

The TwoDay Algorithm: A New Algorithm to Identify the Fertile Time of the Menstrual Cycle

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Women who monitor their fertility signs and recognize when they are fertile can use this knowledge to conceive or to avoid pregnancy. Studies have shown that there is a rather small fertile window of several days during each menstrual cycle. Established methods of identifying the fertile window, such as the Ovulation and the Symptothermal methods of Natural Family Planning, can be very effective in helping couples avoid pregnancy. A new algorithm for identifying the fertile window has been developed, based on monitoring and recording of cervical secretions. The TwoDay Algorithm appears to be simpler to teach, learn, and use than current natural methods. A large existing data set from a World Health Organization study of the Ovulation Method, along with Natural Family Planning charts from women using the Ovulation Method and the Symptothermal Method, were used to determine the potential effectiveness of the TwoDay Algorithm in identifying the fertile window. Results suggest that the algorithm can be an effective alternative for low literacy populations or for programs that find current Natural Family Planning methods too time consuming or otherwise not feasible to incorporate into their services. Further studies are needed to determine the efficacy of the TwoDay Algorithm in avoiding pregnancy and to assess its acceptability to users and providers. CONTRACEPTION 1999;60: 65–70 © 1999 Elsevier Science Inc. All rights reserved.

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Introduction

A substantial number of contracepting women worldwide report using *periodic abstinence* in an effort to avoid pregnancy.¹ Yet, relatively few users of periodic abstinence correctly understand their reproductive cycles or have an accurate knowl-

edge of when they are most likely to conceive.^{2,3} Studies have shown that, when used correctly, some of the family planning methods grouped under the umbrella term “periodic abstinence” are highly effective in preventing pregnancy.⁴ For example, the Ovulation Method is a very effective Family Planning Method for couples who use the method perfectly (3% first-year pregnancy rates). Perfect use implies that the couple abstains from unprotected intercourse during the identified fertile days. Pregnancy with perfect use occurs only in those cycles in which the method does not identify these days correctly. Imperfect use implies that the couple has unprotected intercourse precisely when the method indicates that the woman is fertile. Logically, this results in a high failure rate. Thus, first-year pregnancy rate of couples who sometimes use the Ovulation Method imperfectly is about 20%.^{5,6} Results are similar for users of the Symptothermal Method.⁷

Despite the high perfect-use effectiveness rates and the significant demand for methods based on periodic abstinence, these methods are not offered in most multimethod family planning programs, in part because many providers do not have time to acquire the skills and engage in the extensive teaching process the methods require.⁸ Consider, for example, the Ovulation Method, which is based on self-observation and interpretation of changes in cervical secretions that occur as the woman approaches ovulation and when ovulation has occurred. To use the Ovulation Method effectively, women learn to differentiate between multiple characteristics of their cervical mucus (feel, color, texture, and general appearance), and to correctly interpret and chart their findings.⁹ The Symptothermal Method involves additional monitoring of the basal body temperature and, according to some instructions, characteristics of the cervix itself, as well as other fertility signs. This requires hours of intensive teaching. Instructors need to follow users for several cycles, until users are able to correctly interpret their symptoms of fertility and to use the method independently.¹⁰ The method requires providers to invest substantial time in

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method instruction, more than many providers are willing or able to invest in the provision of a family planning method. Although intensive provider training as well as client-provider contact can result in a highly effective family planning method, for some women it may also limit access to the method.

Also, illiterate and innumerate couples sometimes find current periodic abstinence-based methods difficult to learn and use correctly. Users of these methods are taught to observe and feel these changes in one or more fertility signs, and to note them on a chart. They follow a set of "rules" that allows them to predict the days in their cycles in which they are more likely to conceive. They should abstain from intercourse on these days if they wish to minimize the probability of pregnancy.⁹ Although it is possible to teach these methods using pictures and symbols, couples with very low literacy may find them difficult to learn.

