The Accuracy of Traditional Manual Methods of taking Equine Heart Rates, when compared with Electronic Methods, using a Polar Heart Rate Monitor

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Tania Churchill and Ben Wisbey

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Contents

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- Ben Wisbey (ACTAS Sports Scientist)
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1. Abstract

Five dressage trained horses each conducted two trials, each trial consisted of a warm up, then the preliminary 1F dressage test was ridden. This test takes approximately six minutes to complete. Heart rates were taken at two minutes, four minutes, and six minutes intervals during the test. Recovery heart rates were taken at two minutes, four minutes, six minutes and ten minutes intervals after the completion of the test. Two different manual methods of taking heart rates- counting the beats with a stethoscope for 10 (BPM10) and 30 seconds (BPM30)- were compared to an electronic method using a Polar heart rate monitor (POLAR). The manual raw data was multiplied by the appropriate number to convert it into beats per minute (bpm). The electronic and manual data were entered into a spreadsheet, and analysed statistically using SPSS statistical package. The mean value for data recorded for BPM10 was 49.8. For BPM30 the mean is 46.25. The mean for POLAR is 63.6. The difference between the following pairs; BPM10 and BMP30; BPM10 and POLAR; and BMP30 and POLAR, were all shown to be statistically significant, using a paired samples *t* test (α =0.05). The results show that the higher the heart rate measured by POLAR, the more inaccurate the manual methods become. BPM10 and BPM30 are reasonably accurate to values of 40bpm; at values over 60bpm they become increasingly inaccurate. BPM10 is slightly more accurate the BPM30, particularly in values over 40bpm.

2.0 Introduction

Heart rate is a major variable that is frequently determined when evaluating athletic horses during exercise and recovery (Evans, 2000). Therefore, establishing a reliable means of measurement of heart rate is of great importance.

Heart rate is the number of times the heart beats per minute. There is a close relationship between oxygen uptake and heart rate, allowing the use of heart rate to assess the demand the exercise is placing on the horse. Heart rate increases proportionally to work (Evans, 1985). Heart rate monitoring is one of the most reliable and widely used methods on non-invasively evaluating the physiological demands experienced by a horse during a training session (McKeever 1989).

Monitoring of heart rates is a common practice in most aspects of the equine sports industry. Until recently, a horse's heart rate could only be measured manually, usually with the use of a stethoscope and a watch. Modern technology has led to the development of several electronic heart rate monitoring devices that measures the time between electronic pulses of the beating heart. The Polar heart rate monitor, which is used in this research, uses two electrodes for measurement, one placed on the left side of the withers, and the other at the girth on the left side of the horse. This allows an instantaneous measurement of heart rate to be displayed to a heart rate receiver attached to the rider's wrist (Craig and Nunan 1998).

It is proposed that all forms of manual heart rate assessment are inaccurate, leading to false analysis and conclusions during training. If modern scientific training principles are to be applied in day to day training, an accurate method of assessing heart rate needs to be established.

The heart monitor used to assess actual heart rate was a Polar Horse-Trainer transmitter with a Polar Accurex Plus receiver. This transmitter was shown to have a significant correlation ($p<0.001$) with the telemetric ECG determination of heart rate (Holopherne, et. al. 2000) when used on horses at varying heart rates.

This research was conducted to meet an absence of available data on the accuracy of manual heart rate evaluation methods. As it is believed that the majority of heart rate measurements in the equine industry are still done by the use of a number of manual methods, it is important that the accuracy of this method be assessed. This has practical implications in the industry. Are heart rates worth monitoring if only manual methods are available?

Two common methods for obtaining manual heart rates involve counting the number of beats heard with a stethoscope for a timed period of ten, or thirty seconds. The resulting value is then multiplied by the appropriate number to express the value in beats per minute (bpm).

