ARTICLE

Female gender pre-selection by maternal diet in combination with timing of sexual intercourse – a prospective study

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Abstract  Natural sex selection methods have been applied for several decades, but their use and effectiveness are still a matter of debate. Therefore, this study assessed the efficacy of a maternal diet low in sodium and high in calcium, in combination with timing of intercourse well before ovulation as a method to improve the chances of conceiving a girl. A total of 172 couples wanting a girl participated in the study. For the 150 couples that actually started, compliance with diet was assessed through mineral analyses of blood and timing of intercourse relative to ovulation was determined by ovulation tests. Based on mineral blood values and timing of intercourse of 28 participants, a prediction rule for conceiving a girl was constructed and was tested prospectively for validity on a subsequent group of 50 women. In this group, 21 women satisfied the criteria of the prediction rule and 16 gave birth to a daughter. It is concluded that the combination of maternal diet with timing of intercourse is capable of increasing the probability of conceiving a girl \( P = 0.005 \). The observed percentage of female babies for all 32 women satisfying the prediction rule was 81% (95% confidence interval 68–95%).

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KEYWORDS: gender pre-selection, natural sex selection, pre-conception diet, sex ratio, timing method

Introduction  The desire of the human species to control the gender of its progeny prior to conception has always existed. Reasons range from family balancing to culturally imposed preference for boys to prevention of sex-linked hereditary diseases. In Western society, parents have a strong preference for a balanced composition of sexes in their families and, more specifically, the yearning for a girl in all-boy families tempts parents to revise their family size goals upwards (Ben Porath
Gender pre-selection by diet in combination with timing of sexual intercourse

A study was initiated in 2001 to test the hypothesis that a combination of intercourse well before ovulation and a maternal diet low in sodium and potassium and high in calcium and magnesium will increase the probability of conceiving a girl. A secondary goal was to derive a prediction rule based on mineral blood serum values, that can be used as a go/no-go directive during the treatment and as a check for compliance with diet. In the period from 2001 to 2006, a total of 172 couples with a preference for a daughter who were starting a natural pre-conceptional treatment with the Dutch consultancy bureau Gender Consult were prospectively recruited and all had completed their involvement by the end of 2009. All subjects intended to undergo a treatment consisting of a strict diet in combination with intercourse advice. Sex of the baby after birth was taken as the primary outcome measure for analysis.

The effect of the treatment was studied from two perspectives. First, whether mineral blood values could be influenced by a strict diet was investigated. These mineral concentrations are controlled by a tight homeostasis, so any significant change in these values must be related to the diet. Second, a possible correlation between mineral serum values and timing interval (the number of days between last intercourse and ovulation) on the one hand and the sex of offspring on the other hand was investigated. Sodium, potassium, calcium and magnesium concentrations before starting the diet and immediately after pregnancy were taken into consideration. Mineral serum concentrations for a reference group of subjects who did not follow

**Materials and methods**

**Study design and population**

A study was initiated in 2001 to test the hypothesis that a combination of intercourse well before ovulation and a maternal diet low in sodium and potassium and high in calcium and magnesium will increase the probability of conceiving a girl. A secondary goal was to derive a prediction rule based on mineral blood serum values, that can be used as a go/no-go directive during the treatment and as a check for compliance with diet. In the period from 2001 to 2006, a total of 172 couples with a preference for a daughter who were starting a natural pre-conceptional treatment with the Dutch consultancy bureau Gender Consult were prospectively recruited and all had completed their involvement by the end of 2009. All subjects intended to undergo a treatment consisting of a strict diet in combination with intercourse advice. Sex of the baby after birth was taken as the primary outcome measure for analysis.

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the diet were constructed by Monte-Carlo simulation comprising 1,000,000 subjects with random values based on average starting values of the study group and on within-subject biological variations from literature (Fraser, 2001).