The introduction of a simple means of identifying the fertile time could help overcome these obstacles, and assist some couples in correctly timing their intercourse to avoid pregnancy. The proposed algorithm is another approach to interpreting cervical secretions, one of the primary signs of changes in fertility status, that appears to be easier for providers to teach, and for clients to learn and to use. The TwoDay Algorithm requires only that a woman monitor the presence or absence of cervical secretions, by sensation or by observation, to determine on each day whether she is fertile. Following the rules of the algorithm does not require differentiating among different types of cervical secretions. Rather, secretions would be any substance the woman perceives as coming from her vagina, except for menstrual bleeding.^a The woman then asks herself two simple questions: 1) Did I note secretions today? and 2) Did I note secretions yesterday? Her answer is "Yes" if she notices (or noticed yesterday) secretions of any type, and "No" if she notices (and noticed yesterday) no secretions at all. If she notices any secretions (today or yesterday), she is probably fertile, and needs to abstain from unprotected intercourse if she wishes to avoid pregnancy. If she notices no secretions on *both days*, it is very probable that she is not fertile.

Materials and Methods

The theoretical effectiveness of the TwoDay Algorithm was studied using two data sources. The first source was data from a study of women using the Ovulation Method that was conducted by the World Health Organization (WHO) in the late 1970s. Data

were collected in five locations representing a variety of geographic and cultural settings. After a teaching phase of 3-6 months, 725 women entered the effectiveness phase of the study. These women were <39 years of age, with proved fertility and regular menses, who had successfully learned the Ovulation Method during the teaching phase.⁶ They were followed for up to 18 cycles.^b These data offer information on various characteristics of the cycle, including days of cervical secretions and signs of ovulation. The second source was actual charts of women using the Ovulation Method and the Symptothermal Method.^c Charts were provided by three Natural Family Planning programs,^d and 183 charts were analyzed. These charts were not collected for research purposes, and no attempt was made to control for fertility, age, regularity of cycles, etc.

Three types of information were used to calculate estimated probability of pregnancy from intercourse occurring on various days of the cycle. The first type of information was the percentage of cycles in which the woman would have been protected by the Two-Day Algorithm. That is, the percentage of cycles in which observing the rules of the algorithm would have resulted in the woman correctly identifying her fertile period (ie, classifying as fertile the same days that were identified as fertile by the Ovulation Method). According to the Ovulation Method, the fertile period begins with the onset of mucus secretions, or with a sensation of dampness or wetness, detectable at the vulva. The peak day is the last day on which fertile-type mucus is recognized, or the last day on which the wet or lubricative sensation is felt. The fertile period ends on day 4 after peak day.⁶ These percentages were calculated using the two data sources described above.

The second type of information was the probability that conception occurs from intercourse on various days relative to the days of ovulation. Wilcox et al¹¹ show that there is a fertile window—several days each menstrual cycle—during which a woman can, with varying degrees of likelihood, conceive if she has unprotected intercourse. Unprotected intercourse on the day of ovulation results in conception about 33% of the time. Then, because of the life span of the ovum, which is quite short, the probability of conception from unprotected intercourse drops sharply, so that

^bSome previous studies using this data set analyzed only the first 13 cycles, because relatively few women were followed for the entire 18 cycles.

^cA periodic abstinence method that is based on observations of cervical secretions and other signs of impending ovulation or the occurrence of ovulation.

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^aIssues of pathological fluid or semen are addressed in the discussion below.

Table 1. Percentage of cycles covered by the TwoDay Algorithm on days relative to peak day

| | P-8 | P-7 | P-6 | P-5 | P-4 | P-3 | P-2 | P-1 | Peak | P+1 | P+2 | P+3 |
|--------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|
| WHO data (7592 cycles) | 20 | 31 | 47 | 65 | 80 | 90 | 97 | 100 | 100 | 100 | 45 | 34 |
| Program charts (183 cycles) | 30 | 37 | 55 | 69 | 82 | 91 | 95 | 96 | 100 | 100 | 64 | 44 |

P denotes peak day.
WHO = World Health Organization.

the day after ovulation has occurred unprotected intercourse is very unlikely to result in pregnancy.^e Before ovulation, because of the life span of sperm, intercourse ≥ 6 days before ovulation can rarely result in conception. The probability of conception increases progressively from about 10% 5 days before ovulation, to 33% on the day of ovulation, with the sharpest increase about 2 days before ovulation.¹¹ These estimates include all hormonally detected conceptions, including those that ended in very early loss. In a more recent work¹² the authors calculated the probabilities of clinically detected pregnancies (at 6 weeks LMP) from intercourse on different days relative to ovulation. The probability of clinically detected pregnancies increases progressively, from about 4% 5 days before ovulation, to 29% 2 days and 27% 1 day before ovulation, declining to 8% from intercourse occurring on the day of ovulation.^{f13,14} We use the latter figures in our calculations.

