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Effect of physical activity on gestational age and preterm birth: The HUNT study

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Abstract.

Background The level of physical activity (PA) in the general population is considered too low, and this has also been shown for pregnant women. Although recent research has shown that regular moderate PA may be beneficial both for the mother and the fetus in relation to complications during pregnancy, the effect of being physically active before and during pregnancy is still debated.

Objectives The aim of this study is to examine the effect of PA before and during pregnancy in relation to mean gestational age and risk of preterm birth in a large cohort of women.

Subjects The study included a total of 2,515 women in HUNT 1 and 2,921 women in HUNT 2 aged between 20 and 35 years at the time of participation, and who had given birth during the following 5 years after the HUNT study.

Methods Gestational age obtained from The Medical Birth Registry of Norway. In HUNT 1, PA was reported as frequency, intensity and duration, and in HUNT 2, hours of light and hard PA per week was reported. For both studies a summary score combining information from the separate items was constructed, classifying participants into the following groups: No, light, medium, or high activity. Using linear regression to calculate adjusted mean differences in gestational length between the activity groups, and logistic regression to calculate adjusted odds ratios (ORs) as estimates of relative risk of preterm birth (gestational age <37 weeks). A 95% confidence interval (CI) was calculated to indicate the precision of the estimated associations.

Results PA before pregnancy was not related to mean gestational age, whereas for PA reported during pregnancy; inactive women had a non-significant 5.9 days (95% CI 2.2-13.9) shorter gestational length than active women. A similar pattern was evident for the risk of preterm birth; PA before pregnancy did not affect the risk of preterm birth. For PA during pregnancy there was a tendency that women who reported any level of activity had a lower risk of preterm birth compared with inactive women. The adjusted OR for women with low PA level was 0.26 (95% CI, 0.05-1.35), for those with medium PA level 0.46 (95% CI, 0.10-2.13), and for those with high PA 0.29 (95% CI, 0.04-2.05), all compared to the inactive.

Conclusion PA before pregnancy does not seem to affect either mean gestational age or the risk of preterm birth, whereas there were some evidence that being physically active during pregnancy, at a level above inactivity, may reduce the risk of preterm birth.

Keyword Physical activity • preterm birth • gestational age • pregnancy

Contents

Introduction.

The impact of physical activity (PA) on numerous health outcomes has received much interest during the last years. It is well established that the level of PA in the whole population is generally too low, and data indicate that pregnant women are no different from the rest (1, 2, 3).

In later years, research has shown that regular moderate PA may be beneficial both for the mother and the fetus in relation to complications during pregnancy (4). It is believed that PA can affect the duration of labor, the weight of the infant, and protect against preeclampsia and preterm birth (1, 5). Among other complications related to pregnancy, preterm birth represents a public health concern worldwide (6). Preterm birth is defined as birth occurring before completed 37 weeks of gestation (7). The incidence of preterm birth ranges from 5% to 7% of live births in the most developed countries, and can be as high as 25% in developing nations (8). According to data from the Medical Birth Registry of Norway (MBRN), the incidence of preterm births has increased during the last 20 years, from 6% in 1980 to 8% in 2001/2002 (9). Also in Denmark, a study has found an increase in the incidence of preterm births from 1995 to 2004 (10).

From a public health perspective it is important to identify modifiable risk factors, such as those related to lifestyle, and their influence on preterm birth. Since the causes of preterm birth are not well understood, preventive factors have been difficult to identify. Inflammatory response and smoking during pregnancy are suggested risk factors for preterm birth (11). In addition, factors such as maternal infection, preeclampsia, and maternal age below 20 and above 35 years seem to increase the risk of preterm birth (12).

Premature infants may face a number of health challenges like low birth weight, breathing problems because of underdeveloped lungs and other serious lung conditions, other underdeveloped organs or organ systems, higher risk for life-threatening infections, higher risk for cerebral palsy (CP), and a higher risk for learning and developmental disabilities (13). Preterm birth is also a leading cause of perinatal mortality and a major predictor of neonatal mortality and infant morbidity (6, 14).

Until the last decades, pregnant women were advised to reduce their level of PA since PA was associated with higher risk of pregnancy complications (4). But in recent years, research has shown that regular moderate PA may be beneficial both for the mother and the fetus (4). In 2002, the American College of Obstetricians and Gynecologists, among others, stated that 30 minutes or more of moderate exercise on most days of the week can be recommended to healthy pregnant women as well as people who are not pregnant (5, 15). Despite this, there is disagreement regarding the amount of PA recommended for pregnant women.

