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The Psychological Effects of Maternal Smoking on Fetal Movements

Jennifer F. Little and Peter G. Hepper

Fetal Behaviour Research Centre, School of Psychology, Queen's University of Belfast, Belfast, Northern Ireland

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Abstract: Smoking has both physiological and psychological effects on the smoker. Whilst the physiological effects of maternal smoking on the fetus have been well documented, the 'psychological' effects have been largely ignored. This study investigates the effects of maternal cigarette smoking and maternal sham cigarette smoking on the movements of the human fetus using real time ultrasound. Fetuses from three groups of pregnant mothers; smokers, sham-smokers and non-smokers, were studied. The number of spontaneous fetal movements and startles were recorded. Fetuses were observed using ultrasound for three consecutive, five minute periods; before 'smoking', during smoking – subjects either smoked, sham-smoked or did not smoke, and after 'smoking'. In response to maternal smoking and sham-smoking both general movements and startle movements increased. However the increase of startles was much more pronounced in the sham-smoking group compared to both the smoking and non-smoking groups. Thus the fetus is not only influenced by the constituents of tobacco smoke, but also by the psychological effects the mother experiences from smoking behaviour.

Zusammenfassung: *Die psychologischen Wirkungen des mütterlichen Rauchens auf die fötalen Bewegungen.* Rauchen hat physiologische und psychologische Wirkungen auf den Raucher. Während die physiologischen Wirkungen des mütterlichen Rauchens auf den Fötus gut dokumentiert sind, sind die psychologischen Wirkungen bisher weitgehend ignoriert worden. Diese Studie untersucht die Wirkungen des mütterlichen Rauchens auf die Bewegungen des Fötus durch Ultraschallbeobachtung, und zwar im Vergleich mit Müttern, die eine Scheinzigarette rauchen und die nicht rauchen. Die Zahl der spontanen fötalen Bewegungen wurde aufgezeichnet. Die Föten wurden in drei aufeinanderfolgenden Fünfminutenperioden mit dem Ultraschall beobachtet: eine Vorphase, eine Untersuchungsphase und eine Nachphase. In Reaktion auf das mütterliche Rauchen einer echten oder einer Scheinzigarette nahm die Zahl der allgemeinen spontanen Bewegungen und der reflexhaften Bewegungen zu. Dabei war der Anstieg der reflexhaften Bewegungen bei der Gruppe, die eine Scheinzigarette rauchte, sehr viel ausgeprägter als bei den Rauchern und Nichtrauchern. So wird der Föt also nicht nur durch die Inhaltsstoffe des Rauches

Correspondence to: Peter G. Hepper, Professor, Fetal Behaviour Research Centre, School of Psychology, Queen's University of Belfast, Belfast BT7 1NN, Northern Ireland, Tel: +44 1232 245133 ext. 4230, Fax: +44 1232 664144

selbst, sondern auch durch die psychologischen Auswirkungen auch des Rauchverhaltens auf das Erleben der Mutter beeinflußt.

Introduction

One of the earliest associations between smoking and pregnancy was recorded by Ballantyne (1902) who noted an increase in abortions in women who worked in a tobacco factory. Now it is known that cigarette smoking during pregnancy adversely effects the fetus resulting in: reduced birth weight (Abel, 1980; Newnham et al., 1990); increased risk of premature birth (Miller et al., 1976); increased risk of spontaneous abortion (Koop, 1986); increased incidence of stillbirth and increased perinatal mortality (Meyer et al., 1976); and increased risk of congenital abnormalities (Himmelberger et al., 1978). The risks of these increase the more heavily the mother smokes.

Pre-natal exposure to tobacco increases the risk of SIDS (Spastics Society, 1982). Infants of smokers often have lower Apgar scores at birth (Kikuchi and Takahashi, 1985); and lower Bayley scores at eight months (Garn et al., 1980).

By smoking a cigarette, the mother inhales a huge number of compounds into her body which may pass directly to the fetus and be responsible individually, or in combination with others, for the reported effects of smoking during pregnancy. These compounds include nicotine, carbon monoxide, acetaldehyde, acetic acid, nitrogen oxides, formic acid, hydrogen cyanide, acetone, and methanol (Mactutus, 1989). Many of which are toxic compounds (USHEW, 1979).

Smoking is a relatively complex behaviour that can not be explained by simple physiological addiction. Smokers as a group do not report a single, common, motive for smoking and, depending on the immediate psychological need, will adjust their smoking behaviour to meet mental demands (Schachter et al., 1977). Smoking thus involves a large psychological component. Sham-smoking, where the individual puffs on a unlit cigarette thus obtaining no physiological benefit, can be used to assess the psychological effects of smoking. Sham-smoking effects the CNS in a manner similar to cigarette smoking. For example, Woodson et al. (1983) reported sham-smoking as having equal stress dampening effects as true smoking. Mangan and Golding (1978) produced similar effects to real smoking by sham-smoking and concluded that some effects of true smoking may be simply due to psychological expectations. It is the aim of this study to examine the psychological effect of maternal smoking on the fetus.

