Physical Exercise During Pregnancy and the Risk of Preterm Birth: A Study Within the Danish National Birth Cohort

Article *in* American journal of epidemiology · May 2008

DOI: 10.1093/aje/kwm364 · Source: PubMed

American Journal of Epidemiology

Vol. 167, No. 7
DOI: 10.1093/aje/kwm364
Advance Access publication February 25, 2008

Original Contribution

Physical Exercise during Pregnancy and the Risk of Preterm Birth: A Study within the Danish National Birth Cohort

Mette Juhl[1], Per Kragh Andersen[2], Jørn Olsen[3], Mia Madsen[4], Tina Jørgensen[1], Ellen Aagaard Nøhr[5], and Anne-Marie Nybo Andersen[4]

[1] National Institute of Public Health, Copenhagen, Denmark.
[2] Department of Biostatistics, Institute of Public Health, University of Copenhagen, Copenhagen, Denmark.
[3] Department of Epidemiology, School of Public Health, University of California, Los Angeles, Los Angeles, CA.
[4] Department of Epidemiology, Faculty of Health Sciences, University of Southern Denmark, Odense, Denmark.
[5] Department of Epidemiology, Institute of Public Health, University of Aarhus, Aarhus, Denmark.

Received for publication July 20, 2007; accepted for publication November 13, 2007.

According to many national recommendations, women should be physically active during pregnancy, but empirical evidence to support this recommendation is sparse. The authors' aim in this study was to examine the relation between physical exercise during pregnancy and the risk of preterm birth. Self-reported data on physical exercise during pregnancy were collected prospectively for 87,232 singleton pregnancies included in the Danish National Birth Cohort between 1996 and 2002. Hazard ratios for preterm birth according to hours of exercise per week, type of exercise, and metabolic equivalent-hours per week, respectively, were calculated using Cox regression analysis. Results showed a reduced risk of preterm birth among the almost 40% of women who engaged in some kind of exercise during pregnancy in comparison with nonexercisers (hazard ratio = 0.82, 95% confidence interval: 0.76, 0.88), but no dose-response relation was seen. The association was not affected by the type of exercise, and the results were not altered when the degree of preterm birth was taken into account. These findings do not indicate any adverse effects of exercise on the risk of preterm birth and therefore do not contradict current recommendations.

exercise; pregnancy; premature birth

Abbreviations: CI, confidence interval; MET, metabolic equivalent.

Health authorities in the United States, Great Britain, Norway, and Denmark recommend a level of physical activity for pregnant women similar to that of the nonpregnant population (1–4). According to the National Board of Health in Denmark, pregnant women should engage in exercise according to Borg Scale level 12–13 (5) (corresponding to moderate/somewhat hard exercise) at least 30 minutes per day (4). Furthermore, light fitness training can be commenced and hard fitness training (Borg Scale level 14–15) need not be discontinued in pregnancy. The recommendations are based on the health benefits of physical activity for the mother, including prevention of obesity (6–8), gestational diabetes (9, 10), and preeclampsia (11, 12). Whether this is good for the fetus is unclear (13).

Recent results from the Danish National Birth Cohort challenged these recommendations by indicating an increased risk of spontaneous abortion among women who engaged in physical exercise (14). The threat of preterm birth has been an indication for sick leave and confinement to bed rest.

Almost all attempts to prevent or predict preterm birth have failed, and the incidence even seems to be increasing in

Correspondence to Mette Juhl, National Institute of Public Health, Oster Farimagsgade 5A, 2nd floor, 1399 Copenhagen K, Denmark (e-mail: mju@niph.dk).

some countries, such as the United States and Denmark (15, 16). During exercise, both adrenaline and noradrenaline levels rise, and since noradrenaline affects the uterus, exercise could theoretically induce preterm birth via uterine contractions. Mechanical stimulation of the uterus during exercise has also been suggested to explain the increased uterine contractility observed in relation with physical activity (17). Intervention studies (17–20) and an observational study (21) showed conflicting results as to whether physical exercise actually increases uterine contractility.

Intervention studies have been small and carried out in selected groups (22, 23). A recent Cochrane review concluded that trials on physical exercise and preterm birth were few and too small to provide scientifically based documentation (13). From cohort studies, either no association between exercise and preterm birth (24–26) or a possible reduced risk (27–29) has been reported, and except for one cohort study that included 7,101 women (28), previous studies have been rather small.

Our aim in this study was to examine the relation between physical exercise during pregnancy and the risk of preterm birth in a large cohort of pregnant women.

