of physical activity of women during pregnancy according to the PPAQ questionnaire. The objective of this study was also to evaluate the influence of daily physical activity by pregnant women and outcomes for newborns health. It was assumed that Polish women are characterized by too low physical activity which, according to the hypothesis of the Developmental Origin of Health and Diseases may result in the risk of contracting chronic diseases at the age of adulthood and affect the state of health of future generations.

Study population

A randomized group of post-partum Polish mothers and their newborn infants were monitored. The women were recruited from all hospitals in Poland where mothers (lying-in women) had been hospitalized after giving birth to newborns. The study was performed on a single day in the second week of November 2011, as legally designated by the Chief Sanitary Inspector. The survey was carried out by staff from Provincial Sanitary-Epidemiological Stations previously and freshly trained by public health experts from the Chief Sanitary Inspectorate and Regional Sanitary-Epidemiological Stations, adopting a cascade system. Subjects were interviewed face-to-face. Mothers hospitalized after delivery provided replies to the questions in the first section of the questionnaire, while the second section was completed by medical staff (physician or nurse) providing care for the mother and her baby, based on medical records (pregnancy chart and hospitalization history). Consent for the study was obtained from the Bioethical Commission.

Of the total number of 398 hospitals where deliveries took place, 373 managers expressed their consent to participate in the survey. On the day of the study, 3,979 'lying-in' mothers with their babies were hospitalized in Poland. 3,064 of them completed the questionnaire forms, of which 2,852 were suitable for statistical analysis.

Pregnancy physical activity questionnaire (PPAQ)

The pregnancy physical activity questionnaire (PPAQ) is the only widely available tool for assessing a pregnant woman's physical activity. The PPAQ is a semi-quantitative questionnaire that asks the respondents to report on the time spent participating in 32 activities, including household/caregiving activities (13 activities), occupational (5 activities), sports/exercise (8 activities), commuting (3 activities), and inactivity (3). The respondents are asked to select a category for each activity to the nearest amount of time spent per day or week. The duration ranges from 0-6 or more hours per day, and from 0-3 or more hours per week during the respondent's current trimester. An open-ended section at the end of the PPAQ allows each respondent to add activities not already listed. Self-administration of the PPAQ takes approximately 10 min. The PPAQ is short in length, self-administered, and easily understood by respondents in a variety of settings, making it useful for epidemiologic research and health education during pregnancy. The types of sports and exercise activities assessed in the PPAQ include walking, jogging, prenatal exercise classes, swimming and dancing. To calculate weekly energy expenditure using the PPAQ, the duration of time spent in these exercise activities was multiplied by specific intensities (i.e. MET values), and scores expressed as MET-hours per week.

In addition, each activity was classified by intensity: sedentary (<1.5 METs), light (1.5–3.0 METs), moderate (3.0–6.0 METs) or vigorous (>6.0 METs) and the average number of MET-hours per week expended at each intensity level was calculated. Activities were also classified by type (household/caregiving, occupational, and sports/exercise) and the average number of MET hours per week spent in each activity type was calculated.

STATISTICAL ANALYSIS

Statistical analysis was performed with the use of the statistical package *Statistica 8.1 PL*. The variables were presented by means of frequency tables, tables with descriptive statistics, and contingency tables. Analysis of the relationships between interval variables were performed by ANOVA test, or, if the assumptions of the parametric method were not satisfied, the non-parametric Kruskal-Wallis one-way analysis of variance was applied.

Table 1. Physical activity of pregnant women according to the PPAQ questionnaire in met hour/week

	No.	Mean	Median	Minimum	Maximum	Lower quartile	Upper quartile	St. dev.	Mean as % of total activity
total activity	2,840	211.07	190.83	0.00	1,273.78	132.18	264.51	121.76	100.00
household activity	2,840	157.32	142.54	0.00	765.00	98.18	197.93	91.98	74.54
occupational activity	2,840	20.70	0.00	0.00	592.20	0.00	19.25	46.25	9.81
commuting activity	2,840	26.34	20.13	0.00	168.00	7.00	35.88	25.23	12.48
activity in leisure time	2,840	6.70	4.80	0.00	104.10	1.80	9.60	8.07	3.17

