



**Warsaw University
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Estimation of a sample entropy value useful for prediction of an upcoming labour based on an electrohysterographical signal

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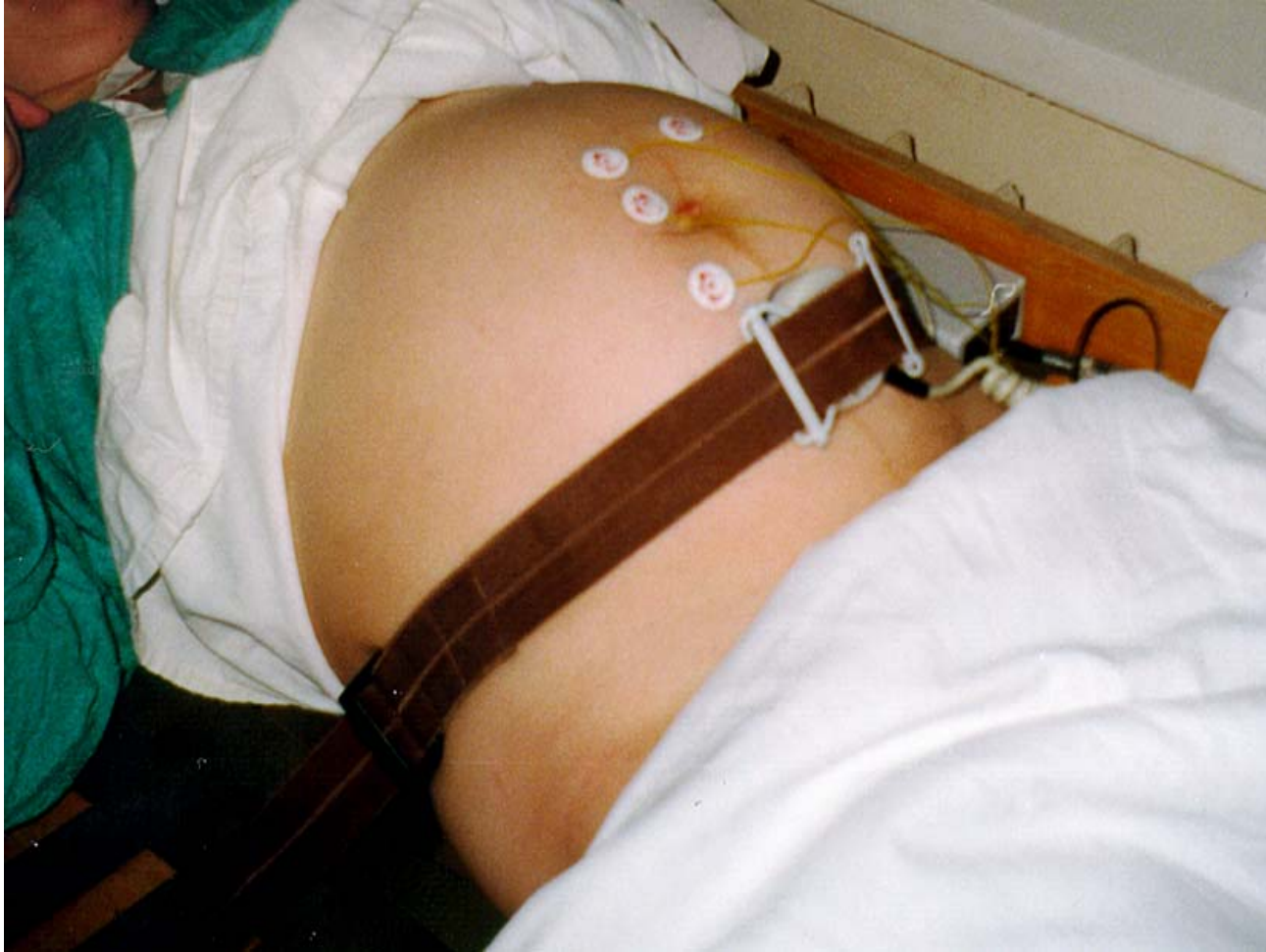
Introduction

- **A serious problem in reproductive epidemiology is still minimization of preterm labour occurrences.**
- **Monitoring of uterine mechanical contractions does not enable to predictive an upcoming labour.**
- **The complementary method is proposed which bases on monitoring of an uterine bioelectrical signal (called EHG) and its analysis using Sample Entropy Index.**
- **However, a cut off value of a Sample Entropy Index which differentiates physiological states of a pregnant uterus is still unknown.**