MATERIALS AND METHODS

From 1996 to 2002, pregnant women were recruited into the Danish National Birth Cohort, a nationwide study of pregnant women and their offspring. The intention was to invite all eligible women in Denmark to participate in early pregnancy. Approximately 50 percent of all general practitioners in Denmark agreed to take part in the study. Recruitment was carried out mainly by the general practitioners, and approximately 60 percent of the women invited chose to participate. The national taxpayer-funded antenatal care program is used by 99 percent of all pregnant women in Denmark (S. Rasmussen, National Board of Health, personal communication, 2007). Among other things, the women agreed to participate in two computer-assisted telephone interviews during pregnancy. More details about the Danish National Birth Cohort are presented elsewhere (30).

In total, 100,422 pregnant women were enrolled in the cohort. For this study, we initially included the 90,165 pregnancies for which we had a first pregnancy interview. Subsequently, 941 pregnancies were excluded because the pregnancy ended before 22 completed weeks of gestation, and 28 pregnancies were excluded because the first pregnancy interview had been carried out later than 37 completed weeks of gestation, when the woman was no longer at risk of having a preterm birth. The final study population comprised 89,196 pregnancies, of which 1,964 were multiple pregnancies. In the main analyses, only singleton pregnancies were included ($n = 87{,}232$).

In the study population, 93 percent of women with singleton pregnancies also participated in the second interview ($n = 81{,}001$). The median gestational age for the first pregnancy interview was 114 days (10th percentile, 84 days; 90th percentile, 160 days), corresponding to 16.3 completed weeks. For the second interview, the median gestational age was 218 days (10th percentile, 195 days; 90th percentile, 249 days), corresponding to 31.1 completed weeks.

Measurement of physical exercise

Information on physical exercise was obtained from the first and second pregnancy interviews. The first question was:

1) "Now that you are pregnant, do you engage in any kind of exercise?"

   In case of a positive answer, the following questions were posed:

2) "What kind of exercise do you engage in?"
3) "How many times per week do you engage in… (answer in question 2)?"
4) "How many minutes per time do you engage in… (answer in question 2)?"
5) "Do you engage in other types of exercise?"

A positive answer to the last question released a loop with the above questions, which continued until a negative response was given. All questionnaires are available in English on the website of the Statens Serum Institut (http://www.ssi.dk/sw379.asp) (please note that this is an unauthorized translation of the interviews).

Physical exercise was subsequently categorized into total time spent in exercise, in hours per week: 0, >0–≤1, >1–≤2, >2–≤3, >3–≤5, and >5 (four women who reported more than 40 hours of exercise per week were assigned as missing). For descriptive analyses, we assigned the active women to a preferred type of exercise, defined as the type of exercise performed more than 50 percent of the time. Women who did not perform any single activity more than 50 percent of the time were classified as "mixed exercisers." There were 13 predefined categories, which were categorized into the following seven groups: 1) swimming, 2) low-impact activities (aerobics/gymnastics for pregnant women, aerobics/gymnastics, dancing, walking/hiking, yoga), 3) high-impact activities (jogging, ball games, racket sports), 4) working out/fitness training, 5) bicycling (which is a common means of commuting in Denmark), 6) horseback riding, and 7) nonclassifiable types of exercise (including the mixed category). Swimming and bicycling are non-weight-bearing activities and were therefore treated separately. Low-impact activities are activities in which at least one foot is always on the ground, whereas in high-impact activities there are moments at which both feet leave the ground simultaneously.

Furthermore, we calculated total metabolic equivalent (MET)-hours of leisure-time physical activity per week by multiplying a certain MET score by the total number of minutes per week of a given activity. The sum of total MET-hours/week for each woman was then calculated. The choice of MET score for each activity was based on our best estimation from the updated list of MET intensities by Ainsworth et al. (31) (see the Web Appendix, posted on the *Journal*'s website (www.aje.oxfordjournals.org), for a list of all MET scores used in this study). Total MET-hours per week were categorized into: 0, >0–≤5, >5–≤10, >10–≤15, and >15 (based approximately on quartiles).

For additional analyses, the pregnancies were categorized according to possible changes in exercise habits from early to late pregnancy.