Observations of the immediate effects of smoking on the fetus indicate that maternal smoking alters both fetal heart rate and movement. For example, Eriksen and Marsal (1984) reported a 13in response to maternal smoking, which lasted for 40 minutes. Goodman et al. (1984) reported a significant reduction in fetal movement during the first 16 minutes of smoking. Alterations in fetal breathing movements have also been reported; Manning and Feyerabend, (1976) noted a significant reduction in breathing movements five minutes after the start of smoking and recovery was not complete until 90 minutes after the onset of smoking.

The psychological effects of maternal smoking on the fetus have yet to be examined. The aim of this study is to examine the effects of maternal smoking and maternal sham-smoking on the spontaneous movements in the human fetus.

Materials and Methods

Subjects

Twenty seven pregnant women were recruited from the Royal Maternity Hospital, Belfast, to take part in the study. All fetuses were singleton with no complications and had Apgar scores of greater than 7, 1 and 5 minutes after birth. No problems were reported during labour and delivery. There were no differences between the three groups on gestational age, age of mother or parity. These mothers were divided into three groups of nine subjects each. Groups 1 (smoking) and 2 (sham-smoking) were fetuses of mothers who smoked. The mean number of cigarettes smoked per day by these mothers was 8.1 and 8.5 respectively. Both groups of smoking mothers refrained from smoking for 60 minutes prior to the start of the study. Group 3 (non-smokers) acted as a control group. Thus eighteen smokers and nine non-smokers participated in the study.

Apparatus

The fetus was observed using an Ultramark 4 plus ultrasound machine with a 3.5 MHz scan head. Mothers lay in a semi-recumbent position and the scan head positioned to obtain a longitudinal view of their fetus.

Procedure

The fetus was observed for 15 minutes with the observation period divided into three consecutive, five minute, periods:

Before (0–5 mins). This was a period of baseline observation. All mothers behaved the same.

During (6–10 mins). The behaviour of the mothers during this period depended on their group. In the **smoking** condition (Group 1) mothers lit and smoked a cigarette of their usual brand at their usual pace. All mothers accomplished this easily within 5 minutes. In the **sham-smoking** condition (Group 2) mothers went through the motions of smoking. This involved using an unlit cigarette and placing it in their mouth but not inhaling. Mothers were asked to repeat the actions as if smoking at their usual pace. This was performed for 5 minutes. In the **non-smoking** (control) group (Group 3), mothers touched their nose at fifteen second intervals over the 5 minute period. This was undertaken to mimic the physical motions of smoking.

After (11–15 mins). The 5 minutes following 'smoking' during which mothers in all 3 groups behaved identically.

All ultrasound observations were recorded on video for later analysis. Two types of fetal movements were examined:

1. General movements: These were defined as any simultaneous or sequential movements of the head, trunk and limbs (Birnholz et al., 1978).
2. Startles: These were defined as a sudden movement of the entire fetal body often initiated by an extensor movement of the legs (Birnholz et al., 1978).

The number of each movement during each time period was recorded for each fetus.

The results were analyzed using an analysis of variance for factors of group (smoking, sham-smoking and non-smoking), and observation period (before, during and after).

Results

The results are reported separately for general movement and startles.

General Movement

Initial observation of the number of general movements exhibited by each group in the before (baseline) period revealed that there was a significant difference in the number of general movements elicited by each group (mean number of movements $\pm$ standard error for each group: Smokers 13.556 ± 1.4, Sham-smokers 27.875 ± 6.5, Non-smokers 34.556 ± 7.7). This supports previous observations that fetuses of mothers who smoke exhibit decreased movement (Goodman et al., 1984) For this reason analysis of these scores was performed by using difference scores. That is the number of movements observed during the before (baseline) period were subtracted from the number of movements observed in both the during and after period for each fetus. If either smoking or sham-smoking has no effect these scores should be zero, thus a positive score indicates an increase in fetal movements from baseline activity and a negative score a decrease from baseline activity.

Using these difference scores the ANOVA yielded a significant interaction between smoking group and time of observation, ($F(2,24) = 4.666$, $p < 0.05$). (See Fig. 1). Post-hoc Newman-Keuls tests revealed that change in movements exhibited by fetuses in the smoking and sham-smoking group did not differ from one another, but both differed from fetuses in the control group. Control fetuses showed a decrease in movements whereas smoking or sham-smoking mothers showed a slight increase in movements.