Heart rates can drop considerably in 30 seconds once exercise has ceased (Ackland 1998). It is therefore proposed, that by counting the heart beats for thirty seconds, an average will be obtained, as during those thirty seconds, the heart rate can drop considerably. This would also be true, to a lesser extent, when counting the beats for ten seconds. As it is important to gain a picture of the horses heart rate whilst it is working at a particular intensity, it can be seen that taking a manual heart rate over ten or thirty seconds is likely to be less useful than the instantaneous result that the electronic heart rate monitor can provide.

Although the racing industry uses heart rates extensively as a training tool, up till now the use of such technology in the sport of dressage has been very limited. Dressage is a very popular equestrian sport, and Australia is gradually becoming more competitive as a nation. It is believed that scientific training principles will become increasingly prevalent in the dressage industry over the next few years. To facilitate this, studies need to be done focusing on the area of dressage. For this reason, the study examined the accuracy of manual heart rate methods during the course of a dressage test. Due to the type of work involved in a dressage test, all heart rates were below 125bpm.

3. Method

The hypothesis was tested using a repeated measures test: one group design.

3.1 Subjects:

5 horses were used, three geldings and two mares. Ages ranged from 8-16. All horses were trained for dressage.

3.2 Materials:

Polar Heart Rate Transmitter

Polar Accurex Plus Receiver, with tape over the first digit of the heart rate

Polar Advantage Interface System 2.01

Stethoscope

Watch

Pen and paper to record results

Preliminary 1F dressage test

3.3 Data collection:

1. Each subject underwent a normal warm-up before the trial commences.
2. Each trial consisted of two phases- the dressage test and the warm-down.
3. The dressage test performed was the Preliminary 1F test
4. Warm-down consisted of a walk on a loose rein
5. Heart rates were taken at the following intervals during the dressage test:
    - 2 minutes
    - 4 minutes
    - 6 minutes

6. During the warm-down, heart rates were taken at the following intervals:

- 2 minutes
- 4 minutes
- 6 minutes
- 8 minutes
- 10 minutes

The rider wore a watch set to alarm to signal each two-minute interval

7. The following heart rate variables were recorded:

- Manual for 10 secs (BPM10)
- Manual for 30 secs (BPM30)
- Electronic, using the Polar Horse-Trainer Heart Rate Monitor (POLAR)

8. To take each heart rate the procedure was as follows:

- rider dismounted
- rider pressed the button on the heart rate watch (receiver) to record the electronic heart rate
- the watch was taped over the first digit of the heart rate readout, so the rider was not aware of the digital heart rate recorded
- rider found the horses heart beat, using the stethoscope positioned on the left ride of the girth
- rider counted the heart beats for 10 seconds (timed on watch) and recorded result with pen and paper. Rider continued to count until beats were counted for a total of 30 seconds.

9. After heart rates were recorded, rider remounted and continued from where the test ceased.

3.4 Data Analysis

The Polar heart rate receiver was downloaded by way of the Polar Advantage Interface System onto Polar Precision Performance software 2.1 to enable heart rate analysis. The heart rate at the set time periods was recorded into Microsoft Excel.

The raw data from the 10 and 30 second measurements were also entered into an Excel spreadsheet after the conclusion of each trial. Once all the raw data was collected, heart rates were converted to beats per minute before being transferred to the SPSS statistical package (Student Version). Using SPSS, descriptive statistics for each variable were calculated; mean, range and standard deviation.

Three two-tailed t tests were conducted, for non-independent or paired samples. The confidence level chosen was 95%, or $\alpha = 0.05$. Degrees of freedom were 74 for the first two tests, and 79 for the third.

The *t* tests determined whether the differences between the means of each method of heart rate measurement were statistically significant. The first *t* test compared the means of the 30-second manual method (BPM30) with the Polar electronic method (POLAR). The second test compared the 10-second manual method (BPM10) with the baseline- the Polar electronic measurement (POLAR). The third test compared the two manual methods (BPM10 and BPM30). A comparison of each pair of variables was graphed, using SPSS software. Scattergrams were created to display the information graphically and allow for a visual interpretation through a range of values.