TABLE 1. Distribution (%) of physical exercise according to gestational age at birth, Danish National Birth Cohort, 1996–2002

Exercise	Data from pregnancy interview 1* (n = 87,232)					Data from pregnancy interview 2† (n = 81,001)		
	No. of pregnancies	Completed weeks of gestation at birth				No. of pregnancies	Completed weeks of gestation at birth	
		22–27 (n = 333)	28–31 (n = 435)	32–36 (n = 3,511)	≥37 (n = 82,953)		22–36 (n = 2,949)	≥37 (n = 78,052)
Hours per week								
0	55,226	66	64	65	63	56,366	73	70
>0–≤1	11,616	12	12	13	13	11,801	13	15
>1–≤2	8,749	10	9	9	10	6,534	7	8
>2–≤3	4,762	5	6	6	5	2,704	3	3
>3–≤5	4,312	5	6	5	5	2,251	3	3
>5	2,373	2	2	3	3	1,194	1	1
Preferred type								
None	55,226	66	64	65	63	56,366	73	70
Swimming	6,901	9	8	7	8	8,517	10	11
Low-impact activities‡	9,857	9	11	11	11	8,501	9	11
High-impact activities§	2,459	2	2	2	3	244	0	0
Working out/fitness training	1,473	1	2	1	2	556	1	1
Bicycling	8,001	10	9	9	9	4,299	5	5
Horseback riding	988	1	1	1	1	224	0	0
Other	2,133	2	3	2	2	2,143	2	3

* There were 194 missing values for exercise variables in the first interview.

† There were 151 missing values for exercise variables in the second interview.

‡ Low-impact activities were defined as activities in which at least one foot is always on the ground (included were: aerobics/gymnastics for pregnant women, aerobics/gymnastics, dancing, walking/hiking, yoga).

§ In high-impact activities, there are moments at which both feet leave the ground simultaneously (included were: jogging, ball games, racket sports).

Measurement of other covariates

Information on potential confounders was obtained from the first pregnancy interview and was categorized as displayed in table 1. We also considered chronic diseases (yes/no), uterine fibroids or malformations or cone biopsy (yes/no), subfecundity (time to pregnancy >12 months vs. time to pregnancy ≤12 months), working hours (day, evening, night, rotating shifts without night work, rotating shifts with night work), working position (predominantly standing or walking, predominantly sitting, or a mixture), and psychosocial job strain (relaxed, active, passive, strained). Furthermore, data from the second pregnancy interview on vaginal bleeding, painful contractions, loss of amniotic fluid, and cervical incompetence were used in subanalyses.

Measurement of outcome

Gestational age was based upon information from birth record data reported to the National Patient Registry in Denmark. Preterm birth was defined as delivery (both live- and stillbirth) after 153 days and before 259 days (equivalent to 22 and 36 completed weeks of gestation, respectively). Preterm births were further categorized as extremely preterm (22–27 completed weeks of gestation), very preterm (28–31 completed weeks), or moderately preterm (32–36 completed weeks) (15).

Statistical analysis

Hazard ratios for preterm birth according to total amount of exercise per week and MET-hours per week, respectively, were estimated using a Cox regression model. Time at risk started from the day a woman completed the 22nd week of gestation or on the day of her first pregnancy interview, whatever came last. Follow-up ended at birth, emigration, or maternal death or by the time a woman completed gestational week 37, whatever came first. If a second interview was available, exercise data would be updated at the time of the second interview. In order to adjust for the different times of entry into follow-up related to the fact that some women were interviewed early in pregnancy and others later, we stratified our models by gestational age at the time of the first interview when exercise data from the first interview were used, and by gestational age at the time of the second interview when data from the second interview were used.

We conducted tests for trend over all exposure groups and for the situation in which the response of no exercise is allowed to differ from the general relation (32). To examine a possible nonlinear relation between MET score and hazard of preterm birth, we analyzed both a model with linear splines (33) and a model allowing for a quadratic relation.

The importance of type of exercise was analyzed by dividing each type into no engagement, small amounts, and large amounts, with the results for the different types of exercise being mutually adjusted for each other.

In the analysis of possible changes in exercise habits from early pregnancy to late pregnancy, we restricted the data to observations with a first pregnancy interview performed before 22 completed weeks of gestation and a second pregnancy interview performed between 22 and 36 weeks, both inclusive. Hence, entry time started by the time of the second interview.

To examine time-dependent associations, we estimated the influence on extremely, very, and moderately preterm birth, respectively, by including an interaction term between exercise and time categorized into intervals corresponding to the degree of preterm birth. This procedure corresponds to making separate analyses for each time interval, except that common estimates of the influence of each of the other covariates are obtained.