After receiving training in predicting ovulation, participants followed a diet and planned their last intercourse well before ovulation. The results of the first 28 participants to complete the treatment (reference group) were used to derive a prediction rule. The results of the subsequent participants (validation group) were used to validate this rule. To guarantee the prospective character of this validation, the results of each participant were communicated to the guarantor (JG) after the last serum sample was analysed, but before the sex of the baby was known. The prediction rule was determined before any results from the validation group were available.

All participants provided written informed consent prior to enrolment. The study was carried out according to the Declaration of Helsinki and the University of Maastricht Research Ethics Committee approved the study protocol (NL14251.068.07).

Procedures

Prior to treatment, each participant filled in a questionnaire about her eating habits and preferences and a blood sample was analysed for Na⁺, K⁺, Ca²⁺ and Mg²⁺ concentrations. All serum analyses were performed at the same laboratory. These parameters were taken into account in a detailed personal diet advice, stipulating both allowed and excluded foods, aimed at decreasing sodium and potassium concentrations while increasing magnesium and calcium concentrations in the blood. As there is no evidence that a paternal diet might influence the sex of offspring, the diet was prescribed only for the mother. Some fathers followed the diet in support of their partner. The diet complied with guidelines of the Dutch National Bureau for Nutrition. All food preparation had to be without salt and an ample amount of dairy products had to be consumed (at least 500 g/day). A normal feeding pattern could be followed, including bread, vegetables, fruit, meat, rice and pasta. The intake of potatoes was limited because of its high potassium content. The effect of the diet was enhanced with daily food supplements: 400–600 mg magnesium (Orthica; Almere, The Netherlands), 500–700 mg calcium (Solgar; Leonia, NJ, USA), and 5–7.5 μg vitamin D (Davitamon; Chefaro, Rotterdam, The Netherlands), depending on the initial blood values. Based on previous experiences, the objective of the diet was to obtain a Na⁺ value of at most 140 mmol/l and an increase in serum Ca²⁺ concentration of at least 0.1 mmol/l. The effect of the diet was checked after 5 weeks by a second serum analysis. The diet was maintained during a period starting at least 9 weeks before planned conception, until a pregnancy home test provided proof of pregnancy. In most cases, the diet was started at the beginning of the menstrual cycle, two and a half cycles before planned conception. One last blood sample was taken as soon as possible – no more than a couple of days – after confirmation of pregnancy by positive home test, to check whether the blood values were still at the correct concentrations. The participant could then discontinue the diet. If the blood concentrations showed insufficient effect after 5 weeks, diet and food supplement levels were adapted accordingly and blood values were checked again after 4 weeks.

All participants were trained for self-examination and before becoming pregnant, they were asked to monitor from four to six menstrual cycles to be able to predict the moment of ovulation as accurately as possible. This was done by registering basal body temperature, consistency of cervical mucus, cervical position, os diameter and cervix texture. Home-use ovulation prediction tests based on urinary LH surge (Clearblue; Unipath, Bedford, UK) were used to accurately gauge these observations (Grenache and Gronowski, 2003). Ovulation was assumed to take place 1 day after the start of the LH surge. Couples were advised to have regular intercourse, but to refrain from having intercourse in the period from 2 days before to several days after ovulation.

The study protocol required that the diet was followed uninterruptedly for at least 9 weeks preceding pregnancy, that blood samples were analysed before starting the diet and shortly after pregnancy, that the timing interval was determined using fertility charts and ovulation tests and that proof of the baby’s sex was obtained. The group of participants satisfying these basic requirements will be referred to as protocol group. Other subjects were excluded from those analyses for which data were incomplete.