Startles

There was a significant main effect of observation period, ($F(2,48) = 7.620$, $p < 0.01$), and of group, ($F(2,48) = 10.633$, $p < 0.01$). (See Fig. 2). These main effects were largely explained by a significant interaction between group and observation period ($F(4,48) = 5.870$, $p < 0.01$). A post-hoc Newman-Keuls test revealed this is due to the significant increase in startles shown by the sham-smoking group in comparison to the other groups (smokers, non-smokers) where no change in the incidence of startles is noted, in both the during, ($p < 0.0001$), and after, ($p = 0.004$), periods.

Discussion

The results obtained in this study indicate that both sham-smoking and smoking effect the behaviour of the fetus.

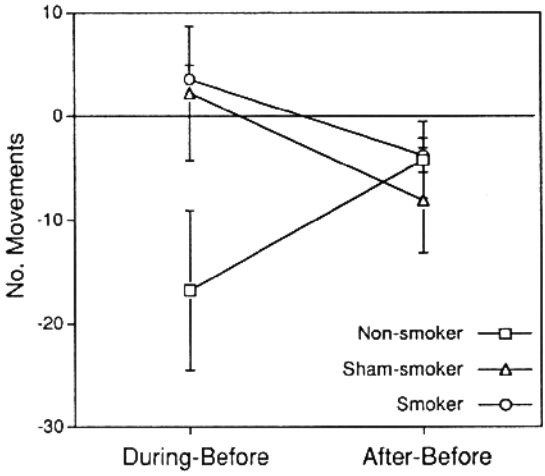

Fig. 1. The mean (± s.e.) change in general movements exhibited by fetuses of mothers who smoked, sham-smoked and controls, in the during and after period.

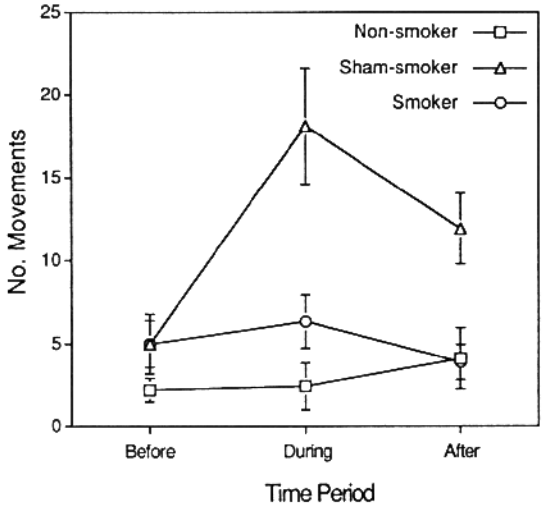

Fig. 2. The mean (± s.e.) number of startles exhibited by the fetuses of the smoking, sham-smoking and control groups.

Smoking a cigarette alters both fetal heart rate and movement. Previous studies have reported a decrease in fetal heart rate and fetal movements both in immediate response to maternal smoking and in the period after onset of smoking (Eriksen and Marsal, 1984; Manning and Feyerabend, 1976; Goodman et al., 1984). Likewise this study noted a depression in fetal movements following maternal smoking, but only in the incidence of startles, not general movements.

Previous studies of the effect of smoking on behaviour have reported that sham-smoking effects the CNS in a similar manner as actual cigarette smoking (Woodson et al, 1983; Mangan and Golding, 1978). Yet in sham-smoking the cigarette is unlit

thus the change in movement observed in this group can not be attributed to the constituents of tobacco smoke. The physiological changes observed in previous research (stress-dampening effects on subjective and autonomic measures of the CNS and ANS similar to those observed during actual smoking and a similar increase in heart rate and skin response as observed during actual smoking) have shown sham-smoking to exert a physiological effect on the smoker. Physiological changes such as these may explain the change in fetal activity observed in this study (increase in startles while mothers sham-smoked followed by a decrease on cessation). Thus it appears the fetus not only responds to the physiological effects of tobacco constituents but also to the psychological effects of maternal smoking behaviour.

Smoking is a behaviour that is highly reinforced. It is possible that the sham-smoking mother in holding the cigarette and placing it in her mouth expected a familiar effect from performing these actions. That is, previous reinforcement would lead to an expectation of a physiological response from the actions of smoking. However, the expected effect from smoking a cigarette was not achieved in the sham-smoking group as the cigarette was unlit, thus no tobacco substances, such as nicotine, could reach the CNS. This may result in dissonance and the cause of some degree of stress. Subsequently this may lead to a change in maternal physiological state and thus a change in fetal activity. Previous research has shown that under conditions of increased maternal stress fetal movements increase (e.g. Hepper and Shahidullah, 1990).

It appears the observed change in fetal activity in the sham-smoking group is due to a change in maternal state in response to psychological expectations derived from performing the actions of smoking using an unlit cigarette. This change in maternal psychological state leads to alterations of maternal physiological state and is reflected in altered fetal behaviour. This study suggests that the fetus responds to psychological expectations of the mother, a response mediated by physiological changes.

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