Previous preterm birth is a strong risk factor for subsequent preterm birth and is therefore likely to be a cue for reducing activity level in later pregnancies. Hence, we repeated the analyses for primigravid and nulliparous women, respectively. Likewise, we assumed that women with symptoms possibly related to preterm birth during pregnancy might decrease their physical activity. In the attempt to elucidate possible reverse causation, we carried out analyses restricted to women who reported none of these symptoms in the second interview and compared risk estimates with those for all women with a second interview. Finally, separate analyses were carried out for multiple-gestation pregnancies.

To evaluate the possible effect arising from a woman's having more than one pregnancy during follow-up, we compared all standard errors with robust standard errors taking cluster sampling into consideration (34).

The selection of potentially confounding factors was based on an a priori search of the literature, and all available factors identified were included in the model. All analyses were carried out using SAS statistical software, version 9 (SAS Institute, Inc., Cary, North Carolina).

RESULTS

The total number of preterm births was 4,279, corresponding to 4.9 percent of all singleton pregnancies. Almost two thirds (63 percent) of the participants did not engage in any kind of physical exercise around the time of the first pregnancy interview, and at the time of the second interview this figure was 70 percent (table 1). Exercising more than 2 hours per week was infrequent, and in late pregnancy approximately half of the active women exercised for 1 hour per week or less. Among physically active women, the most common activities were swimming, low-impact activities, and bicycling. The prevalence of bicycling, however, was markedly reduced in the second interview.

Apart from parity, there were no essential differences in the occurrence of preterm birth according to the maternal characteristics considered (table 2). From the first interview to the second interview, there was a decrease in the proportion of women who exercised that was consistent over exposure groups.

Table 3 shows that women who engaged in some kind of exercise while pregnant were less likely to give birth before term than women who did not engage in physical exercise. Tests for trend indicated that the difference was seen between nonexercisers and exercisers and that the amount of time spent on exercise played less of a role; hence, there was no indication of a dose-response relation among active women. Adjustment for possible confounders did not alter the estimates substantially, either in this analysis or in the following analysis.

When the importance of type of exercise was examined, all types of exercise were associated with a reduced risk of preterm birth (except for horseback riding, which had hazard ratios around 1 and broad confidence intervals; data not shown). However, risk estimates were statistically significant only among women who engaged in low-impact activities of limited duration or in swimming.

When amount and type of exercise were combined according to MET scores, a leisure-time activity level of up to 5 MET-hours per week was associated with an almost 25 percent decreased risk of preterm birth in comparison with nonactive women, while the hazard ratio among women who exercised for more than 15 MET-hours per week was 0.88 (table 4). With regard to amount analyses in table 3, no trend was seen among exposed women in the MET analyses. Furthermore, neither a linear spline model nor a model with a quadratic relation provided a better fit than the simple linear model.

From table 5, it follows that exercise late in pregnancy was associated with a reduced risk of preterm birth, whereas for exercise in early pregnancy, no association was seen. In this analysis, adjusting for warning signs of preterm birth did not alter the estimates substantially (data not shown). When the data set was restricted to women with no prenatally recorded warning signs for preterm birth, the association among women who exercised in late pregnancy was attenuated, whereas a slightly increased risk of preterm birth was seen among women who had stopped exercising (data not shown).

The association between exercise and moderate preterm birth did not differ from what was presented in table 3 for overall preterm birth (data not shown). The hazard ratio for very preterm birth among exercisers as compared with nonexercisers was 0.86 (95 percent confidence interval (CI): 0.70, 1.07), and for extremely preterm birth the corresponding hazard ratio was 1.01 (95 percent CI: 0.74, 1.38).

When we restricted the analyses to primigravid and nulliparous women, respectively, the results were similar to those for the whole population. The hazard ratio for exercise versus no exercise for primigravidae was 0.81 (95 percent CI: 0.73, 0.89), and it was close to identical for nulliparae. Correspondingly, the estimates for women with no warning signs of preterm birth were similar to those for the total cohort (hazard ratio = 0.82, 95 percent CI: 0.73, 0.92). However, when we analyzed exercise data from the first and second pregnancy interviews separately, almost the whole association was seen in the analysis based on data from the second interview.