Although several recent studies have focused on the influence of PA on pregnancy and pregnancy outcomes, the effect of PA before or during pregnancy is not fully understood. Some studies have investigated PA before pregnancy, others during pregnancy and a few have not defined if the PA is performed before and/or during the pregnancy. However, the results have been inconsistent, even when a specific outcome such as preterm birth has been in focus. First, a few studies have found that regular PA can provide protection against preterm birth (16-18). One example is the effect of PA in early pregnancy that was reported by Misra and colleges (17). Their study shows that an amount of more than 60 days with leisure-time PA during the first and second trimesters had a protective effect on preterm delivery compared to women with a low activity level. Second, studies have suggested that during PA, both adrenaline and noradrenaline levels rise, and since noradrenaline affects the uterus, PA could theoretically induce preterm birth via uterine contractions (11, 20). Regarding gestational age, some studies have reported no difference in mean gestational length between active and inactive women (21, 22). Moreover, a review article concluded that after 37 weeks of gestation, active women deliver on average 6 days earlier if exercise is continued throughout late pregnancy and that less intense PA did not affect gestational length (16).

The aim of this study is to examine the effect of PA, before and during pregnancy, in relation to mean gestational age and risk of preterm birth in a large cohort of Norwegian women.

Materials and methods.

The HUNT study.

The Nord-Trøndelag Health Study (HUNT) is the largest health study performed in Norway, and also one of the largest worldwide. The HUNT study has been carried out in Nord-Trøndelag Country, Norway, and consists of three cross-sectional waves; HUNT 1 (1984-1986), HUNT 2 (1995-1997) and HUNT 3 (2006-2008). All residents in Nord-Trøndelag County aged 20 years or older at the different time periods were invited to participate in the studies. The population of Nord-Trøndelag is considered to be fairly representative of the total Norwegian population (23).

In HUNT 1, 85,100 eligible individuals were invited, and 75,043 (88.2%) accepted the invitation, completed questionnaires and attended a clinical examination, of these 36,769 were men and 38,274 were women (24). Similarly in HUNT 2, 92,936 eligible individuals were invited, and 64,943 (69.9%) accepted the invitation, completed questionnaires and attended a clinical examination; 30,425 men and 34,518 women (25).

Information was collected by questionnaire on a range of lifestyle and health related factors, including past medical and reproductive history, measures of physical activity, smoking, alcohol consumption, marital status, and education, among other things. Body height and weight were also measured.

The Medical Birth Register of Norway.

The Medical Birth Registry of Norway (MBRN) is a health register for the whole Norwegian country. It contains information about all births and ended pregnancies after the 12th week of gestation. A wide range of variables are available from the registry, including; gestational age, maternal parity, offspring birth weight and length, pregnancy complications, offspring health and congenital diseases, as well as some information on maternal lifestyle and health during pregnancy (9).

Subjects.

For the purpose of this prospective study, women aged between 20 and 35 years at time of participation either in HUNT 1 (10,164 subjects) or HUNT 2 (8,251 subjects) are included.

Exclusion criteria and number of subjects excluded for the two studies are shown in figure 1 and 2.

Figure 1: Exclusion in HUNT 1.