Finally, the third type of information was the timing of peak day relative to day of ovulation. Hilgers et al.¹⁵ show that peak day is a good proxy for ovulation. Most ovulations occur during the period starting 2 days before peak day and ending 2 days after peak day, but more before peak day than after peak day, with the majority (38%) occurring on peak day itself.

Coverage by the TwoDay Algorithm on any given day is defined as the presence of noticeable secretions on that day or the day before, so that the woman can recognize the day as fertile and can abstain from unprotected intercourse to avoid pregnancy. The algorithm’s coverage of the fertile window is identified by applying the rules of the algorithm starting 8 days before peak day and continuing through 3 days after peak day. Recognizing that the fertile window begins 5 days before ovulation and ends on the day of ovulation, and that peak day can occur from 3 days before through 3 days after ovulation, this period consists of the entire potentially fertile window.

Results

Table 1 shows the percentage of cycles that are covered by the TwoDay Algorithm, from 8 days before to 3 days after the peak day (see above definition of coverage).

Estimated probabilities of pregnancy were calculated by multiplying these percentages by the probability of pregnancy from unprotected intercourse around the peak day. Table 2 shows the estimated probabilities of pregnancy from intercourse occurring on various days in the prepeak phase of the cycle. Because these rates change depending on when ovulation occurs relative to peak day, they are weighted by the probability that ovulation occurs on that day (relative to peak day). These estimates are very conservative. The calculations assume that women have the same probability of pregnancy from unprotected intercourse on days relative to peak day, whether or not they have noticeable secretions. That is, if they notice secretions, they may abstain from unprotected intercourse to avoid pregnancy; if they do not notice secretions, they will wrongly consider themselves infertile, and can conceive because they will not abstain from unprotected intercourse on days that are close to ovulation. However, research has shown that sperm can only survive (≤ 5 days) in a friendly environment. A vagina without cervical secretions is hostile to sperm.¹⁶ The high effectiveness of the Ovulation Method when used correctly confirms the accuracy of this assertion. We expect actual method effectiveness rates of the TwoDay Algorithm to be comparable to Ovulation Method rates (3% first-year pregnancy rates when used perfectly).

The identified fertile period using the TwoDay Algorithm equals the number of days with noticeable secretions plus one day. If the woman notices secretions on nonconsecutive days, then additional days are perceived as fertile. Figure 1 shows the total number of days with secretions in the WHO data. For each number of days, Figure 1 shows the number of cycles in which this was the total number of days with secretions. For example, there are 1218 cycles in which the total number of days with secretions is 6.

^e These probabilities were calculated with a 95% confidence interval.
^f An older study, and preliminary results from a multi-center European study show a similar pattern.

Table 2. Estimated probability of conception from unprotected intercourse, weighted by the probability that ovulation occurs on different days relative to peak day, for women observing the rules of the TwoDay Algorithm

| | Assuming that ovulation occurs on | | | | | | | Total |
|----------------|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|
| | P-3 | P-2 | P-1 | Peak | P+1 | P+2 | P+3 | |
| WHO Data | | | | | | | | |
| P-8 | 0.001 | 0 | 0 | 0 | 0 | 0 | 0 | 0.001 |
| P-7 | 0.001 | 0.005 | 0 | 0 | 0 | 0 | 0 | 0.006 |
| P-6 | 0.001 | 0.012 | 0.004 | 0 | 0 | 0 | 0 | 0.017 |
| P-5 | 0.002 | 0.005 | 0.009 | 0.005 | 0 | 0 | 0 | 0.021 |
| P-4 | 0.001 | 0.011 | 0.003 | 0.009 | 0.001 | 0 | 0 | 0.025 |
| P-3 | 0 | 0.005 | 0.006 | 0.003 | 0.002 | 0 | 0 | 0.016 |
| P-2 | 0 | 0 | 0.001 | 0.003 | 0 | 0 | 0 | 0.005 |
| P-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.001 |
| Peak | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P+1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P+2 | 0 | 0 | 0 | 0 | 0 | 0.003 | 0.023 | 0.025 |
| P+3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.008 | 0.008 |
| Program charts | | | | | | | | |
| P-8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P-7 | 0.001 | 0.005 | 0 | 0 | 0 | 0 | 0 | 0.006 |
| P-6 | 0.001 | 0.010 | 0.004 | 0 | 0 | 0 | 0 | 0.014 |
| P-5 | 0.001 | 0.005 | 0.008 | 0.005 | 0 | 0 | 0 | 0.018 |
| P-4 | 0.001 | 0.010 | 0.003 | 0.008 | 0.001 | 0 | 0 | 0.023 |
| P-3 | 0 | 0.005 | 0.006 | 0.003 | 0.002 | 0 | 0 | 0.015 |
| P-2 | 0 | 0.001 | 0.003 | 0.006 | 0.001 | 0 | 0 | 0.011 |
| P-1 | 0 | 0 | 0.001 | 0.004 | 0.002 | 0 | 0.001 | 0.008 |
| Peak | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P+1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P+2 | 0 | 0 | 0 | 0 | 0 | 0.002 | 0.015 | 0.017 |
| P+3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.007 | 0.007 |