Finally, separate analyses were carried out for the 1,964 multiple pregnancies that had been excluded from the main

TABLE 2. Distribution of selected maternal characteristics according to gestational age at birth and physical exercise during pregnancy (n = 87,232), Danish National Birth Cohort, 1996–2002

Variable*	No. of pregnancies	Preterm birth† (%) (n = 4,279)	Term birth‡ (%) (n = 82,953)	Proportion (%) of exercising women§	
				Interview 1	Interview 2
Maternal age (years)					
<25	11,221	15	13	35	28
25–<35	65,920	72	76	37	31
35–<40	9,184	12	10	33	27
≥40	907	1	1	34	28
Gravidity					
1	30,260	43	34	46	40
≥2	56,938	57	66	31	25
Parity					
0	40,955	60	46	45	40
≥1	46,241	40	54	29	22
Previous spontaneous abortions					
0	70,549	79	81	38	31
1	12,560	15	14	32	28
≥2	4,052	6	5	26	24
Coffee consumption (cups/day)					
0	48,237	55	55	37	32
>0–<2	14,889	16	17	40	34
2–<4	12,625	13	15	36	28
≥4	11,449	16	13	30	22
Alcohol consumption (drinks/week)					
0	48,247	59	55	34	29
>0–<1	13,722	15	16	39	32
1–<3	21,256	22	25	40	33
3–<5	3,054	3	4	38	31
≥5	859	1	1	37	32
Smoking in early pregnancy (tobacco g/day)					
0	64,504	69	74	39	33
1–<10	12,434	15	14	33	26
≥10	10,062	15	11	24	19
Body mass index¶					
<18.5	3,878	5	4	31	26
18.5–<25	58,253	66	68	38	32
25–<30	16,596	19	19	34	27
≥30	7,066	10	8	32	25
Occupational status					
Higher-grade professional	7,944	8	9	42	37
Lower-grade professional	23,744	25	27	41	35
Skilled worker	16,151	19	18	34	27
Unskilled worker	22,030	28	25	30	23
Student	11,670	13	13	43	37
Out of work for >3 months	4,857	6	6	28	22
Nonclassifiable	836	1	1	35	29

* Missing values: for gravidity, n = 34; for parity, n = 36; for previous spontaneous abortion, n = 71; for coffee consumption, n = 32; for alcohol consumption, n = 94; for smoking, n = 232; for body mass index, n = 1,439.

† Delivery between 22 and 36 completed weeks of gestation, inclusive.

‡ Delivery at 37 completed weeks of gestation or later, including postterm births.

§ Missing values for exercise variables: first interview, n = 194; second interview, n = 151.

¶ Weight (kg)/height (m)^2.

TABLE 3. Crude and adjusted hazard ratios for preterm birth according to amount of physical exercise during pregnancy (n = 87,232), Danish National Birth Cohort, 1996–2002

Exercise	Crude HR*	Adjusted HR†	95% CI*	*p* for trend	*p* for trend‡
None	1	1			
Any	0.86	0.82	0.76, 0.88		
Hours/week					
0	1	1		0.0002	0.2461
>0–≤1	0.82	0.80	0.72, 0.87		
>1–≤2	0.86	0.81	0.72, 0.92		
>2–≤3	0.93	0.89	0.76, 1.05		
>3–≤5	0.94	0.89	0.75, 1.06		
>5	0.87	0.81	0.64, 1.04		

* HR, hazard ratio; CI, confidence interval.

† Adjusted for age, gravidity, parity, previous spontaneous abortions, uterine fibroids/malformations/cone biopsy, subfecundity, coffee consumption, alcohol consumption, smoking, body mass index, job status, working hours, working position, and job strain.

‡ When zero exposure was separated from the dose-response.

analyses (1,933 twin births and 31 triplet births). In multiple pregnancies, the hazard ratio for preterm birth was 0.87 (95 percent CI: 0.74, 1.03) among women who engaged in any kind of exercise in comparison with nonactive women (data not shown). When amount or type of exercise was subcategorized, hazard ratios were just below or around 1, with broad confidence intervals.

The cluster effect due to the fact that some participants had more than one pregnancy in the cohort was found to be negligible (data not shown).

DISCUSSION

In almost 90,000 pregnancies, a little more than one third of the women engaged in physical exercise in early pregnancy, and this proportion decreased somewhat in late pregnancy. These women had a moderately reduced risk of preterm birth, but no dose-response relation was seen. The findings indicate either that physical exercise is associated with a reduced risk of preterm birth or that women with a low generic risk of preterm birth are more likely to be physically active (a ''healthy exerciser effect''). Restricting analyses to primigravidae, nulliparae, or women with no symptoms of threatening preterm birth did not change the estimates substantially, nor did detailed analyses of the types of exercise performed.