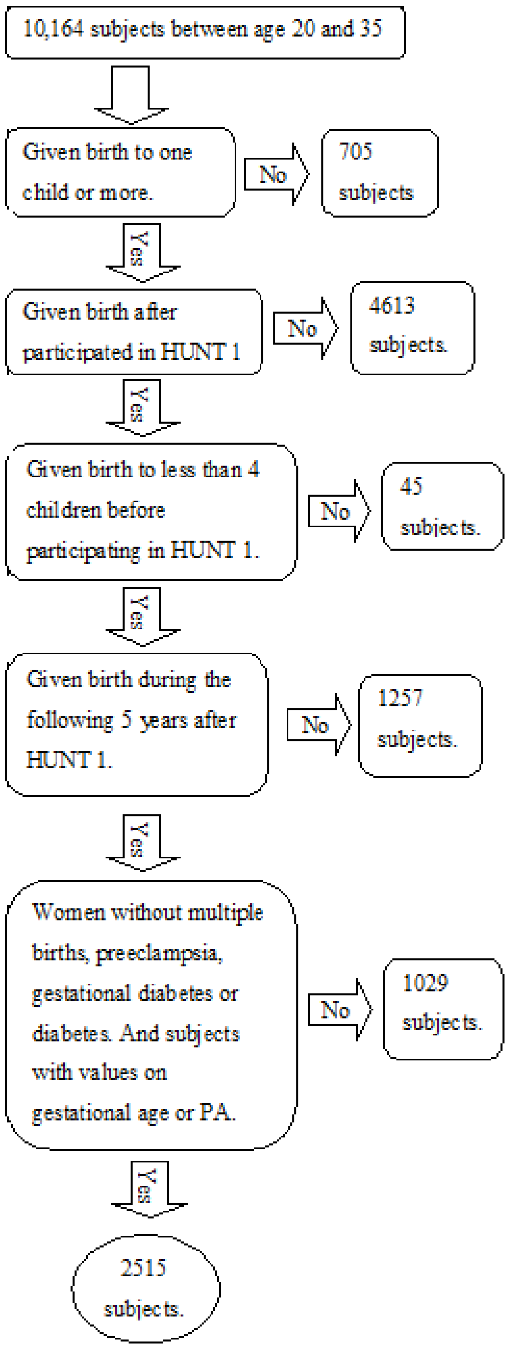
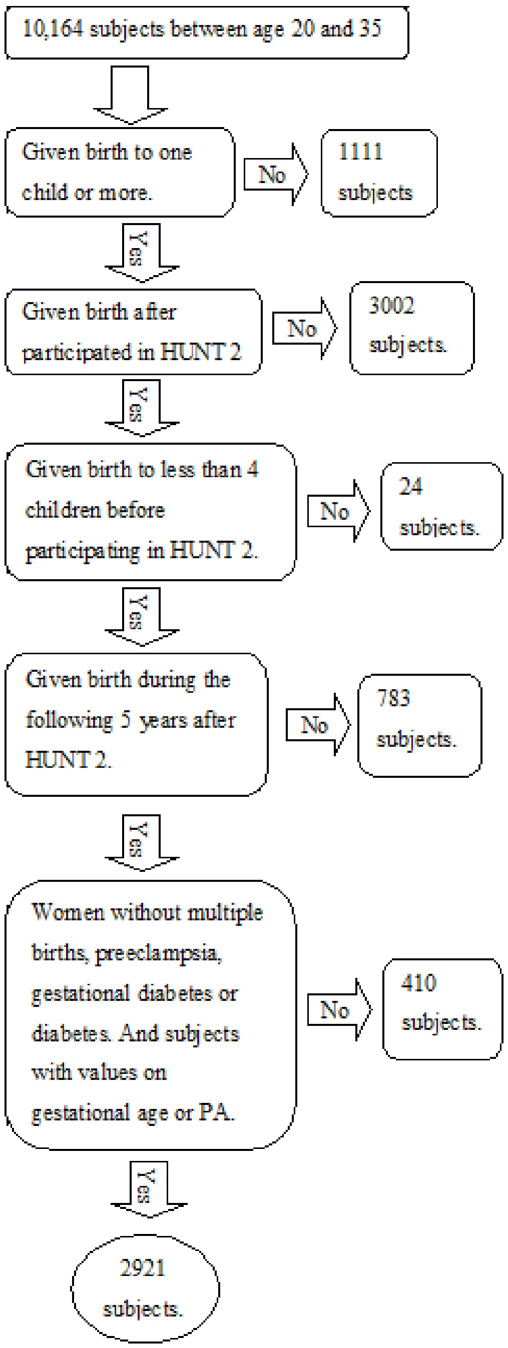


Figure 2: Exclusion in HUNT 2.



In the end a total number of 2,515 births by women who had participated in HUNT 1 and 2,921 births by women who had participated in HUNT 2 were identified. Only birth occurring minimum 6 months after participating in the study were used to analyze PA before pregnancy, leaving a number of 2,280 subjects in HUNT 1 and 2,603 subjects in HUNT 2. Considering

PA during pregnancy women who have given birth within the first 6 months after the study were included, which resulted in a total of 235 subjects in HUNT 1 available for analysis.

Measurement of physical activity.

Information on PA was obtained from a self reported questionnaire in both HUNT 1 and HUNT 2, using somewhat different questions in the two studies (Appendix). Due to the construction on the PA questions, data from HUNT 1 will be used to look at PA during and before pregnancy, and HUNT 2 will only be used to study PA before pregnancy.

In HUNT 1, PA is defined as walking, skiing, swimming or different kinds of sport etc. When answering the questions the participants should consider PA the last period of time. The first question was about weekly frequency of PA (0, <1, 1, 2-3, and ≥4 times; coded 1-5). The participants who reported exercising at least once a week were also asked to answer two more questions about the duration (<15, 15-30, 31-60, and >60 minutes; coded 1-4) and intensity (light, moderate, and vigorous; coded 1-3) of the activity. For women who were physically active once a week or more, a summary score of frequency, duration, and intensity according to the following equation was constructed: $1/5 \times$ frequency + $1/4 \times$ duration $+1/3 \times$ intensity. This gives a maximum score of 1.0 for each of the three components of the summary score. The median score value was 1.9667. Further the score was used to construct a PA variable for use in the analyses; this variable was classified as no activity, low activity (<1 a week), medium activity (<median score) and high activity (≥median score).

In HUNT 2 there were two questions regarding PA. The participants were to consider a mean amount of PA per week for the last year, and then answer if the activity was light or hard and how many hours per week they were physically active. A PA index that combined the information on light and hard activity were constructed; this value was classified as no activity, low activity (<3 h light and no hard), medium activity (≥3 h light and/or <1 h hard) and high activity (any light and ≥1 h hard).

