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Influence of occupational physical activity on pregnancy duration and birthweight

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Objectives The influence of occupational physical activity on pregnancy duration and birthweight was examined.

Methods In this prospective study information on levels of occupational physical activity was collected during a personal interview before pregnancy, and possible changes were registered during follow-up, which lasted until after birth. Data on pregnancy duration and birthweight were obtained from midwives, physicians, and obstetricians. The occupational energy expenditure was operationalized in intensity and fatigue scores, which were studied as such and in combination with workhours and work speed. The occupational biomechanical load was operationalized in a peak and a chronic pressure score.

Results The participants were part of a group of 260 cleaners, kitchen staff, and clerical workers enrolled from 39 Dutch hospitals between August 1987 and January 1989 before they became pregnant. One hundred and twenty-eight of these women were eligible for study because they became pregnant, they worked at least six weeks during pregnancy, and information on work aspects during pregnancy and pregnancy outcome was com plete. Work with a high intensity score, and to a less extent work with a high fatigue score, had the most outstanding effect (up to 18 d shorter) on pregnancy duration when the work speed was high. None of the studied aspects of occupational physical activity showed a relevant influence on birthweight when adjusted for pregnancy duration.

Conclusions This study indicates that the levels of occupational physical load found in the work of nonmedical hospital staff, especially when combined with high work speed, can lead to a shorter pregnancy period.

Key terms biochemical load, cleaners, clerical workers, energy expenditure, kitchen staff.

Over the past few decades, interest has grown in research into the relationship between maternal occupational activity level and pregnancy outcome, especially low birthweight and premature delivery (1). It has been stated that high levels of occupational physical activity may influence uterine blood flow (2—5), which may interfere with the supply to the fetus and, subsequently, with fetal growth and premature delivery. It is also possible that occupational tasks which include reaching, bending, and lifting may (over)load the spine and increase intraabdominal pressure, predisposing to premature birth (6).

The first studies on occupational physical activity and premature birth or birthweight (7) did not focus on specific work conditions. Studies published later were better designed and took specific aspects of occupational physical activity into account. The results were, however, controversial, but seemed to indicate an association between strenuous work and adverse pregnancy outcomes, such as prematurity and low birthweight (8—21). The strength of this association has decreased over the years in which the studies were conducted.

We performed a prospective study on the influence of occupational factors on fecundability and pregnancy outcome among nonmedical hospital staff. It enabled us to test the hypothesis that the level of occupational activity during pregnancy in this population influences pregnancy duration and birthweight.

Subjects and methods

Subjects

From June 1987 to January 1989, female workers between 18 and 39 years of age and working in nonmedical

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functions at 39 Dutch hospitals were invited to participate in this study if they were planning to become pregnant during the forthcoming year. We approached 7000 women and estimated that 330 would be eligible for participation [using the Dutch pregnancy rate of 5% (22), an estimation of unplanned pregnancies of 20% (23), and an infertility rate of 15%]. The 283 actual participants represent a response rate of about 85%. However, 23 participants did not belong to the occupational categories under study and were excluded from the analyses.

Eligible for the analyses on pregnancy duration and birthweight were the women who conceived during the year of follow-up with a duration of pregnancy of at least 26 weeks (menstrual age).

Data collection

At enrollment (ie, before pregnancy) the participants were interviewed personally using a structured questionnaire. Information on the current daily occupational activity was obtained by recording all the activities of a usual workday in chronological order, supplemented by questions on the time spent on activities such as sitting, standing, walking, bending, reaching, and lifting. In addition, information on the number of workdays, workhours, and work speed was collected, as was information on other occupational exposures, such as work with detergents, medical drugs (including antibiotics, hormones, and antineoplastic drugs forming part of the hospital environment) and other chemical substances, exposure to noise, vibration and draft, and work with video display terminals, correction fluids and photocopiers. Finally, there were questions on the amount of time spent on housekeeping, the size of the family, and household help.

Questions on the menstrual cycle, reproductive history, demographic characteristics, and life-style factors were also included.

