Reliability and validity of portable lactate analysers?

David Bishop Ph.D.
Western Australian Institute of Sport.

Purpose: It has been suggested that lactate concentrations may provide a guide to an optimal training intensity. However, lactate concentrations established during incremental exercise in the laboratory are not always indicative of what is occurring during constant-load exercise at the same intensity. Ideally, lactate concentrations should be measured during a training session and immediately reported to the athlete to ensure that the athlete is working at the desired intensity. The purpose of this investigation was, therefore, to determine the reliability and validity of a compact, portable lactate analyser (ACCUSPORT; Boeringer Mannheim, Castle Hill, Australia). **Methods:** A total of 224 capillary blood samples were taken from 25 athletes who took part in routine laboratory testing. Seventy-three of these capillary blood samples were analysed in duplicate with the Accusport for determination of intraclass, single-trial reliability. Day-to-day reliability of the Accusport was assessed by measuring known concentrations of aqueous lactate solutions every day for seven days. The validity of the Accusport analyser was assessed by comparing the 224 capillary blood lactate concentrations determined on the Accusport with the lactate concentration obtained using a MICRO STAT LM3 (Analox Instruments Ltd., London, GB). In addition, lactate parameters derived from the lactate concentrations obtained with the two analysers were compared. **Results:** The Accusport showed high single-trial reliability (R=0.992; Standard Error of Measurement (SE_M) = 0.2 mmol·l^{-1}; n = 73) and high day-to-day reliability (R=0.997; SE_M = 0.2 mmol·l^{-1}; n=42). Despite a strong correlation between blood lactate concentrations obtained on the two analysers (r=0.96; n=224) the limits of agreement were $^{+}$1.9 to $^{-}$2.2 mmol·l^{-1}. Although the mean values for power output, HR and lactate concentration associated with the lactate parameters were not significantly different when determined on the Accusport or Micro Stat, some individuals did record large differences between analysis methods. **Conclusion:** In summary, the results of this investigation have shown that lactate concentrations can be reliably determined within a single trial and from day-to-day using the Accusport analyser. It is not valid to compare lactate concentrations determined on the Accusport with lactate concentrations determined using the Micro Stat LM3 lactate analyser. Due to differences between the analysers, it is recommended that to more precisely control training intensity in the field that a threshold should first be determined in the laboratory using an established laboratory analyser (eg. Micro Stat). Blood samples taken at two to three workloads around the expected threshold power output should also be analysed on the Accusport. This would allow the user to determine an Accusport lactate value at the threshold power output determined using the laboratory analyser. As the Accusport has been shown to reliably measure lactate concentration, this Accusport lactate value could then be used in the field to monitor training intensity.

To obtain optimal training effects, and to prevent overtraining, it is important to monitor and control the intensity of training. While many athletes use a heart rate monitor, there are a number of limitations that need to be taken into account when using heart rate to control training intensity. For example, a rider's position on the bicycle may change heart rate at a constant intensity.

A more important limitation is the increase in heart rate over time, a phenomenon known as 'cardiac drift'.

An alternative marker of training intensity is the lactic acid concentration in the blood. Until recently however, lactic acid measurements have only been available within the laboratory environment. In order to be most applicable, blood lactate information should be made available to the athlete as soon as possible, preferably during the training session. The recent development of compact, portable, lactate analysers (e.g., Accusport and Lactate Pro) now allows coaches, athletes and physiologists to gain immediate measurement of lactate concentrations in the field. It is common practice for results obtained in the field to be compared with lactate concentrations determined in the laboratory. Therefore, it is crucial that the two methods produce similar results.

The purpose of this investigation was to determine the validity and reliability of the Accusport analyser. Blood lactate concentrations were determined on the Accusport and then compared with the blood lactate concentration obtained using a common laboratory lactate analyser (Micro Stat LM3). Blood samples were analysed in duplicate to assess the reliability of lactate measurements obtained with the Accusport. Lactate threshold (LT) estimates obtained from the Accusport and Micro Stat were also compared to determine whether the Accusport could be used to determine the LT in the field.

Results

Validity of lactate measurements.
There was a strong correlation (r = 0.96; *P*<0.05) between blood lactate concentrations obtained with the two methods of measurement. Despite the strong correlation, 95% of the lactate concentrations obtained with the Accusport ranged from 1.9 mmol·l^{-1} above to 2.2 mmol·l^{-1} below the lactate concentrations obtained with the Micro Stat (Figure 1).