Statistical analysis

The protocol group was divided into two groups in order of completion of all data (n = 28 and n = 50, respectively). A prediction rule for a baby girl was constructed based on results from the first group, by applying logistic regression and optimization techniques. The second group was used to prospectively verify the validity of this rule. The P-value for evaluating the null hypothesis of no relation between methods and sex was calculated directly from a binomial distribution. Fisher’s exact test and a G-test for three-way contingency tables were used to analyse dependencies between timing, diet and resulting sex. The G-test is based on the likelihood-ratio principle and is closely related, but preferable, to the more familiar chi-squared test (Sokal and Rohlf, 1994). For two-way contingency tables chi-squared testing is an approximation that will not be valid for small size samples, so Fisher’s exact test is preferred. The effect of diet on blood values was evaluated with a paired t-test and also by comparison with results from an untreated group that was obtained by Monte-Carlo simulation. A P-value <0.05 was considered statistically significant and not to have occurred by chance. Means are given with standard deviations (SD); no standard errors are used. Special care was taken to rule out effects of regression towards the mean and selective bias during all analyses by comparison with missing data analyses. The statistical analyses were conducted with the Statistical Package for Social Sciences version 16.0 (SPSS, USA). Monte-Carlo simulations were performed with Maple mathematical software version 12.
Results

In the period from 2001 to 2006, 172 couples volunteered to participate in the study. All the women were healthy, of Western European origin, between 23 and 42 years of age, with mean ± SD age 34.0 ± 3.3 years, and all had already given birth to one (16%), two (59%), three (23%) or four boys (2%). Of a total of 358 previous children, there were only two girls, so family balancing was clearly the main reason for seeking to apply sex pre-selection.

The study overall (Figure 1) shows the contributions of all participants that registered for the study. Of the 172 participants, 63 discontinued the treatment and 109 pregnancies continued to term delivery; no birth disorders were reported. Reasons for discontinuation were unplanned pregnancy \( (n = 9) \), impatience due to not becoming pregnant \( (n = 8) \) or fertility problems \( (n = 3) \), finding the treatment too demanding \( (n = 5) \), personal circumstances/divorce \( (n = 12) \) or illness \( (n = 8) \) and discontinuation after a miscarriage \( (n = 11) \); seven participants were lost to follow-up. Of these 63 subjects, 22 discontinued before starting the treatment, while 30 stopped during treatment, so of the 172 registered participants, 150 provided (partial) data for the study. All births were singletons, except for one twin girl, counted as one girl. Of these, 78 live births conformed to basic protocol requirements. For the remaining 31 births \( (16 \text{ boys, } 15 \text{ girls}) \) the diet was not started \( (n = 8) \) or not followed for the required minimum of 9 weeks \( (n = 8) \), no post-pregnancy blood sample was drawn \( (n = 12) \) or no ovulation test was applied \( (n = 3) \), leaving the day of ovulation unconfirmed. Most participants \( (95\%) \) were able to predict correctly their ovulation 3–4 days in advance using self-assessment methods.

Of the 135 pregnancies \( (109 \text{ live births and } 26 \text{ miscarriages}) \), 77% were conceived within three menstrual cycles (Figure 2). The average number of cycles to pregnancy was 2.9 ± 2.4. The average length of the treatment from start of diet to birth was 1.50 ± 0.50 years.

Six participants underwent 24 h home urine collection in parallel to blood sampling, before, during and after diet. Sodium intake measure, as derived from urine excretion, dropped from 2.0 ± 0.2 to 0.8 ± 0.3 g/day \( (P < 0.001) \) after 5 weeks, corresponding to a decrease of serum sodium content from 143.0 ± 1.0 to 139.7 ± 0.5 mmol/l \( (P = 0.02) \).