Table 2. Physical activity of pregnant women according to the PPAQ questionnaire in methour/week according to categories of intensity

	No.	Median	Median	Minimum	Maximum	Lower quartile	Upper quartile	St. dev.	Mean as % of total activity
total activity	2,840	211.07	190.83	0.00	1,273.78	132.18	264.51	121.76	100.00
static activity	2,840	66.02	59.50	0.00	224.70	33.95	93.63	42.97	31.28
light activity	2,840	91.92	83.65	0.00	385.70	52.50	121.10	53.30	43.55
moderate activity	2,840	53.74	31.75	0.00	730.63	10.10	70.24	66.64	25.46
considerable activity	2,840	0.74	0.00	0.00	40.50	0.00	0.00	2.83	0.35

RESULTS

Analysis of the physical activity of pregnant women according to the PPAQ questionnaire covered the following 4 types of activity: household, occupational, commuting, and leisure time activity. Household activity calculated in MET hour/week constituted the highest level level of activity among respondents – 74.54% of the total activity (Tab. 1). The fact was surprising that among the pregnant women's activity during leisure time was only 3.17% of the total activity.

An evaluation of the respondents' activity according to the classes of intensity showed that light activity constituted 43.55% of the activity of pregnant women (mean: 91.92 MET hour/week), followed by static activity – 31.28% (mean: 66.02 MET hour/week), moderate activity – 25.46% (mean: 53.75 MET hour/week), and considerable activity – only 0.35% (mean: 0.74 MET hour/week) (Tab. 2).

Analysis of physical activity according to the place of residence showed a statistically significant relationship between the mean level of physical activity among the rural and urban population ($p=0.0001$). The mean physical activity of urban women was 215.39 MET hour/week, whereas among pregnant women living in the rural areas – 205.40 MET hour/week (Tab. 3).

Table 3. Physical activity of pregnant women according to the PPAQ questionnaire in met hour/week according to respondents' place of residence

	mean	No.	St. dev.	p ANOVA rank test
urban area	215.39	1,587	116.31	
rural area	205.40	1,232	128.89	
total	211.02	2,819	122.05	0.0001

No significant effect of the level of physical activity of pregnant women was observed acc. to the PPAQ questionnaire expressed in MET hour/week on: evaluation of the newborn according to the APGAR scale ($p=0.981$), term of delivery ($p=0.804$), and birth weight of the baby ($p=0.798$) (Tab. 4-6).

A considerable percentage of women in the survey (40.32%) reported that pregnancy considerably limited their physical activity, while 30.58% of respondents declared the lack of such an effect (Tab. 7). The main causes of limiting physical activity by the women examined were: fear about normal



Table 4. Physical activity of pregnant women according to the PPAQ questionnaire in met hour/week and apgar scale in 3 min

	mean	No.	St. dev.	p ANOVA rank test
1-6 extremely low	208.37	103	104.61	
7-8 low	211.25	250	120.09	
9-10 normal	211.22	2,177	123.68	
total	211.11	2,530	122.57	0.981

Table 5. Physical activity of pregnant women according to the PPAQ questionnaire in met hour/week and term of delivery

term of delivery	mean	No.	St. dev.	p ANOVA rank test
premature <38	211.46	378	129.90	
at term 38-42	212.00	2,271	120.80	
post term >42	244.20	5	235.55	
total	211.98	2,654	122.35	0.804

Table 6. Physical activity of pregnant women according to the PPAQ questionnaire in met hour/week and birth weight

birth weight	mean	No.	St. dev.	p ANOVA rank test
<2kg very low	211.38	63	118.81	
2-2.5kg low	214.66	129	160.44	
2.5-3.5kg normal	209.48	1,335	120.09	
3.5-4kg high normal	212.10	775	118.45	
>4kg excessive	216.52	286	125.07	
total	211.35	2,588	122.37	0.798

course of pregnancy (59.85%) and doctor's recommendations (32.27%). As many as 8.23% of the women in the study limited their activity due to the lack of knowledge that sports may be practiced in pregnancy (Tab. 8).