Aims of the study

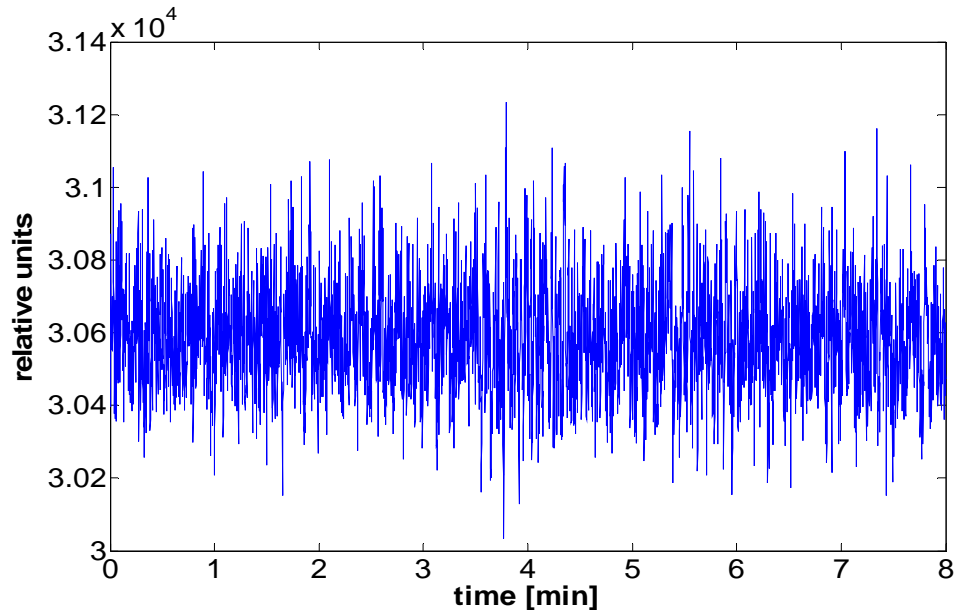
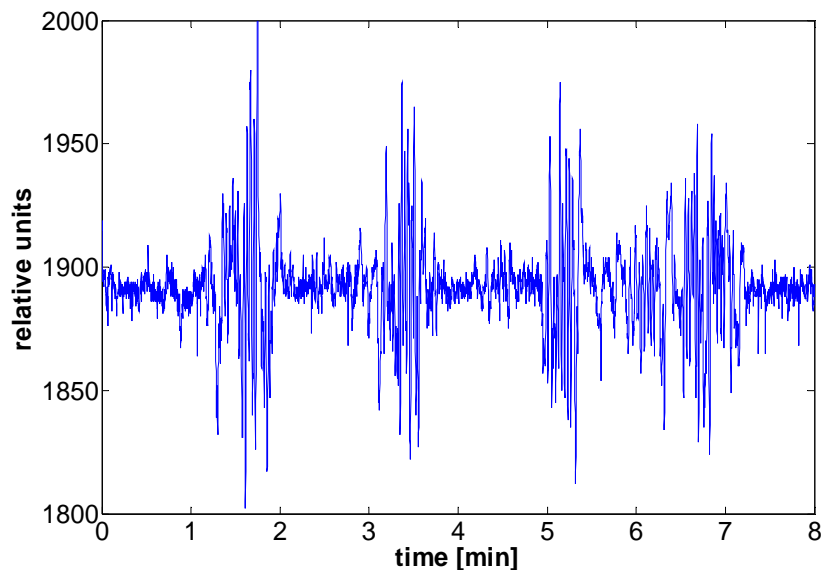
- **The goal of the perform preliminary study was to estimate such value of a sample entropy index computed for EHG which enables to differentiate between an upcoming labor and a being labor.**

The EHG measurements



Methods

- The idea supporting application of sample entropy to EHG analysis results from the observations that an electrical activity of an uterus becomes more regular when a labor is forthcoming



An example of EHG signal during a labor and during a puerperium

The sample entropy estimation

Let $x(n) = [x_1 \ x_2 \ \dots \ x_N]$ denotes N -elements time series representing EHG signal. Then, the estimation algorithm is consisted of the following steps:

(i) creating of m vectors defined as;

$$\mathbf{X}(i) = [x_i \ x_{i+1} \ \dots \ x_{i+m-1}] \text{ for } i = 1, \dots, N - m + 1$$

(ii) calculation of a distance between two vectors in the following way:

$$d_m[\mathbf{X}(i), \mathbf{X}(j)] = \max_{k=0, \dots, m-1} [|x_{i+k} - x_{j+k}|]$$

(iii) calculation of number of similar segments in two vectors:

$$n_m = \# d_m[\mathbf{X}(i), \mathbf{X}(j)] \leq r, \text{ dla } i \neq j$$

$$n_{m+1} = \# d_{m+1}[\mathbf{X}(i), \mathbf{X}(j)] \leq r, \text{ dla } i \neq j$$

where r is a tolerance parameter

(iv) calculation of similarity measures of these segments:

$$B_i^m(r) = \frac{1}{N - m - 1} n_m \text{ dla } i = 1, \dots, N - m$$

$$A_i^m(r) = \frac{1}{N - m - 1} n_{m+1}$$

(v) calculation of mean measures of the similar signal segments:

$$B^m = \frac{1}{N - m} \sum_{i=1}^{N-m} B_i^m(r)$$

$$A^m = \frac{1}{N - m} \sum_{i=1}^{N-m} A_i^m(r)$$

(vi) calculation of Sample Entropy estimation

$$\text{SamEn}(m, r) = -\ln \frac{A^m(r)}{B^m(r)}$$

The GAM for cut-off estimation

- The GAM was used to estimate a cut-off of the sample entropy value which differentiates between an upcoming labour and a labour.
- The used generalized additive model is expressed in the following form:

$$P(L = 1 | \text{SamEn}) = \frac{\exp[\alpha + f(\text{SamEn})]}{1 + \exp[\alpha + f(\text{SamEn})]}$$

