Deacon's Challenge No. 45 Answer

It is suspected that the glucose results obtained with a near patient testing (NPT) device on the ward are positively biased. One of the investigations into the problem involves analysing a series of blood specimens on both the NPT device (A) and an analyser in the laboratory which measures whole blood glucose (B), with the following results:

		A	B
		Blood glucose (mmol/L)	
Specimen	1	4.5	4.2
	2	6.8	7.0
	3	3.2	2.8
	4	5.8	5.6
	5	8.9	8.7
	6	9.5	9.7
	7	4.8	4.9
	8	7.3	6.8
	9	5.1	4.6
	10	7.8	7.7

Do these results support the suspicion of bias?

The variability of the results in groups A and B are due to differing glucose concentrations in the specimens and to the analytical variation between the instruments. Therefore a standard t-test comparing the means of both sets of results would be inappropriate for comparing the analytical performance of method B with method A. As the data are paired, i.e. the same samples were assayed by both instruments, a paired t-test can be used.

Calculate the difference (x) between each pair of results: $x = A - B$

A	B	x	x^2
Blood glucose (mmol/L)			
4.5	4.2	0.3	0.09
6.8	7.0	-0.2	0.04
3.2	2.8	0.4	0.16
5.8	5.6	0.2	0.04
8.9	8.7	0.2	0.04
9.5	9.7	-0.2	0.04
4.8	4.9	-0.1	0.01
7.3	6.8	0.5	0.25
5.1	4.6	0.5	0.25
7.8	7.7	0.1	0.01
		$\sum x = 1.70$	$\sum x^2 = 0.93$

If there is no bias then the differences between each pair of results (x) would be very small and on average would be very close to zero. A paired t-test is used to compare the mean difference (i.e. the mean of x) with a hypothetical value of zero taking into account the standard error of the values of x. The mean and standard error of the difference is calculated in the usual way:

$$\text{Mean} = \frac{\sum x}{n} = \frac{1.70}{10} = 0.17 \text{ mmol/L}$$

$$\text{Variance} = \frac{\sum (x - \text{mean})^2}{n - 1} = \frac{\sum x^2 - (\sum x)^2 / n}{n - 1}$$

$$= \frac{0.93 - 1.7^2 / 10}{9} = \frac{0.93 - 0.289}{9} = 0.0712$$

i.e. assuming a Gaussian distribution the differences in results between the two instruments (x) belong to a distribution in which the mean is 0.17 mmol/L and the variance is 0.0712.

$$\text{Standard deviation of } x = \sqrt{\text{Variance}} = \sqrt{0.0712} = 0.267 \text{ mmol/L}$$

$$\text{Standard deviation of the mean (standard error)} = \frac{\text{Standard deviation}}{\sqrt{n}}$$

$$= \frac{0.267}{\sqrt{10}} = \frac{0.267}{3.16} = 0.0845 \text{ mmol/L}$$

$$\text{Paired } t = \frac{\text{Mean} - 0}{\text{Standard error}} = \frac{0.17 - 0}{0.0845} = 2.01$$

From a table of t, the probability of obtaining a value for t of 2.01 for 9 degrees of freedom (i.e. n - 1) by chance if there is no significant difference between the methods is greater than 0.05 (since for 9 degrees of freedom tables give a p value of 0.05 when $t = 2.262$). Therefore the data show no significant difference in the results obtained with the two instruments and do not support the suspicion of bias.

Exam tip: Most modern pocket calculators allow the direct calculation of mean and standard deviation upon entering a series of individual values. ■

Question 46

A plasma contains 140 mmol/L of sodium and 95% water by volume. Neglecting sodium binding by plasma proteins, calculate the apparent plasma sodium concentration determined from measurements with an electrode system which responds to water sodium (a) in undiluted plasma, and (b) in plasma diluted 1 in 20 with water.