Table 7. Self-reported physical activity of pregnant women in the survey

How did pregnancy affect physical activity	No.	%
No, pregnancy did not limit my physical activity	872	30.58
Yes, pregnancy considerably limited my physical activity	1,150	40.32
Yes, pregnancy slightly limited my physical activity	830	29.10
total	2,852	100.00

Table 8. Causes of limiting physical activity in pregnancy by women in the survey

For what reason was physical activity limited in pregnancy?	No.	%
due to fear about normal course of pregnancy	1,185	59.85
due to lack of knowledge that sports may be practiced in pregnancy	163	8.23
due to financial reasons	55	2.78
due to pressure on the part of the environment	62	3.13
due to doctor's recommendations	639	32.27
none of the above-mentioned reasons	107	5.40
total	1,980	100.00

More than a half of the women examined (n=1,581; 55.77%) admitted that the gynaecologist did not mention the problem of physical activity in pregnancy. In the case of 503 women (17.74%), the doctor recommended limiting physical activity due to medical contraindications, while as many as 304 women (10.72%) were ordered to limit physical activity in pregnancy without reporting any contraindications.

Only 14.81% of respondents (n=420) indicated that the gynecologist informed them that they should maintain their to-date physical activity and avoid activities and sports risky for the course of pregnancy. There were also physicians who recommended that the women increased physical activity in pregnancy (n=27; 0.95%). Nearly 2/3 of respondents (29.61%) admitted that they received sick leave from the 3rd month of pregnancy or earlier, while 18.61% of women in the survey obtained sick leave from 4th-6th month of pregnancy (Tab. 9). This allows the conclusion that at this time they also decreased physical activity. Only 32.21% of the pregnant women in the survey declared that they did not have any sick leave in pregnancy.

Table 9. Sick leave during pregnancy by women in the survey

Did you have any sick leave during pregnancy?	No.	%
I did not have any sick leave	922	32.31
Yes, from 3rd month of pregnancy or earlier	845	29.61
Yes, from 4th-6th month of pregnancy	531	18.61
Yes, from the 7th month of pregnancy	287	10.06
Yes, from 8th month of pregnancy	166	5.82
Yes, from later than 8th month of pregnancy	103	3.61
total	2,854	100.00

Analysis of physical activity among pregnant women according to the PPAQ questionnaire in MET hour/week in classes of intensity according to age categories, showed a statistically significant relationship between age and sedentary activity (p=0.000). A downward tendency was observed in the level of sedentary activity with age. This tendency was also clear while analyzing the total level of physical activity according to age (Tab. 10). In addition, a significant relationship was noted between place of residence and the level of sedentary activity (p=0.000) and intense activity (p=0.007) (Tab. 11).

Table 10. Physical activity of pregnant women according to the PPAQ questionnaire in met hour/week in classes of intensity according to respondents' age categories

	sedentary	light	moderate	intense	TOTAL
under 20	78.87	86.35	53.46	0.74	219.42
21-25	68.58	92.19	56.38	0.90	218.04
26-30	64.48	90.55	52.95	0.74	208.71
31-35	60.77	94.10	52.34	0.51	207.72
36 and over	55.41	96.69	50.38	0.57	203.05
Total	65.72	91.67	53.58	0.72	211.70
p ANOVA rank test	0.000	0.162	0.731	0.161	

Table 11. Physical activity of pregnant women according to the PPAQ questionnaire in met hour/week in classes of intensity according to respondents' place of residence

	sedentary	light	moderate	intense	TOTAL
urban area	71.15	91.60	52.98	0.86	216.59
rural area	59.43	92.17	54.81	0.57	206.98
Total	66.03	91.85	53.78	0.74	212.39
p ANOVA rank test	0.000	0.779	0.469	0.007	



DISCUSSION

Information contained in official, government recommendations for public health purposes defines that physical activity of a minimum moderate-intensity performed by adults for 150 minutes weekly for the majority of days during the week has positive health effects [69, 70, 71, 72, 73, 74, 75]. The majority of recommendations concerning women during pregnancy and postpartum period concern moderate physical activity, e.g. a quick march for 150 minutes weekly, evenly distributed in individual days of the week [76, 77, 78, 79]. Thus, according to these recommendations, pregnant women should be physically active throughout most days a week for 30 minutes daily [80]. These recommendations are similar to those pertaining to the healthy adult population, excluding pregnant women with medical or post-partum complications. It is also generally considered that a pregnant woman should maintain her activity on the level similar to that before conception, avoiding only anaerobic exercises. In the presented study, it was confirmed that a very low percentage of Polish pregnant women perform physical activity at the commonly recommended level. In the majority of pregnant women in Poland, a fear of physical activity is observed, as well as concern about the negative effect of any physical activity on the course of pregnancy and delivery. Medical recommendations concerning medical complications threatening pregnancy due to physical activity, to a great extent, are inconsistent with generally adopted recommendations.