Measurement of other covariates.

The self reported questionnaire in HUNT for all participants over 20 years in both HUNT 1 and HUNT 2, and the questionnaires for women between 20 and 69 years in HUNT 2, was used to obtain information about potential confounders. Some information was also obtained from MBRN.

Body mass index (BMI kg/m^2) was calculated from standardized measures of height and weight and categorized according to the World Health Organization standards (WHO). Those with BMI < 18.5 are classified as underweight, 18.5 – 24.9 as normal weight, 25.0 – 29.9 as overweight, 30.0 – 34.9 as obese and a BMI ≥ 35.0 as extremely obese (26).

Systolic and diastolic blood pressure (BP) was measured two times in HUNT 1 and three times in HUNT 2. In the present study the second measure form HUNT 1 and the mean of the second and third measure in HUNT 2 has been used.

Considering use of alcohol, the participants were asked about the number of times they drank alcohol the last 14 days (in HUNT 1), and during the last month (in HUNT 2). In HUNT 2 there was an own question about being an abstainer, while in HUNT 1 it was part of the main question. In HUNT 1 use of alcohol is categorized into 0, 1-4, ≥5, abstainer or unknown and in HUNT 2 into 0, 1-8, ≥9 and unknown.

The different questions on smoking habits (e.g. do you smoke daily, number of cigarettes, age when started smoking, have you stopped smoking) from HUNT 1 and HUNT 2 were used to classify the participants into never, former, or current smokers, as well as an unknown category.

Information regarding education was collected from one question in both HUNT 1 and HUNT 2. The participants were asked about the highest education completed. Both questionnaires were categorized from minimum 7 year primary school or shorter and up to 4 year or more on university. Education is categorized as low (< university), high (> university) and unknown.

Information about parity (number of births after 12th week of gestation), was obtained from MFR.

Measurement of outcome.

Gestational age and preterm birth are based on information from MBRN. Gestational age are measured between 153 and 314 days (week 22 and 45), and preterm birth are defined as delivery after 153 days (22 weeks) and before 265 days (37 completed weeks) of gestation (7).

Statistical analyses.

Some chosen baseline characteristics of the study population were compared by descriptive analysis, and are presented as numbers of subjects, mean values, or percentages of total numbers for each category of PA.

Linear regression was used to calculate crude and adjusted mean differences in gestational age for different categories of PA. Logistic regression analyzes were used to calculate crude and adjusted odds ratios (ORs) as estimates of the relative risk of preterm birth (<37 weeks) in different categories of PA. Precision of the estimated associations was assessed with a 95% confidence interval (CI). Trend tests for categories of PA were conducted by treating the categories as an ordinal variable in the regression model.

First we considered age, BMI, parity (1, 2, 3 or 4), daily smoking, use of alcohol, education and BP as potential confounders. After the first preliminary analysis, we discovered that several of the potential confounders did not affect the result, whereas BMI and BP could be considered as intermediate factors. We therefore ended up using parity, smoking, and alcohol as confounding variables in the analyses. Additional analyses including women with preeclampsia were also performed. Because there was no meaningful difference between the various group of women reporting being active, we also performed additional analyses with a dichotomous variable were all active women (reference group) were classified together in one group and compared them with women who reported being inactive.

The statistical analyses were performed using SPSS 17.0 for Windows (SPSS Inc,. Chicago Illinois, USA).

Ethics.

All participants signed a written consent upon participation in the HUNT study, and the study has been approved by the Regional Committee for Medical Research Ethics.

Results.

Some baseline characteristics of the study population are presented in Table 1 according to the different levels of PA. The women in the various groups of PA in HUNT 1 and HUNT 2 did not seem to differ in mean systolic BP and mean age. The distribution in percentage between the various groups of PA, for the rest of the variables, before pregnancy do seem to differ.

Table 1: Selected baseline characteristics of the study population.