During the follow-up of at least one year, pregnancy was confirmed as early as possible using standardized urine test methods (24). During pregnancy, the participants used a special calendar to keep a record of changes in their occupational activities and exposures, sick leave, life-style factors, and medical drug use, supplemented by data regarding the course of pregnancy and birth. Every three months the participants were reminded of the study and stimulated to keep records on the calendar. Obstetric data, including the birthweight and full-term date, were collected from midwives, physicians, and obstetricians; in cases with missing information, the data reported by the participants were used in the analyses. Instead of pregnancy duration, gestational discrepancy was used in the analysis, being the difference in days between the date of birth and the expected full-term date.

Operationalization of occupational physical activity

Two components of occupational physical activity were considered, an energy and a biomechanical component.

Energy expenditure

Energy expenditure weights were assigned to the different occupational activities according to mean energy expenditures reported for adult women with normal body weight in the literature. These weights (in parentheses) roughly estimate the rate at which the basal metabolism is increased for that particular activity: sitting (1.5), standing (2.0), walking (4.0), standing alternated with walking (2.5), reaching (3.0), bending (4.0), and lifting (5.0) (25—28). The daily occupational energy expenditure was calculated as the sum of hours spent per day on the different activities, each multiplied by the energy expenditure weights. This is called the fatigue score. To estimate the mean occupational energy expenditure per hour an intensity score was calculated as the ratio of the fatigue score and the number of workhours per day (table 1). The time of day and work speed are aspects which are very likely to influence the fatigue and intensity scores. Hours before 0800 and after 1800 are considered unfavorable workhours. The participants were asked to divide their workday into periods of work at a low, moderate, and high speed. The work speed was considered to be high if the work was done at a high speed for more than 50% of the time (table 1).

Biomechanical load

According to the estimated pressure on the spinal cord during different work postures, which was assumed to parallel the intraabdominal pressure (29—33), pressure weights were assigned to the different postures. These weights (in parentheses) estimate the rate at which intraabdominal pressure increases during the particular posture, with walking as the reference: sitting (3.0), standing (2.0), walking (1.0), standing alternated with walking (1.5), reaching (4.0), bending (8.0), and lifting (8.0). The daily occupational abdominal pressure was calculated as the sum of hours per day spent in the different postures multiplied by the intraabdominal pressure weights. This is called the chronic pressure score. To estimate the mean occupational abdominal pressure per workhour, a peak pressure score was calculated as the ratio of the chronic pressure score and the number of workhours per day. Both scores were classified into high and low categories (table 1). In addition, participants were classified according to their engagement in lifting or bending work for more or less than 1 h per workday.

Statistical analysis

The period of pregnancy was divided into the following three segments: weeks 6—22; weeks 23—30, and weeks

Table 1. Operationalization of occupational physical activity, workhours, and work speed.

Occupational physical activity	Levels
Intensity score = energy expenditure per workhour	Low: < 3.5 times the basal metabolic rate (BMR) High: ≥ 3.5 times the BMR
Fatigue score = energy expenditure per workday	Low: ≤ 2 times the BMR Moderate: > 2 times the BMR and < 3 times the BMR High: ≥ 3 times the BMR
Workhours	Normal: between 0800 and 1800 Unfavorable: outside 0800 and 1800
Work speed	Low: high speed for < 50% of the workhours High: high for ≥ 50% of the workhours
Peak pressure score = abdominal pressure per workhour	Low: < 4 score points[a] High: ≥ 4 score points[a]
Chronic pressure score = abdominal pressure per workday	Low: < 25 score points[a] High: ≥ 25 score points[a] Very high: ≥ 32 score points[a]
Lifting	No: < 1 h per workday Yes: ≥ 1 h per workday
Bending	No: < 1 h per workday Yes: ≥ 1 h per workday

[a] One point = the intraabdominal pressure during 1 h of walking, 4 points = 30 min of bending. (See the Materials and Methods section.)

31—40. The participants contributed to the information on these segments whenever they worked for at least 1 d in that period. Occupational physical activity scores were adjusted according to the reported changes in workhours or work load during the three segments. The influence of occupational activity on gestational discrepancy was analyzed for each segment by multiple linear regression. To analyze birthweight adjusted for pregnancy duration, gestational discrepancy was added to the regression models with birthweight as the dependent variable. In the regression models with occupational energy expenditure, workhours and work speed were treated as interaction variables; in addition the influence of nonoccupational energy expenditure (ie, the number of children in the household, the number of hours of housework, household help, and additional jobs) was tested in every model.