Many reports indicate pregnant women's belief in the role of an adequate diet in the development of the foetus, whereas their knowledge concerning the beneficial effect of physical activity is insufficient [81]. The presented studies confirm these observations. The majority of pregnant women in Poland decrease their physical activity in pregnancy to a considerable degree, and they do so out of concern about possible side effects for the course of pregnancy and delivery. Data from literature show that frequently excessive attention is paid to injuries acquired as a result of physical exercises performed in pregnancy, and resulting from an excessive flexibility and mobility of the joints caused by hormonal changes in pregnancy [82]. The recommendations concern only the avoidance of contact sports and lifting of loads [83]. Attention is only paid to the fact that physical exercises of high intensity performed for a long time may lead to an increase in the level of metabolism accompanying both pregnancy and physical exercises, and therefore lead to the overheating of the organisms of the mother and foetus. An increase in the minute ventilation during physical exercises of an excessive intensity, and increase in the cutaneous blood flow, may also lead to overheating of the body [84]. The temperature exceeding 39.2 degrees Celsius is potentially teratogenic for the foetus in the first trimester of pregnancy [85]. However, experts emphasize that attention should rather be paid to the adequate hydration of the organism during physical exercises, avoiding exercises in the environment of high temperature or elevated humidity, than excessively warn pregnant women about the negative effects of intensive physical exercises [86]. The experts only recommend that while performing physical exercises one should consume an adequate amount of calories and limit training sessions to less than 45 minutes, due to the risk of the occurrence of hypoglycaemia [87]. It is also considered that physical activity on the sub-optimum

level (more than 30 minutes of intensive activity daily) in the third trimester of pregnancy results in the reduction of the level of glucose in the blood of the mother, which may hinder access of the foetus to this substance [88, 89]. These are therefore recommendations which should be applied in physical exercises performed generally in order to maintain and improve health during the periods of life not associated with pregnancy [90]. Avoiding physical exercises performed in a lying position is also recommended, because it leads to a lower cardiac minute output and symptomatic arterial hypotension due to pressure on the wall of the inferior vena cava vein [90]. Pregnant women should avoid performing physical exercises at the height of over 2,500 meters above sea level, without a period of at least 4-5 days adaptation to these conditions. Intensive physical exercises at this height may result in a decrease in blood flow in the uterine muscle, decrease the maternal placental blood flow, and consequently increase the risk of oxygen deficiency in the foetus [91, 92]. The mother's organism adapts to an increased demand for oxygen by increasing blood hematorite, which also prevents oxygen deficiency in the foetus [93]. Physical effort in pregnancy has a similar effect. The foetuses of women performing physical exercises to a greater extent tolerate physical effort than those of women who do not perform physical exercises [94]. The majority of guidelines recommend physical exercises in pregnancy which increase the heart rate to 60-70% of the maximum, compared to women who were inactive or poorly active during the preconceptual period and increase the heart rate to 60-90% of the maximum, compared to women who were previously active [78]. The above-mentioned recommendations also depend on the age of the mother. In mothers aged under 20, a safe range of heart rate which may occur while performing aerobic physical exercises is 140-155 per minute, those aged 20-29 from 135-150 per minute, women aged 30-39 from 130-145 per minute, whereas in those aged over 40 – from 125-140 per minute. Pregnant women who were inactive before pregnancy and begin physical exercises should start aerobic exercises with a warm-up, beginning from 15 minutes of effort three times a week and slowly prolonging effort to 30 minutes four times a week (Royal College for Sport Exercise). Pregnant women should not dive, because this could cause an air embolism and decompression sickness in the foetus [95]. They should also avoid practising sports likely to cause injury: horse riding, ice hockey, downhill skiing or artistic gymnastics. The benefits from performing physical exercises after delivery result from: improvement in efficacy of the cardiovascular system, facilitation of body weight loss, enhancement of mood, decrease in fear and depression [96]. Women during the post-partum period should begin physical activity of a moderate intensity, and possibly early on. At present, the recommendations suggest that if the course of pregnancy and delivery were normal, the woman may start physical activity of low intensity immediately, in the form of walks, pelvic exercises or stretching. In the case of Caesarean section, physical exercises may be undertaken 6-8 weeks after delivery and after consulting a physician [97].