The data of the treatments leading to the first 28 births were used as references to establish a rule that could be used to predict girls. This prediction rule consists of one timing and two diet criteria components that should be satisfied simultaneously: \( T1 = \text{the last intercourse was at least 3 days before ovulation} \); \( D1 = \frac{\text{Na}_3 + 2\text{Ca}_1 - 10\text{Ca}_3}{C_0} \leq 163 \text{ mmol/l} \); \( D2 = \text{if } \frac{\text{Ca}_3}{\text{Ca}_1} < 1, \text{then } \frac{\text{Na}_1 - \text{Na}_3 - 10\text{Ca}_3}{10\text{Ca}_1 + 10\text{Ca}_3} \geq 4 \text{ mmol/l} \). Here \( \text{Ca}_i \) and \( \text{Na}_i \) are the \( \text{Ca}^{2+} \) and \( \text{Na}^{+} \) serum concentrations in mmol/l at the start \( (i = 1) \) and at the end \( (i = 3) \) of the diet, respectively. These criteria were based on best practices by Gender Consult (D2) and a mathematical analysis of the data of the reference group \( (T1, D1) \). Using linear programming techniques (Mangasarian, 1965) and logistic regression, a linear function was constructed that provided an optimal prediction for girls. The most significant determinants were the \( \text{Na}^{+} \) and \( \text{Ca}^{2+} \) concentrations before diet and at conception. \( \text{Mg}^{2+} \) and \( \text{K}^{+} \) concentrations were not found to be significant. A subsequent group of 50 births resulted in 21 babies from treatments that satisfied all criteria. This group was used to validate the effectiveness of the prediction rule (Table 1).
Fisher’s exact test showed no significant correlation between the two groups, but for each group there was a highly significant association between prediction rule and the offspring sex ($P = 0.0013$ and $P = 0.00045$, respectively).

A further validation for the prediction rule is provided by a sensitivity analysis. **Table 2** shows, for each of the three prediction rule criteria separately, the percentage of girls correctly predicted for the current right-hand-side value in the criteria $T_1$, $D_1$ and $D_2$.

The data enabled us to analyse the effect of diet and timing methods separately. **Table 3** and **Figure 3** summarize the percentage of girls for the 78 live births in the protocol group related to compliance with timing of intercourse and diet advice. Timing of intercourse is correct when criterion $T_1$ is satisfied; diet is correct when criteria $D_1$ and $D_2$ are both satisfied.

Fisher’s exact test shows no significant dependence between failure and success for the two methods. A G-test on the three-way contingency table reveals a very significant dependence between sex and the two methods ($G^2 = 30.8$, $P < 0.0001$), the dependences of sex on diet ($P = 0.0001$) and on timing of intercourse ($P = 0.009$) are both considerable.

The 32 participants satisfying the prediction rule for both diet and timing method, on average, had $2.1 \pm 0.6$ boys and

**Table 1** Percentage of girls related to concordance with prediction rule for the protocol group.

<table>
<thead>
<tr>
<th>Prediction rule</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfied</td>
<td>Not satisfied</td>
</tr>
<tr>
<td>Reference group</td>
<td>11 (91)</td>
</tr>
<tr>
<td>10 girls, 1 boy</td>
<td>4 girls, 13 boys</td>
</tr>
<tr>
<td>Validation group</td>
<td>21 (76)</td>
</tr>
<tr>
<td>16 girls, 5 boys</td>
<td>7 girls, 22 boys</td>
</tr>
<tr>
<td>Total (protocol group)</td>
<td>32 (81)</td>
</tr>
<tr>
<td>26 girls, 6 boys</td>
<td>11 girls, 35 boys</td>
</tr>
</tbody>
</table>

Values in parentheses are percentage of girls.

**Table 2** Sensitivity analysis for the prediction rule: percentage of correctly predicted girls for the protocol group ($n = 78$) related to right-hand-side constants in the criteria $T_1$, $D_1$ and $D_2$.

<table>
<thead>
<tr>
<th>Right-hand-side constant</th>
<th>Smaller value</th>
<th>Current value</th>
<th>Larger value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1$ ($n$)</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Correct (%)</td>
<td>72</td>
<td>81</td>
<td>80</td>
</tr>
<tr>
<td>$D_1$ ($n$)</td>
<td>162</td>
<td>163</td>
<td>164</td>
</tr>
<tr>
<td>Correct (%)</td>
<td>77</td>
<td>81</td>
<td>76</td>
</tr>
<tr>
<td>$D_2$ ($n$)</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Correct (%)</td>
<td>79</td>
<td>81</td>
<td>82</td>
</tr>
</tbody>
</table>