		Physical activity			
	Total	No activity	Low	Medium	High
PA before pregnancy in HUNT 2					
No. of pregnancies (%)	2603	82 (4.8)	591 (22.3)	961 (36.3)	969 (36.6)
Mean age	26.8	27.0	27.4	26.9	26.4
BMI >25 (%)	962	32 (4.7)	252 (25.8)	352 (36.1)	326 (33.4)
Mean systolic BP	120.2	118.4	119.9	119.9	120.9
Parity = 1 (%)	1005	16 (2.8)	169 (16.6)	341 (33.5)	479 (47.1)
Alcohol = 1-8 (%)	1778	46 (3.7)	367 (20.4)	629 (35.0)	736 (40.9)
Smoking = current (%)	707	36 (7.4)	197 (27.2)	253 (34.9)	221 (30.5)
PA before pregnancy in HUNT 1					
Number of pregnancies	2280	163 (7.1)	722 (31.7)	725 (31.8)	670 (29.4)
Mean age	26.5	26.3	26.7	26.6	26.3
BMI > 25 (%)	1943	134 (6.9)	624 (32.1)	614 (31.6)	571 (29.4)
Mean systolic BP	116.5	117.1	116.6	116.5	116.2
Parity = 1 (%)	739	36 (4.9)	209 (28.3)	213 (28.8)	281 (38.0)
Alcohol = 1-4 (%)	1051	72 (6.9)	315 (30.0)	335 (31.8)	329 (31.3)
Smoking = current (%)	899	84 (9.3)	324 (36.1)	278 (30.9)	213 (23.7)
PA during pregnancy in HUNT 1					
Number of pregnancies	235	18 (7.7)	84 (35.7)	92 (39.2)	41 (17.4)
Mean age	27.16	27.22	27.09	27.07	27.48
BMI >25 (%)	138	11 (8.0)	52 (37.7)	56 (40.5)	19 (13.8)
Mean systolic BP	114.5	114.5	113.6	115.0	115.1
Parity = 1 (%)	70	4 (5.7)	27 (38.6)	28 (40.0)	11 (15.7)
Alcohol = 1-4 (%)	39	1 (2.6)	10 (25.6)	20 (51.3)	8 (20.5)
Smoking = current (%)	83	7 (8.4)	37 (44.6)	29 (35.0)	10 (12.0)

Physical activity before pregnancy and mean gestational age.

Regarding PA before pregnancy, in both HUNT 1 and HUNT 2 (table 2a and 2b), mean gestational age did not differ much between the various groups of PA. Also additional analyses performed on active vs. inactive women indicate that inactive and active women did not have a significant different gestational age.

Adjusting for alcohol, smoking, and parity as potential confounders had no material impact on the results based on women in HUNT 1, whereas a similar adjustment attenuated the crude associations found in HUNT 2.

The result did not change meaningfully when including women with preeclampsia in the analyses.

Table 2a: PA before pregnancy and mean gestational age in days in HUNT 1 (n= 2,280)

Physical activity	Number of pregnancies	crude mean gestational age	crude diff.	adjusted diff.[a]	95% CI lower	95% CI upper	P for trend
No activity	163	280.3	0	0	Reference		
Low	722	281.1	0.73	0.81	-1.75	3.37	
Medium	725	282.2	1.86	1.80	-0.76	4.37	
High	670	281.2	0.85	0.88	-1.72	3.49	p = 0.50

[a]Adjusted for alcohol, smoking and parity.

Table 2b: PA before pregnancy and mean gestational age in days in HUNT 2 (n=2,603)

Physical activity	Number of pregnancies	crude mean gestational age	crude diff.	adjusted diff.[a]	95% CI lower	95% CI upper	P for trend
No Activity	82	277.1	0	0	Reference	.	
Low	591	279.5	2.31	0.78	-1.76	3.36	
Medium	961	280.2	3.05	1.74	-0.82	4.30	
High	969	279.5	2.34	0.78	-1.82	3.39	p = 0.57

[a]Adjusted for alcohol, smoking and parity.

Physical activity during pregnancy and mean gestational age.

Women who reported being physically active during their pregnancy had a longer gestational age, and gave birth closer to term than women being inactive (Table 3). Women reporting a medium or high level of PA tended to give birth at term (282 days), but all levels of PA gave a higher tendency for delivering closer to term than the inactive reference group. Because of a small number of subjects in the various groups the associations are imprecise, and the differences are not statistically significant.

Adjusting for confounding variables did not have a material impact on the result. The confidence intervals include the null and trend test lacked statistical significance (p=0.11) for all groups of PA, so no dose-response relation was observed. However, the results suggest that there is a difference between women being active compared to those who are inactive, with longer gestational age for women reporting being physical active during their pregnancy.

In additional analysis, combined all categories of active women into one group (reference group) and compared with inactive women, results showed that inactive women had 5.9 days (95% CI 2.2-13.9) shorter gestational age than active women. As in the analyses of physical activity before pregnancy the result for activity during pregnancy remained similar when including women with preeclampsia.

Table 3: PA during pregnancy and mean gestational age in days in HUNT 1 (n= 235)

Physical Activity	Number of pregnancies	crude mean gestational age	crude diff.	adjusted diff.[a]	95% CI		P for trend
					lower	upper	
No activity	18	274.3	0	0	Reference	.	
Low	84	280.7	6.39	5.17	-3.33	13.69	
Medium	92	282.1	7.80	6.23	-2.26	14.73	
High	41	282.6	8.32	6.61	-2.68	15.91	p = 0.11

[a] Adjusted for alcohol, smoking and parity.