4. Results

The mean for each variable is shown is table 1. The means for BPM10 and BPM30 are relatively similar, while the differences between the means of BPM10 and BPM30 to that of POLAR are much greater. The standard deviation for POLAR is higher than BPM10 by 10.66, and higher than BPM30 by 12.02.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
BPM10	80	30	72	49.80	8.67
BPM30	80	26	60	46.25	7.31
POLAR	75	25	125	63.60	19.33
Valid N (listwise)	75				

Table 1. Descriptive statistics of the three variables

The paired samples *t* test results are shown in Table 2. The results show that for the given confidence level (α =0.05), the difference between the means for BPM30 and POLAR are statistically significant. The mean for POLAR is significantly higher than the mean of BPM30.

The difference in the means for BMP10 and POLAR are also statistically significant; again, the mean for POLAR is significantly higher than the mean for the manual measurement, in this case BPM10 (see table 2).

For a 95% confidence level, the difference between the means of the two manual methods; BPM10 and BPM30 are statistically significant. The mean for BPM10 is significantly higher than the mean for BPM30 (see table 2).

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	BPM30 - POLAR	-17.36	15.99	1.85	-21.04	-13.68	-9.404	74	.000
Pair 2	BPM10 - POLAR	-13.68	13.99	1.62	-16.90	-10.46	-8.470	74	.000
Pair 3	BPM10 - BPM30	3.55	5.00	.56	2.44	4.66	6.349	79	.000

Table 2. Paired Sample T-test Results

The scattergram graph of the results (see figure 1) shows that the higher the heart rate recorded by the Polar heart rate monitor (POLAR), the more inaccurate the manual method (BPM30) becomes. At a heart rate of 40bpm, the manual method is reasonably accurate. However, at 60bpm and over, BPM30 becomes increasingly lower than the POLAR value.

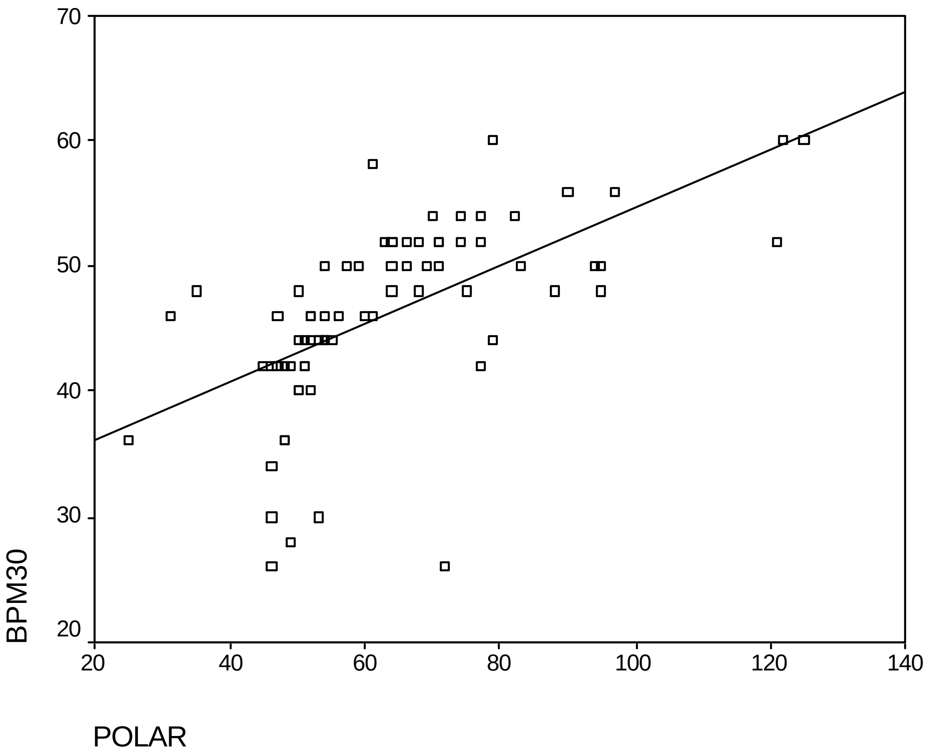

Figure 1. Scattergram: Polar vs. 30-second measurement

The graph comparing POLAR with BPM10 shows a similar trend, if less exaggerated, to that of figure 1. It can be seen that BPM10 is reasonably accurate at heart rates of 40 as measured by the Polar heart rate monitor. At 60BPM and above, BPM10 becomes increasingly inaccurate.

