INTERFERING SUBSTANCES FOR GLUCOSE SENSING BY NEAR-INFRARED SPECTROSCOPY

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Background and aims

Near-Infrared (NIR) Spectroscopy could be an alternative method to measure blood glucose concentration, with access to low-cost components and potential for non-invasive use. Possible interferents to this method are not widely investigated. We aimed to identify lactate, ethanol, acetaminophen (APAP) and caffeine for possible interference. The interferents chosen can reach high physiological levels in critical patient situations (workout, being drunk or sick), when it is critical to have correct blood glucose measurements.

Methods

Glucose and the four interferents were mixed in varying physiological concentrations and measured by NIR spectroscopy on a commercial spectrometer in vitro (details in (1), spectrum in Fig. 1). A calibration model was built by partial least squares regression (PLSR). A new measurement is multiplied with the regression vector (Fig. 1) to obtain a glucose prediction. The full set (273 spectra) was divided into subsets (59-73 spectra) where one of the interferents was left out and new models were built without knowledge of the interferent. Ten subsets with random samples were used as a reference to the smaller calibration sets of the interferents. All models were applied to a validation set containing all interferents in varying concentrations with an I-optimal model.

To verify the results with biological samples, porcine intraperitoneal fluid (IP) samples were spiked with glucose and lactate in supra-physiological concentrations and measured at a lab setup (1). 38 mixtures were measured, where 18 did not contain lactate.

Results

The models built without ethanol and caffeine had high errors and several points outside of zone A and B in the Clarke Error grid. The model without lactate mistook lactate for glucose and gave false high predictions with a dose response of 0.46 mM/mM. The model without ethanol gave lower glucose predictions with increasing ethanol concentration with a dose response of -0.43 mM/mM. The models without APAP and caffeine were comparable to the random subsets. The dose response for lactate found using the same analysis on the IP samples was 0.56 mM/mM (95% confidence interval [0.49,0.63]), confirming the general trend.

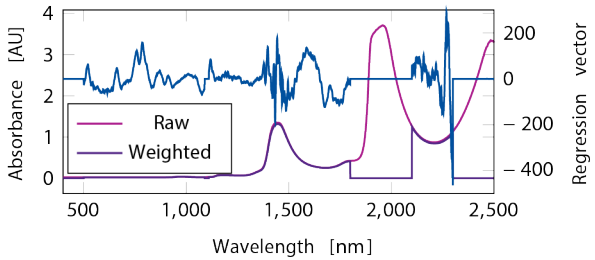

Figure 1: Left y-axis; Example spectra acquired, dominated by water absorption. Right y-axis (blue); regression weights for the full model.

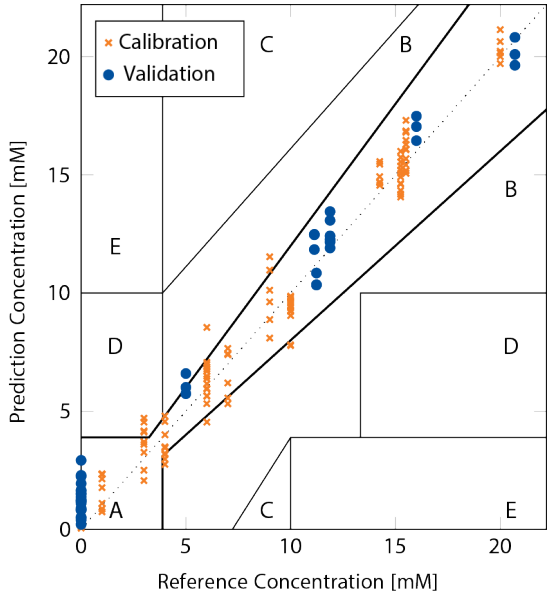

Figure 2: Clarke Error plot grid for the full calibration set.

Table 1: Percentage of points in the validation set in the zones of the Clarke Error grid.

Model	A	B	C	D	E
Full	97.5%	2.5%	-	-	-
Random subset (avg.)	88.0%	9.1%	-	2.8%	-
No lactate	44.4%	48.1%	-	7.4%	-
No ethanol	38.3%	18.5%	-	32.1%	11.1%
No APAP	85.2%	14.2%	-	-	-
No caffeine	91.4%	7.4%	-	1.2%	-

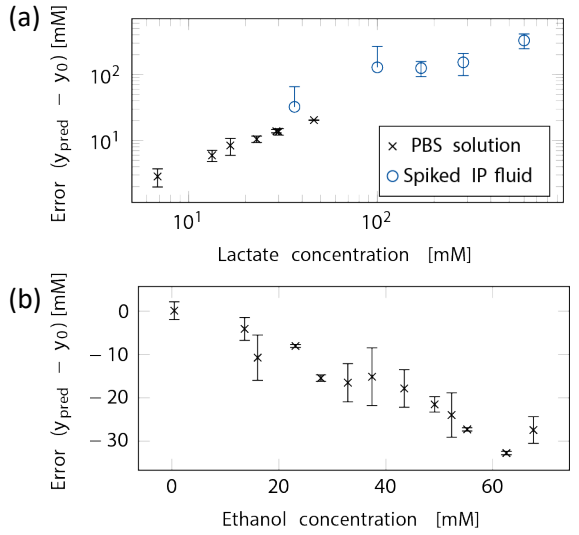

Figure 3: The absolute error of the predictions from the glucose models without (a) lactate, and (b) ethanol.

Conclusions

Lactate and ethanol interfere with glucose prediction by NIR spectroscopy if not included in the model calibration. APAP and caffeine are not interferents to glucose using NIR spectroscopy, showing an advantage to using NIR spectroscopy over common amperometric devices where APAP is a known interferent (2).

Acknowledgements: Thanks to Bjørg Narum, Harald Martens and Ine Jernelv. Funded by Norges Forskningsråd (248872); Helse Midt-Norge (46055510).

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