Physical activity before pregnancy and risk of preterm birth.

The incidence of preterm birth during the following 5 years after HUNT 1, for women who participated in PA before pregnancy, was 7.7% (176 births) of all singleton pregnancies. The association between PA before pregnancy, in HUNT 1, and risk of preterm birth indicates no significant difference in risk between the various groups, and no dose-response relation was observed (p-trend = 0.79) (table 4a). Women who participated in PA before pregnancy have a very small non-significantly reduced risk compared with inactive women. Considering the confidence interval the result do not indicates a strong relation between PA and the risk of preterm birth.

In additional analysis, categorizing all women who reported being active into one group there was still no clear difference in risk of preterm birth compared to the inactive.

Adjusting for potentially confounding factors did not affect the risk of preterm birth. Moreover, including women with preeclampsia did not affect the result.

Table 4a: PA before pregnancy and risk of preterm birth in HUNT 1 (n=2,280)

Physical activity	Number of pregnancies	crude OR.	adjusted OR.[a]	95% CI lower	95% CI upper	P for trend
No activity	163	1	1	Reference	.	
Low	722	0.77	0.76	0.41	1.38	
Medium	725	0.78	0.82	0.44	1.50	
High	670	0.90	0.93	0.50	1.70	p = 0.79

[a]Adjusted for alcohol, smoking and parity.

In the following 5 years after HUNT 2, 10% (265 births) of all singleton pregnancies were preterm births. As for HUNT 1, data from HUNT 2 indicate no significant association between PA measured before pregnancy and risk of preterm birth, but a small reference group makes the results imprecise (table 4b). Adjusting for potential confounders did not change the results, as did not an inclusion of women with preeclampsia. The additional analysis of all active women categorized into one group did not show any clear associations either.

Table 4b: PA before pregnancy and risk of preterm birth in HUNT 2 (n=2,603)

Physical Activity	Number of pregnacies	crude OR.	adjusted OR.[a]	95% CI lower	95% CI upper	P for trend
No Activity	82	1	1	Reference	.	
Low	591	1.05	1.09	0.49	2.39	
Medium	961	0.91	0.96	0.44	2.07	
High	969	1.14	1.17	0.54	2.52	p = 0.62

[a]Adjusted for alcohol smoking and parity.

Physical activity during pregnancy and risk of preterm birth.

There is a tendency that women being inactive have the highest occurrence of preterm birth, where as much as 22.2 % gave birth to a preterm infant. The lowest incidence was among women with a low and high level of PA, respectively 4.8% and 4.9%.

As shown in table 5, pregnant women who are physically active during their pregnancy tend to have a lower risk for preterm birth (OR 0.26, 0.46 and 0.29, respectively) then the inactive groups, but none of the associations were statistically significant. The results were largely similar after including women with preeclampsia. Adjustment for potentially confounding variables slightly attenuated the estimates. After comparing one group including all active women against inactive women the tendency was the same, women being inactive tend to have a larger risk for preterm birth compared to active women (OR 2.88, 95% CI 0.70-11.96).

Table 5: PA during pregnancy and risk of preterm birth in HUNT 1 (n=235)

Physical activity	Number of pregnancies	crude OR.	adjusted OR.[a]	95% CI lower	95% CI upper	P for trend
No activity	18	1	1	Reference	.	
Low	84	0.18	0.26	0.05	1.35	
Medium	92	0.29	0.46	0.10	2.13	
High	41	0.18	0.29	0.04	2.05	p = 0.21

[a]Adjusted for alcohol, smoking and parity.

Discussion.

In this population-based study of Norwegian women aged between 20 and 35 years, no clear association between PA measured before pregnancy and gestational age or risk of preterm birth was observed, whereas data on activity during pregnancy indicate that inactive women may have somewhat shorter gestational length and a slightly higher risk of preterm birth.

Strengths and limitations.

This study has several strengths, including the large number of participants, the population-based nature of the data, the representative study population, and the prospective design. The large sample size, along with the thorough administration of the questionnaires by the HUNT administration, reduces the possibilities of selection- and information bias. The homogeneity of the study population makes confounding due to ethnicity unlikely. The information obtained from MBRN is measured by qualified health professional using standardized procedures, ensuring high quality data. However, there could have been some misclassifications regarding registration of preterm birth or gestational age. In the present study data are collected prospectively, unlike other studies whose information on PA were collected after delivery (6, 17). Information collected retrospectively may be influenced by the outcome of pregnancy and thus result in biased results.

Even if a large sample size is considered a strength of the study, there are limited subjects in some of the categories, especially when evaluating preterm birth. This can make the results imprecise and influenced by chance.