The following variables were scrutinized for their confounding properties by investigating whether there was any association with occupational activity on the one hand and gestational discrepancy and adjusted birthweight on the other: age, previous number of pregnancies (gravidity), previous spontaneous abortions, fertility treatments, medical drug utilization, current chronic disease, smoking, caffeine and alcohol consumption, and educational level. Because of the expected influence of prepregnancy maternal body weight on the birthweight of the child, this covariable was included in every analysis of birthweight. Only occupational exposures to which at least 5% of the pregnant women were exposed were included in the analysis. Such exposures involved detergents, medical drugs, disinfectants, correction fluid, noise, vibration, draft, and work with photocopiers and video display terminals. The scores of the covariables were adjusted according to the reported changes in exposures or consumption during pregnancy in the same way as was done for the occupational activity scores.

If the associations were judged to be relevant, the specific covariables were entered in the multivariate analyses. Covariables were considered confounders and controlled for if they changed the association between the index exposure and the outcome variables.

Results

From the group of 260 participants, 156 became pregnant and continued pregnancy for more than 26 weeks. The analyses on birthweight and gestational discrepancy were restricted to 128 participants with complete information on work aspects and pregnancy outcome and who had worked for at least six weeks during pregnancy. The distribution of occupational physical activity levels and other characteristics are presented in tables 2 and 3. The number of working participants declined during pregnancy, but 98 (75%) were still working after the 30th week of pregnancy. Only 15 participants reported changes in the number of workhours and very few reported changes in work load.

Over the total pregnancy period, 29 participants had reported absenteeism for at least one week. These workers had higher occupational activity scores than the mean scores of the total group.

Participants with a high intensity score had jobs that required walking, bending, reaching, or lifting during most of the workhours. High fatigue scores represented high intensity scores combined with full-time or part-time work but also low intensity scores combined with

Table 2. Distribution of levels of occupational physical activity among 128 participants in the first 22 weeks of pregnancy and their relationship with gestational discrepancy[a] and birthweight (grams) presented by regression coefficients (β) with standard errors.

	Participants		Gestational discrepancy		Birthweight		Adjusted birthweight	
	N	%	β	SE	β	SE	β	SE
High intensity score	34	27	–3	2	–130	101	–67	88
High fatigue score	43	34	–2	3	–233	126	–185	110
Moderate fatigue score	21	16	–3	2	–96	99	–40	86
High peak pressure score	46	36	–2	2	–151	92	–110	80
High chronic pressure score	39	31	–4	2	–182	96	–111	84
Lifting ≥ 1 h per day	32	27	–2	3	–54	111	–21	96
Bending ≥ 1 h per day	57	45	–4	2	–228	88	–144	78

[a] Presented as deviations in days from the full-term date.

Table 3. Distribution of several characteristics among the 128 participants in the first 22 weeks of pregnancy and their relationship with gestational discrepancy[a] and birthweight (grams) presented by regression coefficients (β) with standard errors.

	Participants		Gestational discrepancy		Birthweight		Adjusted birthweight	
	N	%	β	SE	β	SE	β	SE
Occupational exposure								
Disinfectants	22	17	1	3	210	117	184	101
Medicines	15	12	–4	3	–51	139	44	121
Detergents	59	46	–1	2	–135	89	–105	77
Noise	15	12	6	3	206	138	68	122
Copying machines	41	32	2	2	152	95	101	83
Former fertility medication	11	9	3	4	–68	159	–137	138
Former gynecological operation	8	6	–5	4	–440	181	–339	158
Former pregnancies	50	40	1	2	43	92	15	79
Former spontaneous abortion	25	20	2	3	–193	111	–238	96
Regular use of medical drugs	23	18	–3	3	–132	116	–66	101
Smoking	43	34	1	1	–185	93	–199	80

[a] Presented as deviations in days from the full-term date.

full-time work. According to the Spearman correlation coefficient of 0.53 between the scores in the first pregnancy period, they indeed represent partly different aspects of occupational physical activity.

High peak pressure scores were related to jobs predominantly involving bending and lifting. High chronic pressure scores represented high peak pressure scores combined with full-time or part-time jobs and low peak pressure scores with full-time work. The Spearman correlation coefficient between the peak pressure and chronic pressure scores in the first pregnancy period was 0.66.