$D_1 = Na_3 + 20Ca_1 - 10Ca_3 \leq 163 \text{ mmol/l}; \ D_2 = \text{if } Ca_3 \leq Ca_1, \ \text{then } Na_3 - Na_1 - 10Ca_1 + 10Ca_3 \geq 4 \text{ mmol/l}; \ T_1 = \text{the last intercourse was at least 3 days before ovulation.}$

**Table 3** Percentage of girls related to concordance with diet and/or timing method for the protocol group.

<table>
<thead>
<tr>
<th>Timing correct</th>
<th>Timing incorrect</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet correct</td>
<td>Diet incorrect</td>
<td>Total</td>
</tr>
<tr>
<td>32 (81)</td>
<td>5 (20)</td>
<td>37 (73)</td>
</tr>
<tr>
<td>26 girls, 6 boys</td>
<td>1 girl, 4 boys</td>
<td>27 girls, 10 boys</td>
</tr>
<tr>
<td>30 (30)</td>
<td>11 (9)</td>
<td>41 (24)</td>
</tr>
<tr>
<td>9 girls, 21 boys</td>
<td>1 girl, 10 boys</td>
<td>10 girls, 31 boys</td>
</tr>
<tr>
<td>Total (protocol group)</td>
<td>62 (56)</td>
<td>16 (13)</td>
</tr>
<tr>
<td>35 girls, 27 boys</td>
<td>2 girls, 14 boys</td>
<td>37 girls, 41 boys</td>
</tr>
</tbody>
</table>

Values in parentheses are percentage of girls.
no girls before starting the treatment. From data provided by CBS Statistics Netherlands on Dutch population in 2003 (Table 4), the conditional probability for the third child being a girl after two boys is 0.462 (n = 64,000). With treatment, this study observed a success rate (percentage female offspring) of 91% for the reference group, 76% for the validation group, in total 81% (26 girls, 6 boys) for the protocol group (95% confidence interval 68–95%). Based on a binomial distribution with a success rate of 46.2%, the probability that of 32 women with two boys at least 26 women will have a girl, supposing that the pre-selection methods would have no effect, is $P = 0.00005$. For the 21 women in the prospective validation group, this probability is $P = 0.005$. This is very strong evidence that the treatment combined with the prediction rule indeed increases the probability of a girl.

Compliance with timing advice (T1) tended to decrease with the length of time it took to become pregnant. Among the 26 women from the protocol group that became pregnant in the first cycle, the compliance with timing advice was 96%, whereas it was 71% for the 52 women who took two cycles or longer.

Among the 31 pregnancies that did not satisfy basic protocol requirements, 28 had a correct registration for the timing of intercourse. Figure 4 shows the relationship between the timing interval and percentage of girls for the 106 subjects that provided data on timing of intercourse. In particular, in 42 out of 72 cases (58%), intercourse that took place 3 or 4 days before ovulation resulted in a girl ($P = 0.025$).

Table 4 Family composition and birth order for children of autochthonous women in the Netherlands in 2003 (courtesy of CBS Statistics Netherlands).