One major limitation of this study is the few questions to assess PA which may lead to a misclassification, most likely non-differential, and the assessment of the level of PA through questionnaires. The study only relied on information at baseline and no data on change during the follow-up period are available. Because we evaluate births occurring as much as 5 years after the HUNT study, there may have been a change in PA level during the follow-up period and this may influence the result. The information on PA was based on questionnaires that allow for subjective interpretation of the questions and individual definitions of the activity. Some misclassification of PA may therefore occur because PA can be influenced by factors such as age, social context, and seasonal variation (27). Despite these limitations, validation studies have shown that questionnaires may be useful in classifying people into broad categories of PA (low, moderate, or highly active) but less appropriate for quantifying energy expenditure (28).

The questionnaire regarding PA was not design to evaluate activity during pregnancy, and may have caused limited information quality. Thus, misclassification could have occurred, since there is no information regarding if the pregnant women answered based on the time they were pregnant or consider their activity before pregnancy.

As in all observational studies, there is a possibility that uncontrolled confounding could have influenced the results. We have evaluated education, and treated smoking status and alcohol use as a possible confounder. However, diet and other lifestyle related factors which could be possible confounders, was not available.

Comparison with existing literature.

Physical activity and mean gestational age.

The issue addressed in the present study is important and has strong clinical relevance due to the growing number of pregnant women who exercise during pregnancy, the fact that low gestational age remains the leading cause of neonatal morbidity and mortality in the world, and that short gestational length may lead to long-term handicap in surviving infants (6, 3, 13). Despise this, there have been limited studies evaluating the potential effect of PA during pregnancy in relation to mean gestational age, and even less studies evaluating PA before pregnancy and mean gestational age.

In the present study no relation between PA before pregnancy and mean gestational age in the various groups of PA was found, indicating that neither being active nor inactive is more beneficial than the other. This result is consistent with the result of Clapp et al (29) and Leifman et al (7). These studies found no difference in gestational length between women being active, before and during their pregnancy, compared to inactive women.

The result in the present study indicates that all groups of women who were PA during pregnancy had a longer gestational age than the inactive women. It is a weak and non-significant association; however, the results indicate that there is an advantage being active during pregnancy. Among others (7, 29), Hatch et al (30) has found a similar relation. Their study shows that women who engaged in hard PA during pregnancy tend to have a longer gestational age than women being inactive. On the other hand, they also found that light to medium PA during pregnancy did not affect gestational age. In the present study there was found a 5 or 6 days longer gestational age for women reporting light and medium PA, so this study seems to indicate that also these levels may affect gestational age. Other studies have also investigated the relation between PA during pregnancy and mean gestational age, and some have found no difference between women being active and women being inactive and the mean gestational age (5, 21, 31, 32, 33). So even if our results indicate that inactive women tend to have a shorter gestational age, our study cannot deny the no-relation found in other studies because of our weak and non-significant relation.

Physical activity and risk of preterm birth.

In a review from 1993, of risk factors for preterm birth, it was stated that there was insufficient data available regarding women's participation in PA (34). Since this review was published, several other studies have indicated that PA may be associated with a reduced risk of preterm birth (11, 17, 30, 33).

A study by Juhl et al. (11) reported that the risk for preterm birth was lower for women who performed PA during pregnancy compared with those who were inactive (11). However, this relation was not present for all women. Only those who continued PA, or started, in later pregnancy had a lower risk of preterm birth compared with the inactive. For those who stopped performing PA in later pregnancy the effect was not present. Their study also shows that the amount of time spent on PA among the active played less a role because there was no dose-response relation, and that all kinds of PA were associated with a reduced risk of preterm birth. In one of their analyses they found that PA level up to 5 MET-hours a week gave a 25% reduced risk for preterm birth. Other studies have shown that not only PA late in pregnancy gives a protective effect on preterm birth. Misra et al. (17) did see the opposite effect of early pregnancy training. Their study shows that PA, >60 days in the first and second trimesters combined, had a protective effect on preterm birth compared to women with a low activity level. One other study found that the risk of preterm birth was reduced with PA during the first and more so during the second trimester (6). In the present study there is no information to say in what specific period of pregnancy the PA was performed, however, the results support the previous findings; active women have a lower risk of preterm birth compared with inactive women.

Two review articles also support these findings. One of the article states that PA does not seem to have a negative impact on the rate of preterm birth, but that most studies shown a protective effect of PA on preterm birth (16). The second review also suggests a protective effect of PA. It shows that heavy exercise reduced the risk of preterm birth, and that PA during the first and second trimester seem to have a non-significant protective effect on preterm birth (22). This review also refers to a study that shows that women being physical active during their pregnancy halved their risk of preterm birth (22).