There was a moderate association between the number of hours spent bending and lifting per day (Spearman correlation coefficient 0.48). The correlation coefficients between the peak pressure scores or chronic pressure score and hours of lifting were 0.63 and 0.47, respectively. With respect to the number of hours spent bending, these figures were 0.78 and 0.70, respectively.

Gestational discrepancy

Of the group of 128 participants, the mean difference between the date of birth and the full-term date was –2.6 (SD 11.6) d with a range of –54 to +25 d, corresponding with a pregnancy duration of 32—43.5 weeks (since the last menstrual period). Gestation lasted less than 37 weeks (259 d) in nine cases (7%). The univariate relationship between occupational physical activity levels and other characteristics on the one hand and gestational discrepancy on the other are presented in tables 2 and 3.

Intensity score

During all three pregnancy periods, about 75% of the working participants had work with a low intensity score and 25% had a high intensity score. Work with a high intensity score had the most outstanding (adjusted) effect on gestational discrepancy when combined with high work speed (table 4). The effect became larger as pregnancy progressed. Between the 30th and 40th week of pregnancy, the mean pregnancy duration of the participants with work with a high intensity score was 18 d shorter than that of the participants with work with low intensity scores when the work speed was high. No other combination of high intensity score with the other work

Table 4. Occupational energy expenditure (intensity score, fatigue score, and work speed) during different periods of pregnancy and gestational discrepancy[a]: adjusted[b] regression coefficients (β) with standard errors.

	Pregnancy period					
	Weeks 6—22 (N = 128)		Weeks 23—30 (N = 118)		Weeks 31—40 (N = 98)	
	β	SE	β	SE	β	SE
Intensity score						
High = 1, low = 0	–3	2	–2	2	–3	2
Intensity score when work speed was high						
High = 1, low = 0	–13	6	–15	5	–19	5
Fatigue score						
Moderate = 1, low = 0	–2	2	–2	2	0	2
High = 1, low = 0	–1	3	0	3	1	3
Fatigue score when work speed was high						
Moderate = 1, low = 0	–4	6	–1	5	0	6
High = 1, low = 0	–7	6	–5	6	–9	6

[a] Presented as deviations in days from the full-term date.
[b] Adjusted for exposure to medicines, regular use of medical drugs, smoking, and gravidity when necessary.

circumstances showed a relevant effect on gestational discrepancy.

Fatigue score

During all three pregnancy periods, about 50% of the working participants had work with a low fatigue score, 35% with a moderate fatigue score, and 15% with a high fatigue score.

In general there was no clear relationship between the fatigue score of the work and gestational discrepancy. Only when the work speed was high, did the difference in gestational discrepancy between participants with work with high fatigue scores, in comparison with the ones with work with low scores, become more than one week (shorter) during all three pregnancy periods. Controlling for confounders (ie, occupational exposure to medicines, gravidity, and the regular use of medical drugs) decreased the differences in mean gestational discrepancy to nonsignificant levels (table 4).

Biomechanical load

About 35% of the participants had work with a high peak pressure score and about 30% had a high chronic pressure score, including 20% with a very high chronic pressure score. This distribution was not affected by the women who stopped working during pregnancy, nor was the distribution for lifting and bending work. Twenty percent had lifting work for more than 1 h per day, and 40% had bending work for more than 1 h per day.

Work with high peak pressure scores, as well as work with high or very high chronic pressure scores did not influence gestational discrepancy to any relevant extent. Neither did work which involved more than 1 h of lifting per day affect gestational discrepancy (data not shown). Bending for at least an hour a day increased gestational discrepancy, but the adjusted effect became smaller (and nonsignificant) in the later pregnancy periods (table 5).

Adjusted birthweight

The univariate relationship between occupational physical activity levels and other characteristics on one hand and adjusted birthweight on the other are presented in tables 2 and 3. The energy expenditure of the work (intensity score and fatigue score) did not influence the adjusted birthweight after control for confounding (table 6).

With respect to the biomechanical load of the work, only work with very high chronic pressure scores showed some effect on the adjusted birthweight, but the 95% confidence intervals included zero (table 7).