<table>
<thead>
<tr>
<th>First child</th>
<th>Second child</th>
<th>Third child</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boy</td>
<td>—</td>
<td>—</td>
<td>191,032</td>
</tr>
<tr>
<td>Boy</td>
<td>Boy</td>
<td>—</td>
<td>91,249</td>
</tr>
<tr>
<td>Boy</td>
<td>Boy</td>
<td>Boy</td>
<td>34,406</td>
</tr>
<tr>
<td>Boy</td>
<td>Boy</td>
<td>Girl</td>
<td>29,514</td>
</tr>
<tr>
<td>Boy</td>
<td>Girl</td>
<td>—</td>
<td>89,525</td>
</tr>
<tr>
<td>Boy</td>
<td>Girl</td>
<td>Boy</td>
<td>26,514</td>
</tr>
<tr>
<td>Boy</td>
<td>Girl</td>
<td>Girl</td>
<td>23,766</td>
</tr>
<tr>
<td>Girl</td>
<td>—</td>
<td>—</td>
<td>180,974</td>
</tr>
<tr>
<td>Girl</td>
<td>Boy</td>
<td>—</td>
<td>89,267</td>
</tr>
<tr>
<td>Girl</td>
<td>Boy</td>
<td>Boy</td>
<td>27,084</td>
</tr>
<tr>
<td>Girl</td>
<td>Boy</td>
<td>Girl</td>
<td>23,739</td>
</tr>
<tr>
<td>Girl</td>
<td>Girl</td>
<td>—</td>
<td>78,258</td>
</tr>
<tr>
<td>Girl</td>
<td>Girl</td>
<td>Boy</td>
<td>26,095</td>
</tr>
<tr>
<td>Girl</td>
<td>Girl</td>
<td>Girl</td>
<td>23,865</td>
</tr>
</tbody>
</table>

Figure 3 Percentage of girls related to concordance with diet and/or timing method for the protocol group.

Figure 4 Percentage of girls related to timing interval between last intercourse and ovulation.

Table 5 Average values of mineral serum concentrations during treatment (n = 108).

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Before diet</th>
<th>After 5 weeks</th>
<th>End of diet</th>
<th>Reference range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>141.6 ± 2.6</td>
<td>139.9 ± 2.1</td>
<td>139.2 ± 2.7</td>
<td>135–150</td>
</tr>
<tr>
<td>K⁺</td>
<td>4.40 ± 0.48</td>
<td>4.40 ± 0.41</td>
<td>4.38 ± 0.42</td>
<td>3.6–5.4</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>2.38 ± 0.11</td>
<td>2.41 ± 0.09</td>
<td>2.40 ± 0.11</td>
<td>2.1–2.7</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>0.89 ± 0.13</td>
<td>0.91 ± 0.13</td>
<td>0.90 ± 0.12</td>
<td>0.70–1.10</td>
</tr>
</tbody>
</table>

Values are mean mmol/l ± SD.
confirmation of pregnancy. All values stayed within the reference range.

A paired t-test confirms that the average decrease of the sodium values and the increases in calcium and magnesium during the first 5 weeks must be attributed to the diet ($P < 0.0001$, $P = 0.047$ and $P = 0.035$, respectively). Furthermore, of the 78 participants in the protocol group, 37 (47%) managed to satisfy both diet conditions of the prediction rule. In the absence of a reference group of subjects who did not follow the diet, ten Monte-Carlo simulations, each with 1,000,000 subjects with random starting values of 141.6 ± 2.6 mmol/l Na⁺, 2.38 ± 0.11 mmol/l Ca²⁺ and within-subject biological variations of 1.0 and 0.05 mmol/l, respectively, (Fraser, 2001) were performed. It showed that the probability of satisfying the prediction rule by chance alone is 12.6%.

Statistical analyses were performed on the protocol group, but also on the complete group with incomplete data. No significant differences were seen, so the results were not influenced by the restriction to the protocol group.

Discussion

This is the first study to investigate the efficacy of a combined diet and timing approach as a sex pre-selection technique and to give a quantitative approach of the diet method. By analysing mineral serum values, this study was able to quantify the compliance with diet and its influence on the sex of offspring. Thus, this study has constructed a prediction rule based on mineral serum values and the timing interval that can predict girl babies. Its validity was verified prospectively. Of the protocol group, 47% managed to satisfy the dietary part of the prediction rule, whereas Monte-Carlo simulations have shown that expected compliance by chance alone is only 12.6 ± 0.03%. Moreover, results of a paired t-test show a correlation between diet efforts and mineral serum concentrations (Berge-Landry and James, 2004). This confirms that the diet can effectively shift mineral serum content towards the prediction rule regime.