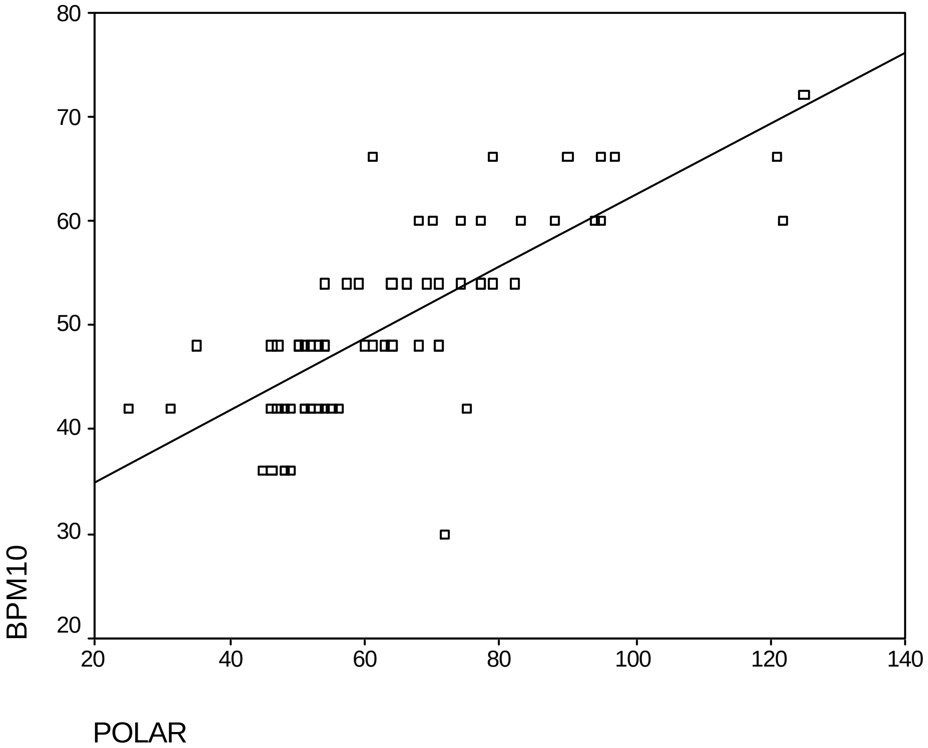

Figure 2. Scattergram: Polar vs. 10-second measurement

Figure 3 allows a comparison of the accuracy of BMP10 and BPM30 to be made, against the baseline of POLAR. It can be seen that BPM10 is more accurate than BPM30 for POLAR heart rates of over 40bpm. The difference between BPM10 and BPM30 becomes more pronounced in the higher heart rate ranges of 100 to 120 bpm.