P denotes peak day.
WHO = World Health Organization.

It is also interesting to examine “false positives,” or how often the algorithm identifies days outside of the fertile period as fertile. This is presented in Table 3, comparing the TwoDay Algorithm with the Ovulation Method. In the prepeak phase of the cycle, the TwoDay Algorithm identifies as fertile exactly the

same days as the Ovulation Method. In almost half of cycles in the WHO data (46.5%) women noted secretions before the fertile days began (5 days before peak day). In most cycles (87.2%) secretions were first noticed ≤8 days before peak day. In the postpeak phase of the cycle, the Ovulation Method identifies as fertile the 3 days after peak day. The TwoDay Algorithm identifies just 2 days postpeak as fertile in 54.6% of cycles. A third day is identified as fertile in 11.3% of cycles. In most cycles (94.4%), ≤5 days would have been identified as fertile postpeak, using the TwoDay Algorithm. Thus, it seems that the TwoDay Algorithm identifies the infertile phase well (ie, has few false-negatives), although some days are identified as fertile when they are not (ie, false-positives).

Finally, as Table 3 shows, the TwoDay Algorithm and the Ovulation Method result in an identified fertile period of about the same number of days. That is, users of the two methods will recognize days as fertile, and abstain from unprotected intercourse to minimize the probability of pregnancy, for 9 days on average, if they use the TwoDay Algorithm and 9.7 days if they use the Ovulation Method.

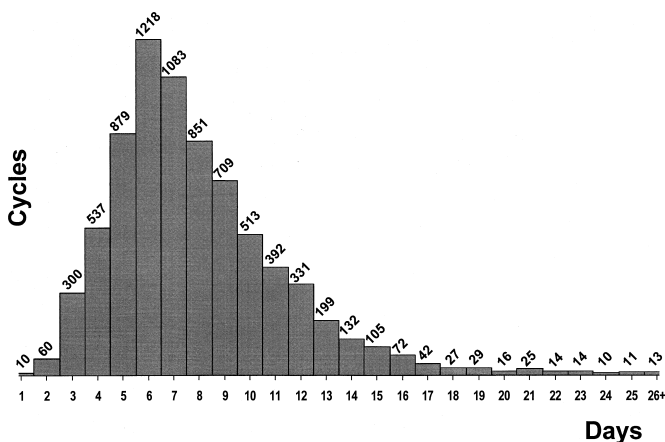


Figure 1. Total number of days with secretions in the WHO data.

Table 3. Percentage of cycles with days identified as fertile (false-positive) outside the presumed fertile window (P-5 through P+3), and mean length of the identified fertile window (WHO data)

| Cycle days outside the fertile window | Percentage of cycles considered fertile outside the fertile window | | | | | | | | | | | | Mean Identified fertile window |
|---------------------------------------|--|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------------------------------|
| | P-12 | P-11 | P-10 | P-9 | P-8 | P-7 | P-6 | P+4 | P+5 | P+6 | P+7 | P+8 | |
| TwoDay Algorithm | 3 | 5 | 8 | 13 | 20 | 31 | 47 | 27 | 6 | 3 | 2 | 2 | 9.0 days |
| Ovulation Method | 3 | 5 | 8 | 13 | 20 | 31 | 47 | 0 | 0 | 0 | 0 | 0 | 9.7 days* |

P denotes Peak day.

*Excluding Ovulation Method rules to abstain during menses and on alternate preovulatory dry days.