Discussion

In this study, female workers were recruited before pregnancy and followed during pregnancy so that the effect could be studied of occupational physical activity in consecutive periods of pregnancy on pregnancy duration (gestational discrepancy) and birthweight. The results showed that pregnancy duration was shortened for participants with work with a high intensity and high fatigue scores compared with lower scores, in particular when the work speed was high. There were no effects of these circumstances on birthweight when adjusted for gesta-

Table 5. Biomechanical work load during different periods of pregnancy and gestational discrepancy[a]: adjusted[b] regression coefficients (β) with standard errors.

	Pregnancy period					
	Weeks 6—22 (N = 128)		Weeks 23—30 (N = 118)		Weeks 31—40 (N = 98)	
	β	SE	β	SE	β	SE
Peak pressure score						
High = 1, low = 0	–2	2	–1	2	–4	2
Chronic pressure score						
High = 1, low = 0	–4	2	–4	2	–3	2
Very high = 1, low = 0	–3	3	–2	2	–2	3
Bending						
≥ 1 hour = 1, < 1 hour per workday = 0	–4	2	–3	2	–2	2

[a] Presented as deviations in days from the full-term date.
[b] Adjusted for exposure to medicines, noise, former fertility medication, former gynecological operations, regular use of medical drugs, and smoking.

Table 6. Occupational energy expenditure (intensity score, fatigue score, and work speed) during different periods of pregnancy and adjusted birthweight (grams): adjusted[a] regression coefficients (β) with standard errors.

	Pregnancy period					
	Weeks 6—22		Weeks 23—30		Weeks 31—40	
	β	SE	β	SE	β	SE
Intensity score						
High = 1, low = 0	–60	100	–58	91	–67	101
Intensity score when work speed was high						
High = 1, low = 0	–134	215	–53	211	–152	211
Fatigue score						
Moderate = 1, low = 0	54	97	41	97	–26	105
High = 1, low = 0	–7	125	–22	123	–148	132
Fatigue score when work speed was high						
Moderate = 1, low = 0	91	244	–92	244	–119	285
High = 1, low = 0	89	257	97	253	–22	290

[b] Adjusted for work with cleaning devices and copying machines, exposure to noise and disinfectants, help in the household, number of hours of housework, smoking, former spontaneous abortions, former gynecological operations, and pregnancy weight when necessary.

Table 7. Biomechanical work load during different periods of pregnancy and adjusted birthweight (grams): adjusted[a] regression coefficients (β) with standard errors.

	Pregnancy period					
	Weeks 6—22		Weeks 23—30		Weeks 31—40	
	β	SE	β	SE	β	SE
Peak pressure score						
High = 1, low = 0	–53	95	–73	86	–85	93
Chronic pressure score						
High = 1, low = 0	–117	100	–77	98	–127	104
Very high = 1, low = 0	–179	111	–152	107	–178	107
Bending						
≥ 1 hour = 1, < hour per workday = 0	–70	89	16	85	–27	90

[b] Adjusted for work with cleaning devices and copying machines, exposure to noise and disinfectants, help in the household, number of hours of housework, smoking, former spontaneous abortions, former gynecological operations, and pregnancy weight when necessary.

tional discrepancy. The biomechanical load (peak pressure score and chronic pressure score) of the work did not influence gestational discrepancy or adjusted birthweight to any relevant extent.

Before one discusses the implications of the findings, the possibility of bias should be considered.

Selection bias

The primary study population was selected with respect to fecundability. (After one year of follow-up 65% were pregnant versus 85—90% expected.) However, these figures do not imply selection on pregnancy outcome. With respect to loss to follow-up, it should be noted that for 20 out of the 156 participants with a pregnancy of more than 26 weeks, information from the pregnancy supervisors was missing. In addition, information was missing on the duration and changes in work during pregnancy in six cases. As the distribution of occupational activity scores before pregnancy among these dropouts was equal to that of the participants with complete information, it is very unlikely that selection could have biased the results.

Information bias

The classification of the occupational physical activity level was based on very detailed job descriptions, supplemented by specific questions on specific tasks. Instead of the overall scoring of physical activity as proposed by Mamelle et al (34—35), we continued to perform the analyses on each of the aspects of physical load and other occupational exposures separately. Per pregnancy period, the reported changes in the number of work hours were incorporated into the occupational physical activity scores.