Many observations show that pregnant women decrease their physical exercises in pregnancy with respect to duration, intensity, and its frequency, compared to practices during the period before conception [98, 99, 100]. This is also confirmed by the latest studies [101]. Scandinavian studies indicate that only 20.3% of pregnant women achieve the recommended



level of physical activity in pregnancy. This is a relatively high percentage of women who are active in pregnancy, compared to the results of the presented studies. It is also noted that pregnant women at a young age and those worse educated, to a greater degree decrease their to-date physical activity in pregnancy [102]. This is also confirmed by the presented observations. Other reports emphasize that apart from encouragement by a physician in charge of pregnancy, a higher level of physical activity among pregnant women is influenced by: younger age, higher level of education, smaller number of earlier deliveries [103, 104, 105]. In comprehensive longitudinal American studies it was confirmed that 22.8% of pregnant women reported physical activity of recommended intensity (moderate to vigorous – MVPA) associated with commuting, e.g. from and to school/work, 54.3% – a similar activity related with household chores, 55.6% – reported physical activity of recommended intensity during leisure time [106]. British studies showed that nearly 50% (48.8%) of pregnant women apply the recommended level of physical activity. This level was similar throughout the entire period of pregnancy [107]. These results are considerably more beneficial for the course of pregnancy and development of the foetus, compared to the presented observations, where a low percentage of pregnant women achieved the recommended level of physical activity. Simultaneously, it should be emphasized that a level of physical activity higher than that recommended, of a moderate intensity, exerts a positive effect on the development of the foetus and the course of pregnancy. It was confirmed that pregnant women who are physically active for three hours a week are more satisfied with own appearance and state of health, and present a higher level of physical endurance and level of energy [108]. Other studies show that pregnant women who participated in physical activity for a minimum of three hours a week were characterized by higher fitness levels associated with a better capability for increased oxygen uptake [109]. Physical activity on a level higher than moderate-intensity exercise often results in the birth of babies with a normal body weight [110]. The presented studies did not show any relationship between the volume of physical activity and its intensity, and body weight of the newborns after delivery. This could be explained by the fact that in the presented studies the recommended level of physical activity was obtained by such a low percentage of women that it had no effect on body weight and state of health of the baby after birth. Many studies, mainly American, indicate that the majority of women (2/3) reported physical activity in pregnancy; however, 1/6 practiced this activity at the recommended level [111, 112]. Similarly, according to other American observations (National US Survey), 42% of pregnant women did not practice physical activity at the recommended level, while only 35% of those who performed exercises at this level before pregnancy, maintained these exercises [111]. Many other reports underline a decrease in physical activity with the advancement of pregnancy [113, 114, 115]. The majority of the above-mentioned studies, in America, Europe and Scandinavian countries, where there is an awareness of beneficial health effects of physical activity for the mother, foetus and newborn, indicate that in the second and third trimester of pregnancy there occurs a reduction in physical activity. Some researchers estimate that this reduction in the physical activity of women is by about 3% in each trimester of pregnancy. In the presented studies, no such relationships were found, because the questionnaires

were collected from women after delivery and concerned only the final trimester of pregnancy.