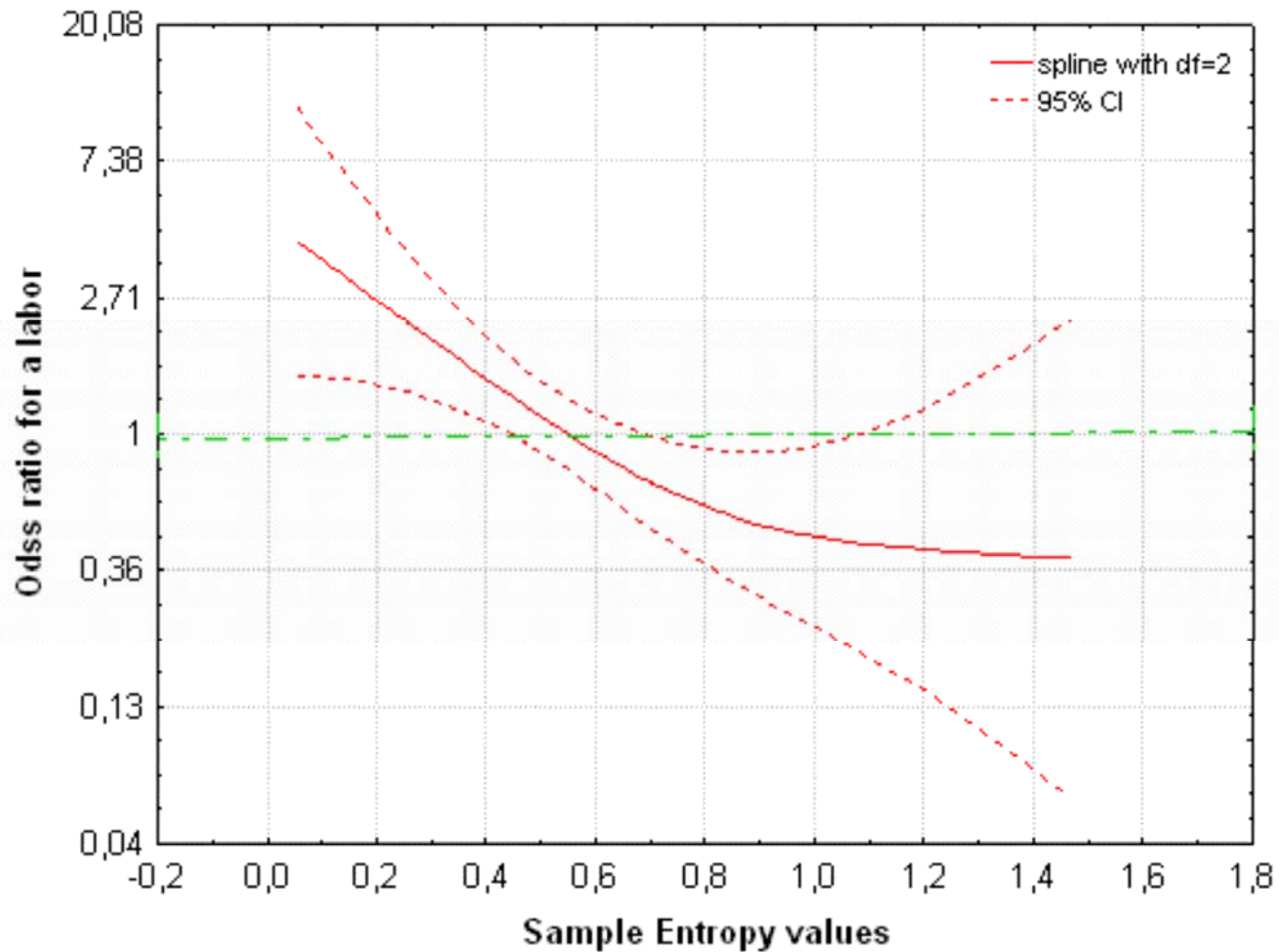
where:

L is a binary variable. $L=1$ denotes a labour occurrence
 f is an unknown smooth function estimated based on sample entropy values.

Clinical observations

- **EHG signal was registered in 49 women being in third trimester of their pregnancies without any clinical symptoms of an upcoming labour and in 31 women during a labour.**

Results



The relation between the values of sample entropy and an odds ratio for a labor.
For SamEn < 0.6 a labour risk increases.

Conclusions

- **The obtained results suggest that there is a nonlinear relation between the regularity of EHG signal measured by Sample Entropy Index and an odds ratio of a labour.**
- **It seems that values lower than 0.6 may predict an upcoming labour.**
- **An identification of factors which can affect this relation such as a patient's obesity, location of an uterus and a gestational age requires further investigations.**