WHO = World Health Organization.

Discussion

By definition, all women experience secretions on peak day. Therefore, they would consider themselves fertile, and abstain from unprotected intercourse. For women using the TwoDay Algorithm the probability of conception from intercourse on peak day, then, is zero. Almost all women experience secretions on the 3 days immediately before peak day, so the probability of pregnancy, following the TwoDay Algorithm rules, is still close to zero (because couples abstain on these days).

On days P-4 (4 days before peak day) and P-5 (5 days before peak day), fewer women notice secretions, so fewer women would consider themselves fertile. However, because the probability of pregnancy from intercourse occurring this many days before ovulation is low, the estimated probability of pregnancy from intercourse on these days for women following the TwoDay Algorithm rules is still low. Actual pregnancy rates of algorithm users would be lower, because women who are not covered by following algorithm rules (and therefore calculated here as fertile) do not have secretions. And unprotected intercourse on days with no noticeable secretions is not likely to result in pregnancy, even if it is only 4 or 5 days before ovulation.¹⁶

This suggests that in the prepeak phase of the cycle, the TwoDay Algorithm would be very effective in helping couples avoid pregnancy. It is expected that the probability of pregnancy from intercourse occurring 5 and 4 days before peak day is, in fact, lower than presented here, because biology suggests that women who ovulate 2 days before peak day start having noticeable secretions earlier, so they are covered by the algorithm rules.

Because all women have secretions on peak day, if they follow the TwoDay Algorithm rules, they are all covered on the day after peak day. Even if they have no noticeable secretions on the day after peak day, when they ask themselves if they had secretions yesterday, the answer is "Yes." Therefore, they consider themselves fertile. On day P+2 (2 days after

peak day), about half of the cycles are covered by the TwoDay Algorithm rules. These are the cycles that had ≥ 1 day of secretions after peak day. Similarly, on day P+3 (3 days after peak day), the TwoDay Algorithm rules cover about one-third of cycles. These are the cycles that have ≥ 2 days with noticeable secretions after peak day.

These figures seem low, but because the probability of pregnancy from intercourse that occurs even just 1 day after ovulation is virtually nil, they translate into very low estimated probabilities of pregnancy from intercourse occurring in the postpeak phase of the cycles. The implication is that the TwoDay Algorithm rules would also be effective in helping couples avoid pregnancy in the postpeak phase of the cycle. It is expected that these probabilities are even lower, because biology suggests that if a woman ovulates after peak day, she also has secretions after peak day, so that she considers herself fertile, and abstains from unprotected intercourse for more days.

The fertile window

Most cycles (86%) have between 4 and 12 days with secretions. Cycles that have ≤ 3 days of noticeable secretions are potentially not as well covered by the TwoDay Algorithm as other cycles, because the identified fertile window is short. However, only 5% of cycles fall into this range, and only 1% of women have a mean number of days with secretions that is ≤ 3 . Also, because of the relationship between fertile mucus and the ability of sperm to fertilize an egg, a woman who has a short identified fertile window, that is, a few days of secretions, is probably fertile for a shorter number of days than a woman with more days of secretions.

Having many days with secretions means a longer fertile window, leading to a period of abstinence that may be too long to be acceptable. For some women who have many days of secretions, this is their normal pattern. The TwoDay Algorithm may not be appropriate for them. For other women, many days of

secretions may be a sign of pathology. If the TwoDay Algorithm is developed into a family planning method, these issues have to be recognized. For example, users would be instructed to see their health provider to assess the possibility of infection in the event that they have more than 12 consecutive days of secretions. Another possible confusing factor is seminal fluid. To minimize confusion between cervical secretions and seminal fluid, users should be taught to note their secretions in the afternoon and evening. Assuming that most couples have intercourse in the evening or early morning, and that most women spend their days in an upright position, this should provide enough time for the semen to exit the woman's reproductive tract.¹⁷

In conclusion, the TwoDay Algorithm appears to be a promising new approach to Natural Family Planning. It does not require literacy or numeracy, nor does it depend on regularity of cycle length. Its simplicity to teach and use would make it an extremely advantageous method in contexts where unmet need for family planning is high. If developed into a family planning method, it may offer an alternative to the Ovulation Method for couples who either have no access to the Ovulation Method or would prefer a simpler approach. Further studies are needed to determine the efficacy of the method and its acceptability to users and providers.

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