These results show that both diet and timing methods increase the probability of a girl, the impact of the diet being the most pronounced. Table 3 and Figure 3 summarize the results of the 78 women who satisfied all basic protocol requirements. It shows a substantial success rate of 81% ($n = 32$), when both methods are applied correctly, whereas the success rate is only 24% ($n = 46$) if one or both of these methods are not applied correctly. If the diet is not followed correctly, the observed probability of a girl drops to 30%. The effect of correct timing of intercourse only, disregarding diet, is small (56%), whereas incorrect timing leads to 87% boys, which is in accordance with earlier hypotheses and studies (McSweeney, 1993). The diet obviously has a larger impact, since the effect of correct diet only, disregarding timing of intercourse, is 73%. Among the 11 subjects that followed both methods incorrectly, there was only one who gave birth to a girl (9%). Clearly, for both diet and timing methods, ‘not correct’ means ‘wrong’ and implies a high probability of a boy, although participants who deliberately circumvented instructions regarding diet or timing of intercourse did not realize this.

Table 2 demonstrates the robustness of the prediction rule since its dependency on the values of the right-hand-side constants is slight. The values found are based on the reference group, but they are also almost optimal for the complete protocol group. This is a further confirmation of the validity of the prediction rule.

Six participants underwent 24 h home urine collection parallel to blood sampling. The results show a concordance between low intake of sodium and decreasing sodium values in serum. This validates the use of blood analysis as a compliance check for the diet. Blood analysis was preferred because it shows more clearly the accumulated effect of the diet whereas urine collection is more demanding for the participants and is susceptible to manipulation.

The current results show that diet can be used to satisfy the prediction rule and that this will substantially increase the probability of a girl. Criterion D1 substantiates that a diet that is low in sodium and high in calcium improves the chances of conceiving a girl. This provides a more quantitative basis for earlier concordant observations (Devaure et al., 1989; Duc, 1977; Jeanbrun, 1989; Lorrain, 1975; Papa et al., 1983; Stolkowski and Lorrain, 1980; Stolkowski and Choukroun, 1981, 1984, 1986). Further support for the effect of diet comes from data on the offspring sex of vegetarian mothers (Hudson and Buckley, 2000). An audit of 5942 deliveries included 254 women who were vegetarian and the percentage of their babies who were girls was 55.0% ($P = 0.02$). Sodium intake for vegetarians is certainly below average (Wyatt et al., 1995) as their diet lacks meat and fish. In combination with a high intake of dairy produce this may account for the observed preponderance of girls.

The combined results of the 106 subjects who had data about timing of intercourse in Figure 4 show that, irrespective of diet, a timing of 3 or 4 days before ovulation yields a success rate of 58% girls ($P = 0.025$). A timing of intercourse that is 2 days or closer to ovulation has a marked adverse effect (17% girls, $P = 0.0025$), but also if the intercourse takes place 5 or 6 days before ovulation the percentage of girls is low (30%, not significant). This suggests a timing window of 3–4 days before ovulation that is favourable to the conception of girl babies. This U-shaped dependence between sex ratio and timing interval is supported by earlier data from Gray et al. (1998), and by James (2008).

The IVF pioneer Landrum B Shettles (1970) called attention to the timing method, which has resulted in a rich literature on the topic (e.g. McSweeney, 1993; Wilcox et al., 1995). Unfortunately, many results are contradictory, mainly because most studies are beset by the same major problem: a low level of accuracy and reliability of estimating the time of ovulation. Multiple inseminations were not always registered and ovulation was determined based on basal body temperature only, or was even supposed to take place for all women on a fixed day during the menstrual cycle. Nowadays urinary LH-based home tests can be used to determine ovulation very accurately (Grenache and Gronowski, 2003). Many consider the article by Wilcox et al. (1995) to be the definite evidence against the timing method and the conclusion by this study, ‘For practical purposes, the timing of sexual intercourse in relation to ovulation has no influence on the sex of the baby’, has been quoted many times. However, closer scrutiny of their data shows that there are a mere five cases for which coitus...
was certain to have taken place inside the female window of 3–4 days before ovulation, out of a total of 129, so the quantitative basis for their conclusion is not very impressive. Data on artificial insemination performed around the ovulation shows a preponderance of male babies (Mortimer and Richardson, 1982; Sampson et al., 1983), which implicitly supports the timing theory. Of a total of 12,346 babies conceived using fresh semen, only 42.3% were female ($P = 0$).