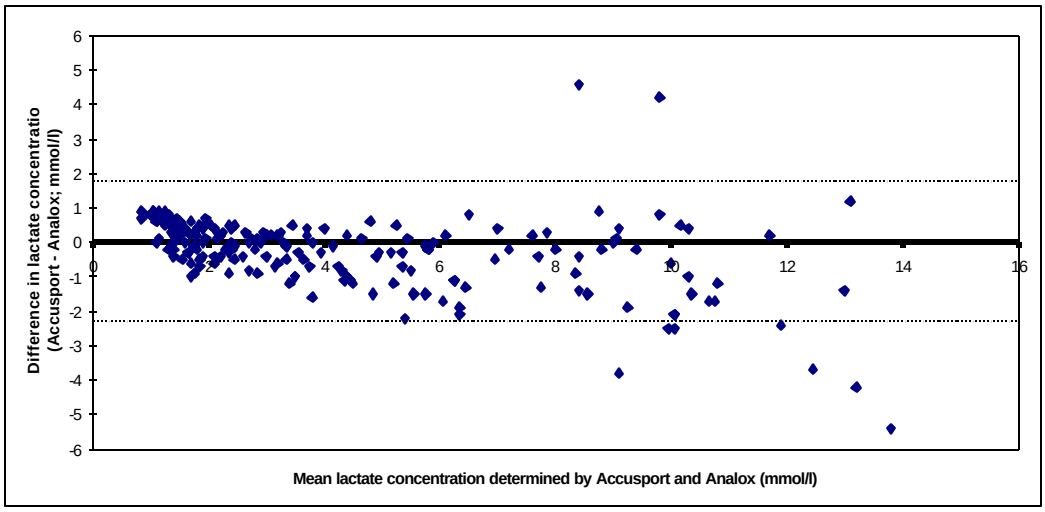

Figure 1. Bland-Altman plot showing relationship between mean lactate concentration determined by both analysers (x-axis) and the difference in concentration between analysers (y-axis).

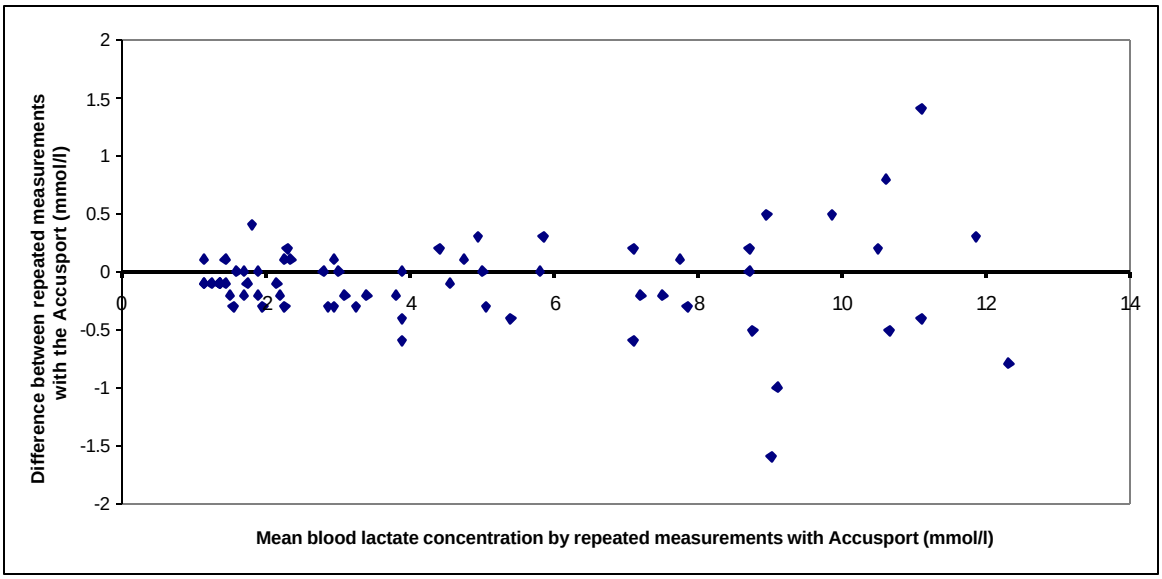

Figure 2. Variation in blood lactate concentrations determined on the Accusport as a function of mean blood lactate concentration

Single-trial reliability.