These results corroborate previous findings, which mostly have been based on small cohorts (24–27, 29) or intervention studies of highly selected samples (22, 23). It may be expected that participants in the Danish National Birth Cohort are healthier, on average, than the general pregnant population, but the overall rates of preterm birth were rather similar among participants (5.5 percent over the years 1997–2003) and the general population (5.2 in 1995 and 6.3 percent in 2004) (15).

The specific time of reported exercise was not very precise in this study, and it is possible that some women registered as nonexercisers or with low levels of exercise had been exercising at higher levels earlier in pregnancy. If participants had stopped because of contractions or other symptoms of threatening preterm birth, we could see ''reverse causation'' leading to overestimation of a possible beneficial effect. On the other hand, excluding women with symptoms of threatening preterm birth did not change the results much.

In this study, we analyzed amount of exercise, type of exercise, and MET scores. One limitation in using MET scores is the risk of adding random variation by applying an assumed intensity to the included activities. Furthermore, if mechanical incidents like bumps and jumps account for an association, this will not necessarily show up in MET analyses.

Information about physical activity was self-reported. Although objective measures would have been preferred, this was not feasible in a study of this size. Because of the prospective nature of the data collection, misclassification of physical activity is most likely to have been nondifferential and would most likely have biased the association towards the null. The questions on exercise posed to participants in the Danish National Birth Cohort were similar to those used in other studies of pregnant women (12, 29, 35) and were

TABLE 4. Crude and adjusted hazard ratios for preterm birth according to metabolic equivalent-hours of physical exercise per week during pregnancy (n = 87,232), Danish National Birth Cohort, 1996–2002

Exercise (MET*-hours/week)	No. of pregnancies	Crude HR*	Adjusted HR†	95% CI*	*p* for trend	*p* for trend‡
0	55,412	1	1		<0.0001	0.1104
>0–≤5	6,393	0.80	0.77	0.68, 0.87		
>5–≤10	10,009	0.85	0.82	0.74, 0.91		
>10–≤15	5,668	0.88	0.83	0.71, 0.96		
>15	9,750	0.92	0.88	0.78, 1.00		

* MET, metabolic equivalent; HR, hazard ratio; CI, confidence interval.

† Adjusted for age, gravidity, parity, previous spontaneous abortions, uterine fibroids/malformations/cone biopsy, subfecundity, coffee consumption, alcohol consumption, smoking, body mass index, job status, working hours, working position, and job strain.

‡ When zero exposure was separated from the dose-response.

TABLE 5. Crude and adjusted hazard ratios for preterm birth according to possible changes in physical activity level during pregnancy (*n* = 67,861), Danish National Birth Cohort, 1996–2002

Exercise (yes/no) (+/−)		No. of pregnancies	Crude HR*	Adjusted HR†	95% CI*
<22 weeks‡	≥22 weeks§				
−	−	34,767	1	1	
+	−	12,233	1.08	1.06	0.96, 1.18
−	+	8,128	0.89	0.83	0.73, 0.95
+	+	12,733	0.86	0.81	0.72, 0.91

* HR, hazard ratio; CI, confidence interval.

† Adjusted for age, gravidity, parity, previous spontaneous abortions, uterine fibroids/malformations/cone biopsy, subfecundity, coffee consumption, alcohol consumption, smoking, body mass index, job status, working hours, working position, and job strain.

‡ Data from the first pregnancy interview, carried out before 22 completed weeks of gestation.

§ Data from the second pregnancy interview, carried out between 22 and 36 completed weeks of gestation, inclusive.

modified from the Minnesota Leisure-Time Physical Activity Questionnaire (36, 37).

This study concentrated on leisure-time activities. Hence, it was not our intention to cover physical activity as a whole in an attempt to explain the physiologic mechanisms behind a possible association with preterm birth. Our aim was to contribute to the discussion regarding whether it is safe to continue or commence leisure-time physical exercise during pregnancy. To account for a possible work-related effect, different measures of strain at work were included as covariates. Unfortunately, information on prepregnancy physical activity was not part of the collected data.

Since preterm birth is a strong predictor of subsequent preterm birth, a previous preterm birth may lead to behavioral modifications, which cannot be well controlled. However, in analyses including only primigravidae or primiparae, the estimates found for the whole cohort were not altered.

We did not separate preterm births into spontaneous births and medically induced births. Savitz et al. (38) concluded that the overall risk profiles of pregnancies resulting in the different types of preterm birth are often similar, which justifies aggregation of the two types of preterm birth. When the preterm births were subclassified according to severity, the protective association in the overall analyses disappeared among very preterm and extremely preterm births, but because of limited power, we cannot conclude that there is a different association with physical exercise across gestational ages at birth.