Although the participants were the source of information on physical activity, differential misclassification was not expected either because there was no relationship between the reporting of changes and the occupational activity level. However, there was a positive relationship between sick leave of more than one week and the occupational physical activity scores, especially with respect to the biomechanical load scores. This finding suggests that the contrast between the activity levels may have been smaller in reality than has been described in this study and, therefore, could have led to underestimation of the quantitative effects.

Regarding gestational discrepancy as an outcome parameter, it should to be mentioned that the full-term date was derived from the date of the last menstrual period. In the case of irregular menses, the expected full-term date was very likely estimated too early and consequently the gestational discrepancy was underestimated. As there was no clear association between occupational physical activity level and length of the menstrual cycle (36), this underestimation of gestational discrepancy should be nondifferential. Birthweight probably had only a small measurement error that was unrelated to the activity scores.

Confounding

The study results were adjusted for the influence of several other occupational and nonoccupational determinants of pregnancy duration and low birthweight. We did not analyze the influence of maternal height because this information was missing for 32 of the participants. No information was collected on paternal height and weight. Although these characteristics have been described as determinants of birthweight (37), there is no reason to expect a strong relationship between parental status and the occupational physical activity of the participants. Therefore this omission will very likely not bias the study results.

A major point is the absence of data on leisure-time physical activities, such as sports, which could have introduced confounding. If any association exists between sports and occupational activity, it would be negative. Therefore, our findings would represent an underestimation of any real associations if this negative association between occupational and leisure-time activities was strong in the study population.

Evaluation of the results

Several other authors have conducted studies on the relationship between work conditions during pregnancy and late pregnancy outcome (8—21). Most of the earlier studies were retrospective with the possibility of recall bias (8—13). All but one (8) reported negative effects of strenuous work on pregnancy duration or birthweight.

Two recent studies conducted in Guatemala (15) and the Philippines (20) found associations between physical activity (eg, physical stress and standing) and prematurity, birthweight, or the number of babies small for their delivery date (15, 19). The total energy expenditure was positively associated with increased birthweight in the Philippines.

Many of the recently published studies from industrialized countries have failed to report a relationship between levels of strenuous work and low birthweight or prematurity (16— 19,21). As an exception, Nurminen et al (14) reported an association between occupational physical activity and low birthweight in a retrospective study. In prospective studies, only Teitelman et al (17) have found an effect of increased levels of standing on prematurity and low birthweight, but not on the adjusted birthweight. However, information on standing was derived purely from the mothers' occupational titles.

The other three prospective studies, all conducted between 1980 and 1988, did not report any clear effects of aspects of strenuous work on low birthweight and prematurity, whether or not controlled for leisure-time physical activity (16, 18, 19). Saurel and his colleagues, who found that physical work conditions had an effect on prematurity in former studies (10, 11), also recently published the results of a retrospective study showing no effect when occupation was controlled for (21). It was suggested by the authors that social status, related to occupation, may be more important than specific work conditions.

In contrast to these recent studies, we did find that occupational physical activity affected late pregnancy outcome, in particular pregnancy duration. One explanation for this discrepancy with the literature is that we analyzed the difference between the date of birth and the full-term date (the gestational discrepancy) in days, whereas other authors studied prematurity (defined as a pregnancy duration of less than 37 weeks). This latter analysis on our population would not have produced effects. This result is in agreement with that of Ahlborg et al (16), who found that heavy lifting had an effect on pregnancy duration (in weeks) but no effect on prematurity in several subpopulations. Our lack of positive results on lifting on the other hand contradicts these findings. A difference between the two study populations in the amount of weight usually lifted cannot be excluded, however. We did not find a clear relationship between occupational physical activity and birthweight adjusted for pregnancy duration. Rabkin et al (18) and Ahlborg et al (16) studied birthweight in grams and found that occupational activity did not have any clear effect on (adjusted) birthweight either.

In summary, this study indicates the levels of physical work load, as found for nonmedical hospital staff, can lead to a shorter period of pregnancy. The combination of physical load and high work speed leads to even shorter pregnancy periods than would be expected from each of the factors individually. This result agrees with the modern view that female workers can generally cope with occupational strain, except for complex situations with multiple exposures.

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