The mechanisms by which diet and timing of intercourse influence sex remain unknown. The effect of timing may be explained by a small size difference between X- and Y-gametes (Geraedts, 1997). The diet possibly induces ionic and/or hormonal changes that interact either through the cervical mucus with spermatooza or at the oocyte level. Finally, differential survival of male and female embryos cannot be ruled out.

The overall compliance with timing criteria was 81%, whereas compliance with diet restrictions was 50%. Indeed, most participants experienced the diet as more demanding than the timing of intercourse, especially because of the social impact that was a consequence of keeping silent about the treatment. Some husbands were more concerned about accomplishing successful intercourse within the specified timing window. Participants who did not become pregnant within a few cycles were more inclined to disregard the timing advice because they expected to become pregnant sooner when intercourse was closer to ovulation. For the 83 participants who became pregnant in one or two cycles, 19% did not follow the timing rule, whereas this percentage doubled for those who took longer.

The discontinuation rate in this study (37%) was small when compared with earlier studies (Devaure et al., 1989; France et al., 1992; Jeambrun, 1989; Papa et al., 1983) in which rates between 60% and 75% were reported; the current study’s participants were probably more motivated to complete the treatment by the personal counselling they received. The maternal age in the study group was above average and, taking the age profile into account, the expected number of 25.8 miscarriages (Nybo Andersen et al., 2000) agrees perfectly well with the 26 observed in the current study.

Parents of all-boy families are more likely to continue having children, but the probability of a girl decreases slightly with the number of boys born previously (Ben Porath and Welch, 1976; Biggar et al., 1999). Reasons for this effect are not known. Data provided by CBS Statistics Netherlands on Dutch population in 2003 (Table 3) shows that, for the current study’s population, the probability for a baby girl can be assumed to be 0.462. Comparing the results of the present study with a binomial distribution based on this value shows that both diet and timing of intercourse have an effect on the sex of offspring. The effect of the diet method is the most pronounced ($P = 0.001$), but in combination with correct timing of intercourse is even better ($P = 0.00005$) and can increase the probability of a girl to around 80% (95% confidence interval 68–95%).

Although the current results are statistically significant, the yield from the 172 participants was not as high as hoped. There are several circumstances that may have affected the motivation of participants adversely. For most participants, a treatment that can take up to 2 years to lead to pregnancy is long by any standard and meanwhile many things may happen or change. Together with social and physical impediments imposed by the diet, restrictions on sexual intercourse, the apparent experimental nature of the treatment and the critical attitude of many medical professionals, this has led to deliberate non-compliance and discontinuations. For compliance with timing of intercourse, this study had to rely on data provided by the subjects themselves. It is likely that some subjects have influenced the results by intentionally mis-classifying themselves as compliers so the effect of timing in fact may be greater than concluded. The headstrong character of the young Dutch generation may account for a relatively high percentage of non-compliers (59%), whose results unfortunately balance the strongly positive effect of the compliers (Table 3). This may also explain several unnecessary violations of basic protocol requirements, especially the omission of the post-pregnancy blood collection.

The Dutch are known for their liberal points of view but expressing a preference for a boy or a girl is still one of the remaining taboos. Clinical sex selection for non-medical reasons has been forbidden by law since 1998. Most participants chose not to talk about their treatment with friends, family or even with their family doctor. Nevertheless, couples with an unbalanced family or with a strong preference for a specific gender appear to have a positive attitude towards sex selection (Himmel and Michelmann, 2008). There is an apparent need for natural sex selection methods as an alternative to clinical approaches and it is hoped that the current results will contribute to the acceptance of their efficacy among medical professionals.

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References


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