The observed associations need not reflect causal effects but could be results of uncontrolled confounding or reverse causation, even though subanalyses did not indicate the latter. The results suggest a protective effect of exercise or perhaps that pregnancies ending in preterm delivery follow an early onset of symptoms that may interfere with the capacity to be physically active. A possible mechanism behind the findings is that increased insulin sensitivity caused by exercise may decrease the inflammatory response that is a suggested risk factor for preterm birth (39).

The results of this study do not suggest any negative effects of physical exercise on the risk of preterm birth; rather, they suggest a minor protective association. Should our findings reflect causal links, they would be of positive public health importance, since very few evidence-based strategies for prevention of preterm birth exist, and prescribing long-term rest to pregnant women may carry unwanted risks.

ACKNOWLEDGMENTS

The Danish National Research Foundation established the Danish Epidemiology Science Centre, which initiated and created the Danish National Birth Cohort. Furthermore, the cohort was established with the support of a major grant from this foundation. Additional support for the Danish National Birth Cohort is obtained from the Pharmacy Foundation, the Egmont Foundation, the March of Dimes Birth Defects Foundation, and the Augustinus Foundation. This specific study was supported by grants from the Danish Medical Research Council, the Augustinus Foundation, the Danish Midwifery Association, and the Danish Graduate School in Public Health Science.

The authors are grateful to Katrine Strandberg Larsen for insightful advice regarding use of data from the Danish National Birth Cohort.

The Scientific Ethical Committee in Denmark approved the data collection in the Danish National Birth Cohort research database. Approval to use data from the birth cohort for the present study on preterm birth was obtained. The Danish Data Protection Agency approved the storage, handling, and linkage of the data.

Conflict of interest: none declared.

REFERENCES

1. Committee on Obstetric Practice. ACOG committee opinion. Exercise during pregnancy and the postpartum period. Number 267, January 2002. American College of Obstetricians and Gynecologists. Int J Gynaecol Obstet 2002;77:79–81.