The most frequent causes of reducing physical activity during pregnancy reported by the mothers were: fatigue, poor general wellbeing, lack of time, discomfort associated with its performance [116], feeling of lack of energy, physical limitations related with pregnancy, lack of motivation, as well as the conviction about the negative effect of exercises on pregnancy and the foetus [117, 118]. The researchers investigated the causes of this phenomenon by analyzing the beliefs of women concerning physical activity in pregnancy, and possible barriers limiting the continuation of physical activity in pregnancy [119, 120]. The majority of observations pointed to the fact that practices in the area of physical activity in the course of pregnancy are affected by the health behaviours of women before becoming pregnant [121, 123]. According to some researchers, the belief and conviction about the benefits brought about by the performance of physical exercises is an important factor in the continuation of to-date physical activity [124]. Pregnant women who had previously been active decrease their activity out of concern about its negative effects – mainly spontaneous abortion [125], as well as due to the negative complaints related with pregnancy – nausea and fatigue [118, 126]. According to the above-mentioned studies, fear and anxiety concerning the negative effect of physical activity on the foetus is of primary importance [125]. The women in the survey rarely reported that they decreased their physical activity because of unpleasant complaints related with the course of pregnancy. They most frequently indicated concerns associated with the course of pregnancy and development of the foetus. While analyzing the replies to the entire set of questionnaire items pertaining to the effect of physical activity on pregnancy and the development of the foetus, it may be presumed that in Poland the low physical activity of women in pregnancy is affected primarily by the physician in charge of the pregnancy. Therefore, the activities of medical organizations and services dealing with pregnant women in the area of public health should be biased towards enhancing the awareness of gynaecologists about the beneficial effect of physical activity on the course of pregnancy and the development of the foetus.

Experts commonly express an opinion that advice in the area of the recommended physical activity for pregnant women should be routinely performed by the gynaecologists taking care of pregnant women. The employees of health services, especially those exercising care over pregnant and lying-in women, in their practice should inform them about the benefits of physical activity during pregnancy and post-partum period, and provide information that in normal pregnancy there are no dangers related with physical exercises, neither for the mother nor the baby [127, 128, 129]. Consultations by medical staff taking care of a woman are recommended, which is being practiced in some countries [130, 131]. For example, in Finland such consultations are carried out by nurses during five of eleven free home visits during pregnancy, according to a strictly defined methodology [132]. Women who have been inactive before pregnancy are encouraged to undertake physical activity with the use of known models of changing health behaviours [133]. For instance, in Canada a standardized questionnaire form of a gynaecological visit has been introduced, containing a set of items asked by the physician to a pregnant woman concerning her physical activity, as well as recommendations which

she has received (The Physical Activity Readiness Medical Examination for Pregnancy - PARmed-X for PREGNANCY) [134, 135, 136]. Other reports also emphasize an important role of medical consultations in the enhancement of the level of physical activity of pregnant women [137]. There are also studies which show that some women who have led a sedentary life style before pregnancy, after conception begin a more active mode of life due to medical advice provided in this area [138]. The presented studies confirmed that the majority of gynecologists taking care of pregnant women do not discuss with them physical activity in pregnancy, and a very high percentage of physicians recommend that they refrain from any physical activity. In Poland, there is also a lack of recommendations by professional medical organizations pertaining to physical activity in pregnancy.

Brazilian studies have shown that 1/3 of women practice some type of physical activity during their leisure time [139, 140]. The presented studies showed only a low percentage of pregnant women performing physical activity in their leisure time, which is surprising when compared with the reports from Brazil. On this background, it should be mentioned that in the United States nearly 2/3 of pregnant women practice physical activity in their leisure time [141]. The observations also confirm that the level of physical activity is determined by the level of a woman's physical activity during the period before becoming pregnant [142, 143]. The presented studies indicate that the physical activity of women before conception is far too low, which may explain why Polish pregnant women are inactive in pregnancy.