When considering intensity of activity, Hatch et al. (30) reported that moderate PA was not related to preterm birth, but only women who engage in long-term hard PA had a reduced risk. On the other hand, in a Danish study, it was found that women who engaged in light PA had a 24% non-significant reduced adjusted risk of preterm birth, and those who engaged in moderate-to-heavy PA had a 66% reduced adjusted risk, compared with inactive pregnant women (18). The same study found that women who engage in sport generally had a 23% non-significant adjusted reduced risk for preterm birth (18). This correlate with the present study, were all levels of PA indicated a lower risk of preterm birth compared to being inactive.

To our knowledge, there has only been one previous study investigated PA before pregnancy. This study found that vigorous leisure PA before pregnancy was unrelated to preterm birth, and that PA during the 3 months before pregnancy was not associated with a reduced risk of preterm birth (8). Our findings partly support this, as there are no strong or significant indications in our results that the risk of preterm birth differs between women being active and women being inactive before pregnancy.

Possible mechanisms.

The relation between infection and preterm birth is well documented. As much as 20 to 50% of all preterm births are triggered by an infection (35), and this is one of the most accepted mechanisms for triggering preterm birth. However, many other possible mechanisms including improvement in muscle tone, effects on the so-called rheobase (or "threshold of excitation"), and better immunologic defenses against urinary tract infection (36-38) have been suggested as an explanation to how PA could play a role in preventing short gestational age or preterm birth.

During pregnancy the uterine blood flow increases with both PA and gestational age. The increase during PA affects the uterine contractility. Some have suggested it is because of hormonal mechanisms (19), other studies have suggested it is because the noradrenaline levels rises and affects the uterus during PA (11, 20). Based on this, PA during pregnancy could theoretically induce preterm birth via uterine contractions (11, 20). PA before pregnancy decreases the blood flow to the uterine (39) and therefore, PA before and during pregnancy have different effect. This may explain why PA before pregnancy does not seem to affect the risk of preterm birth.

On the other hand, it has been suggested that PA during pregnancy can have a protective effect on preterm birth because inactive pregnant women have a higher concentration of tumor necrosis factor-α (TNF-α), a pro-inflammatory cytokine, than active pregnant women (40). TNF-α is involved in the onset of labor and preterm birth (41, 42). A study by Clapp et al (43) has investigated this. They found no significant difference in TNF-α concentration between the active and inactive groups before pregnancy. When it comes to PA during pregnancy they found a decrease in TNF-α concentration during early pregnancy, followed by a rise during mid-pregnancy and late pregnancy. At 36 weeks of gestation the TNF-α values were lowest for women who had continued to exercise, and highest for those who never exercised during pregnancy. Because PA reduces the concentrations of TNF-α in pregnant women (40, 43) PA can be beneficial, and may give a protective effect on preterm birth. The fact that Clapp et al (43) found no difference in TNF-α concentration between the active and inactive groups before pregnancy may explain why PA before pregnancy does not seem to be related to preterm birth.

The mechanisms that trigger preterm birth are complex. Goldenberg et al (44) have found strong indicators that preterm birth is multifactorial. These indications are based on finding of limited overlap between some of the strongest biomarkers in tests of association with spontaneous preterm birth (44). But to get a clear identification of possible mechanisms further studies are needed.

Conclusion.

In the present study the effect of PA on mean gestational age and preterm birth has been investigated. The findings indicate that PA performed before pregnancy does not seem to have a strong effect on mean gestational age or the risk for preterm birth. Furthermore, the analyses on PA during pregnancy indicate that inactive women have shorter gestational length compared with the active women. At all levels of PA the risk for preterm birth among active women was somewhat lower than among inactive women. However, due to limited number of women in some of the categories, results should be interpreted with caution.

Also, the 1994 American College of Obstetrics and Gynecology guidelines for physical activity during pregnancy (45) indicate that women with normal pregnancies can engage in exercise with almost no restriction without compromising fetal growth and development of complicating in pregnancy, labor, or delivery. Our results lend support to this statement; PA before and during pregnancy did not increase the risk of preterm birth or lead to a shorter gestational length.

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Appendix.

HUNT 1 (1984-1986). Exercise

1. How often do you exercise? (give an average)

    Never

    Less than once a week

    Once a week

    2-3 times a week

    Nearly every day

2. If you exercise as often as once or several times a week, how hard do you exercise? (choose an average)

    I take it easy without losing my breath or breaking into a sweat

    I push until I lose my breath and break into a sweat

    I practically exhaust myself

3. For how long do you exercise each time? (take a mean)

    Less than 15 minutes

    16-30 minutes

    30 minutes – 1 hour

    More than 1 hour

HUNT 2 (1995-1997). Physical Activity

1. During leisure time.

    How has your leisure time physical activity been the last year? (Think of a weekly average for the year. The trip to work is counted as leisure time)

	Hour a week			
	None	less than 1	1-2	3 or more
Light activity (No sweating or being out of breath)	☐	☐	☐	☐
High activity (Sweating or being out of breath)	☐	☐	☐	☐