2. Denmark National Board of Health. Physical activity—a handbook on prevention and treatment. (In Danish). Copenhagen, Denmark: National Board of Health, 2003.
3. National Collaborating Centre for Women's and Children's Health. Antenatal care: routine care for the healthy pregnant woman. Clinical guideline, October 2003. London, United Kingdom: RCOG Press, 2003.
4. Directorate for Health and Social Affairs. Guidelines for antenatal care. (In Norwegian). Oslo, Norway: Directorate for Health and Social Affairs, 2005.
5. Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion. Perceived Exertion (Borg Rating of Perceived Exertion Scale). Atlanta, GA: National Center for Chronic Disease Prevention and Health Promotion, 2006. (Accessed April 3, 2007).
6. Magnusson P, Torp-Pedersen CT, Backer V, et al. Physical activity and chronic disease I. Heart disease and hypertension. (In Danish). Ugeskr Laeger 2004;166:1543–7.
7. Magnusson P, Torp-Pedersen CT, Backer V, et al. Physical activity and chronic disease II. Type 2 diabetes, obesity and cancer. (In Danish). Ugeskr Laeger 2004;166:1547–51.
8. Magnusson P, Torp-Pedersen CT, Backer V, et al. Physical activity and chronic disease III. Musculoskeletal diseases and lung diseases. (In Danish). Ugeskr Laeger 2004;166:1552–7.
9. Dye TD, Knox KL, Artal R, et al. Physical activity, obesity, and diabetes in pregnancy. Am J Epidemiol 1997;146:961–5.
10. Solomon CG, Willett WC, Carey VJ, et al. A prospective study of pregravid determinants of gestational diabetes mellitus. JAMA 1997;278:1078–83.
11. Marcoux S, Brisson J, Fabia J. The effect of leisure time physical activity on the risk of pre-eclampsia and gestational hypertension. J Epidemiol Community Health 1989;43:147–52.
12. Sorensen TK, Williams MA, Lee IM, et al. Recreational physical activity during pregnancy and risk of preeclampsia. Hypertension 2003;41:1273–80.
13. Kramer MS. Aerobic exercise for women during pregnancy. Cochrane Database Syst Rev 2002;(2):CD000180.
14. Madsen M, Jørgensen T, Jensen ML, et al. Leisure time physical exercise during pregnancy and the risk of miscarriage: a study within the Danish National Birth Cohort. BJOG 2007;114:1419–26.
15. Langhoff-Roos J, Kesmodel U, Jacobsson B, et al. Spontaneous preterm delivery in primiparous women at low risk in Denmark: population based study. BMJ 2006;332:937–9.
16. Martin JA, Hamilton BE, Sutton PD, et al. Births: final data for 2004. (National vital statistics reports, vol 55). Hyattsville, MD: National Center for Health Statistics, 2006:1–101.
17. Spinnewijn WE, Lotgering FK, Struijk PC, et al. Fetal heart rate and uterine contractility during maternal exercise at term. Am J Obstet Gynecol 1996;174:43–8.
18. Durak EP, Jovanovic-Peterson L, Peterson CM. Comparative evaluation of uterine response to exercise on five aerobic machines. Am J Obstet Gynecol 1990;162:754–6.
19. Mayberry LJ, Smith M, Gill P. Effect of exercise on uterine activity in the patient in preterm labor. J Perinatol 1992;12:354–8.
20. Veille JC, Hohimer AR, Burry K, et al. The effect of exercise on uterine activity in the last eight weeks of pregnancy. Am J Obstet Gynecol 1985;151:727–30.
21. Grisso JA, Main DM, Chiu G, et al. Effects of physical activity and life-style factors on uterine contraction frequency. Am J Perinatol 1992;9:489–92.
22. Duncombe D, Skouteris H, Wertheim EH, et al. Vigorous exercise and birth outcomes in a sample of recreational exercisers: a prospective study across pregnancy. Aust N Z J Obstet Gynaecol 2006;46:288–92.
23. Kardel KR, Kase T. Training in pregnant women: effects on fetal development and birth. Am J Obstet Gynecol 1998;178:280–6.
24. Clapp JF III, Dickstein S. Endurance exercise and pregnancy outcome. Med Sci Sports Exerc 1984;16:556–62.
25. Magann EF, Evans SF, Weitz B, et al. Antepartum, intrapartum, and neonatal significance of exercise on healthy low-risk pregnant working women. Obstet Gynecol 2002;99:466–72.
26. Orr ST, James SA, Garry J, et al. Exercise and pregnancy outcome among urban, low-income, black women. Ethn Dis 2006;16:933–7.
27. Evenson KR, Siega-Riz AM, Savitz DA, et al. Vigorous leisure activity and pregnancy outcome. Epidemiology 2002;13:653–9.
28. Klebanoff MA, Shiono PH, Carey JC. The effect of physical activity during pregnancy on preterm delivery and birth weight. Am J Obstet Gynecol 1990;163:1450–6.
29. Misra DP, Strobino DM, Stashinko EE, et al. Effects of physical activity on preterm birth. Am J Epidemiol 1998;147:628–35.
30. Olsen J, Melbye M, Olsen SF, et al. The Danish National Birth Cohort—its background, structure and aim. Scand J Public Health 2001;29:300–7.
31. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of Physical Activities: an update of activity codes and MET intensities. Med Sci Sports Exerc 2000;32(suppl):S498–504.
32. Clayton D, Hills M. Statistical models in epidemiology. Oxford, United Kingdom: Oxford Science Publications, 1993.
33. Greenland S. Dose-response and trend analysis in epidemiology: alternatives to categorical analysis. Epidemiology 1995;6:356–65.
34. Lin DY. Cox regression analysis of multivariate failure time data: the marginal approach. Stat Med 1994;13:2233–47.
35. Dempsey JC, Butler CL, Sorensen TK, et al. A case-control study of maternal recreational physical activity and risk of gestational diabetes mellitus. Diabetes Res Clin Pract 2004;66:203–15.
36. Folsom AR, Caspersen CJ, Taylor HL, et al. Leisure time physical activity and its relationship to coronary risk factors in a population-based sample. The Minnesota Heart Survey. Am J Epidemiol 1985;121:570–9.
37. Taylor HL, Jacobs DR Jr, Schucker B, et al. A questionnaire for the assessment of leisure time physical activities. J Chronic Dis 1978;31:741–55.
38. Savitz DA, Dole N, Herring AH, et al. Should spontaneous and medically indicated preterm births be separated for studying aetiology? Paediatr Perinat Epidemiol 2005;19:97–105.
39. Goldenberg RL, Culhane JF. Prepregnancy health status and the risk of preterm delivery. Arch Pediatr Adolesc Med 2005;159:89–90.