Physical activity resulting in balancing the energy uptaken with food and expended during physical effort during pregnancy has a decisive effect on body weight gain in pregnancy. An additional amount of energy supplied by the diet is necessary due to its deposit in the tissues of the mother and the foetus, and an increased calorific demand associated with an increased level of the basic metabolism and changes in energy demand related with physical activity. An increase in body weight in pregnancy is caused by the weight of the growing and developing foetus and the placenta, as well as the volume of the amniotic fluid. This is also the result of growth in the mass of many maternal tissues (uterus, breast, circulating blood volume). Generally, weight gain is also related with an increase in the amount of fatty tissue in a pregnant woman [144]. It is commonly assumed that an increase in energy expenditure in association with pregnancy is proportional to the weight gain by a pregnant woman during pregnancy [145]. The benefits for the foetus resulting from physical activity in pregnancy are as follows: decrease in fat mass of the foetus, improvement in tolerance to stress, and acceleration of neuro-behavioural maturity of the foetus. Physically active women more rarely have an induced or assisted delivery, and a shorter course of delivery is noted. The majority of studies unequivocally indicate a lower percentage of Caesarean sections in the case of physically active mothers, as well as a lower percentage of still births. Physical activity before and during pregnancy reduces the percentage of overweight and obese women, and in this way contributes to a smaller number of pregnancies terminated by Caesarean section [146, 147]. While comparing the state of newborns after delivery and the course of pregnancy and delivery in pregnant women who perform physical exercises, or even pregnant sportswomen who resigned from physical exercises before the end of the first trimester, a positive effect

of physical exercises was confirmed, both on the course of pregnancy and the normal course of delivery [148]. No such relationships were found in the presented studies, probably also due to a relatively low volume of physical activity among the pregnant women examined. In addition, the results showed a surprisingly low percentage of pregnant women reaching physical activity at the recommended level. This confirms the hypothesis posed at the beginning, that such a situation may have consequences for the offspring and future generations in the form of increased risk of falling ill with chronic diseases, mainly cardiovascular disorders, obesity, type 2 diabetes, and metabolic syndrome, which is already observed in Poland [149, 150, 151, 152, 153], in the countries of Central-Eastern Europe and the whole of Europe [154, 155, 156].

Conclusions

1. Pregnant women in Poland are characterized by a considerably insufficient physical activity in pregnancy. This is accompanied by low physical activity of women before becoming pregnant, and adolescents at reproductive age [157, 158].
2. Physical activity of Polish pregnant women is practically limited to the activity related with performance of household chores. Physical activity associated with occupational activity is minimal, which is related with common sick leaves provided by physicians for pregnant women and attitude to the state of pregnancy as a disease, and not a physiological state.
3. Physical activity among Polish women during leisure time (Leisure Time Physical Activity - LTPA) is practically nil.
4. Physicians taking care of a woman in pregnancy rarely discuss with her physical activity in pregnancy, and most often warn her against the negative effects of physical exercises during this period, recommending the reduction of this activity.
5. Younger women are characterized by a lower level of physical activity in pregnancy.
6. The low level of physical activity among Polish pregnant women may have negative consequences for the offspring and future generations of Poles.

Recommendations

1. A change is necessary in the education of physicians and medical staff at the university and post-graduate levels in the area of the physiology of physical effort in pregnancy, and the positive effects of physical activity on the course of pregnancy, development of the foetus, and course of the delivery.
2. The recommendations by the Polish Association of Gynaecologists and Obstetricians concerning physical activity of women in pregnancy and during the post-partum period must be changed.
3. An obligation of medical consultations pertaining to physical activity should be introduced during each visit of a pregnant woman to a gynaecologist's consulting room.
4. Public health services should implement population programmes which would popularize physical activity during the periods of pregnancy and post-partum.



SUMMARY

It is plausible to suppose that physical activity, performed at an appropriate level for the physical condition of the woman, is beneficial to fetal growth, with the extremes being inactivity/sedentarism and prolonged duration of vigorous exercises, which are potentially harmful to the supply of necessities for adequate fetal growth. Therefore, it is important to perform intervention studies intended to test this hypothesis, and attempt to identify the most appropriate levels for intensity, duration and frequency of physical exercise during pregnancy. The studies should consider the four domains of daily physical activity and utilize tools that reliably measure exposure variables. Such studies would provide valuable information for recommendations about physical activity during pregnancy.

The results of the presented study support the hypothesis that both excessive and insufficient physical activity impact negatively on pregnancy outcomes and the health of newborns. In order to improve this situation, education for women, medical staff and society in general is paramount, and will target schools, medical universities, nursing colleges, media and post-graduates, and especially GPs and gynaecologists. Decidedly low physical activity levels were observed in pregnant women compared to those before becoming pregnant. Therefore, appropriate interventions can now be targeted through remedial action in Poland.

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