The Accusport was found to have very high single-trial reliability (R=0.99; SE_M = 0.2 mmol·l^{-1}). In addition, 95% of repeated measurements on the Accusport were within 0.4 mmol·l^{-1} of the initial measurement (Figure 2).

Day-to-day reliability.

The Accusport was found to have very high day-to-day reliability when using the same standard lactate solutions each day for seven days (R=0.99; SE_M = 0.2 mmol·l^{-1}).

Validity of lactate threshold determination.

The exercise intensity, heart rate and lactate concentration corresponding to the LT (first rise in lactate concentration above resting value), was significantly higher when determined with the Accusport than when determined with the Micro Stat (Table 1).

Table 1. Means (± SD) for the power output, heart rate and lactate concentration associated with the LT for both analysers. Also reported is the mean difference and difference range between the two analysers. *P< 0.05

	Power output (watts)	Heart rate (beats·min^{-1})	Lactate concentration (mmol·l^{-1})
Analox	105.5 ± 39.2	144 ± 13	1.3 ± 0.3
Accusport	120.1 ± 48.1*	150 ± 10*	1.9 ± 0.2*
Mean Difference	17.4 ± 16.6	7 ± 7	0.6 ± 0.3
Difference Range	-53.7 - 22.7	-18 - 5	-1.2 - 0.1

Discussion

Consistent with previous studies (2,5), there was a strong correlation (r=0.96) between blood lactate concentrations obtained using the Micro Stat and the Accusport analyser. While these results suggest that the two methods are strongly associated, a strong correlation is not a valid measure of how closely lactate concentrations determined with the two analysers agree. To overcome this limitation, a Bland-Altman plot was used to quantify the level of agreement between the two analysers. This revealed that despite the strong correlation, 95% of lactate concentrations obtained with the Accusport ranged from 1.9 $mmol.l^{-1}$ above to 2.2 $mmol.l^{-1}$ below the lactate concentration obtained with the Micro Stat. This is similar to the limits of agreement ($^{+}$2.1 to $^{-}$2.6 $mmol.l^{-1}$) reported in a previous study comparing the Accusport analyser with a YSI 2300 Stat analyser (1).

The Accusport can therefore result in under or overestimations of the blood lactate concentration (see Figure 1) and hence training intensity in some athletes. While an optimal training intensity is yet to be established, it has been suggested that for continued improvements in endurance capacity, some training must be above LT (4). Furthermore, it has been reported that athletes who performed their aerobic training at too intense a level exhibited decrements in performance (3). Caution therefore needs to be exercised if using the Accusport to control training intensity.

Repeated measurements of lactate concentration with the Accusport on two samples drawn at the same time showed high reliability (R=0.996) and a low SE_M (0.2 $mmol \cdot l^{-1}$). While the Accusport does show high single-trial reliability, its reliability appears to decrease as the lactate concentration increases. The Accusport was also found to have very high day-to-day reliability when using the same standard lactate solutions each day for seven days (R=0.998; SE_M = 0.2 $mmol \cdot l^{-1}$; n = 42). Thus, the Accusport analyser is able to reliably measure lactate concentration within one day and from day to day.

In addition to monitoring training intensity, Accusport analysers are also be used to determine LT in the field. The results of this study indicate that the power output, HR and lactate concentration associated with LT is overestimated when the lactate concentration is determined on an Accusport analyser. This can probably be attributed to an overestimation of low lactate concentrations (i.e., < 2 $mmol \cdot l^{-1}$) by the Accusport (Figure 1). Thus, it does not appear valid to determine LT with the Accusport analyser.

Conclusions

1) Lactate concentrations can be reliably determined within a single trial and from day to day using the Accusport analyser.
2) While there is a strong association between blood lactate concentrations obtained using the Accusport and Micro Stat analysers, 95% of lactate concentrations obtained with the Accusport range from 1.9 $mmol \cdot l^{-1}$ above to 2.2 $mmol \cdot l^{-1}$ below those obtained with the Micro Stat. It is not valid to compare lactate concentrations determined on the Accusport with those determined using the Micro

Stat LM3 lactate analyser

3) It is also not valid to determine the LT with the Accusport analyser. It is recommended that to more precisely control training intensity in the field that LT should first be determined in the laboratory. Blood samples taken at two to three workloads around the expected threshold should also be analysed on the Accusport. This would allow the user to determine an Accusport lactate value at the threshold determined using the laboratory analyser. As the Accusport has been shown to reliably measure lactate concentration, this Accusport lactate value could then be used in the field to monitor training intensity.

References

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