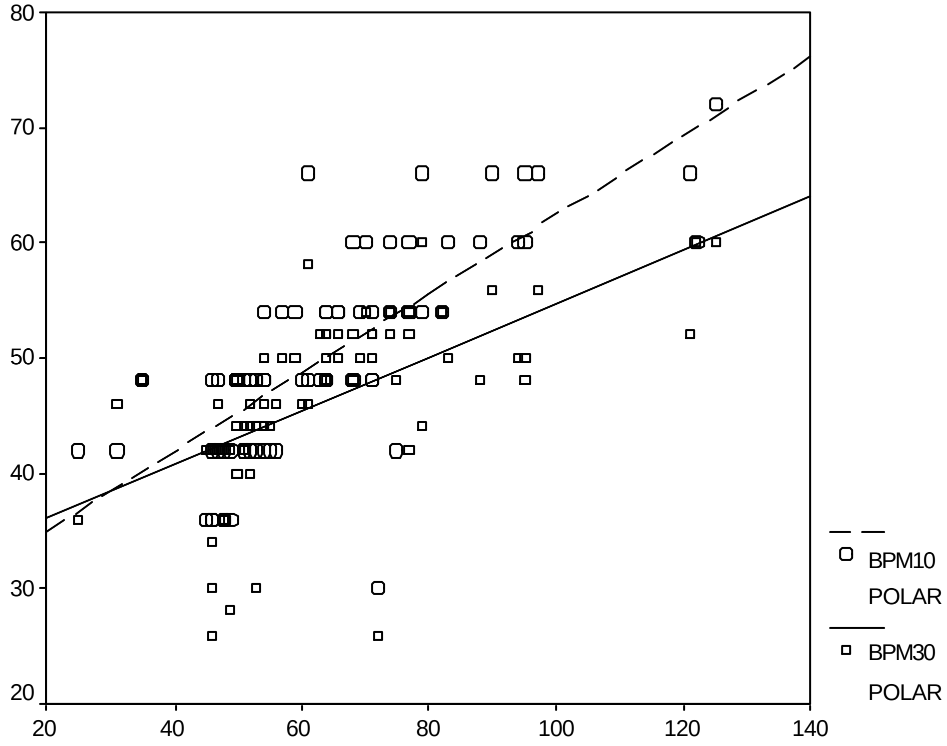

Figure 3. Scattergram: Polar vs. 10-second and 30-second measurement

5. Discussion

The results show that there is a statistically significant difference between the heart rates obtained by manual methods, when compared to heart rates obtained by the use of an electronic heart rate monitor. Both manual methods resulted in means that were significantly lower than those obtained using the Polar heart rate monitor.

The manual methods became increasingly inaccurate at higher heart rates. This is consistent with the literature which states that heart rates can drop considerably in 30 seconds once exercise has ceased. Heart rates may in fact be less than half their initial value (Ackland 1998). Similarly, Krzywanek et al. (1970) demonstrated the rapid speed with which equine heart rate varies by finding that heart rates reached maximal levels from rest in an average of 22 seconds in race horses.

Thus, by counting the heart beats for thirty seconds, an average for this period will be obtained, as during those thirty seconds, the heart rate can drop considerably. This is also true, to a lesser extent, when counting the beats for ten seconds. The results reflect this, showing that BPM30 is more inaccurate that BPM10, particularly in the higher heart rate ranges of 100-120bpm. It can be expected that heart rate will decrease with greater rapidity from ranges such as 100-120bpm, as compared to ranges of 40-60bpm. The results lend support to this supposition.

The manual method of obtaining heart rates usually requires the rider to dismount to take the reading. This was the process that was used in this study. Observations suggest that heart rate drops significantly once the rider dismounts, even if the horse was only walking when the rider dismounted. In an attempt to minimise the bias this creates, the POLAR recording was taken immediately after the rider dismounted, immediately followed by the manual recordings. However, it is likely that the heart rate continued to drop during the manual readings. A study that obtained manual measurements while mounted would therefore be very interesting. This could be achieved by having a helper to take the manual heart rate while the rider remained mounted.

The study design included adequate warm-up time for all subjects before commencement of the trial. A sufficient warm-up results in an increase in heart rate and oxygen transport to working muscles. If exercise is not preceded by a warm-up, heart rate will only increase slowly to reach its maximum value after 2-4 minutes during maximal exercise (Evans and Rose, 1988 quoted in Evans, 2000).

This study looked at heart rate values with a range of 25-125bpm (POLAR). It can be expected that for heart rate values in excess of 125 bpm (heart rates in excess of this level would be found in most medium intensity workouts, for most equine sports with the possible exception of dressage) the accuracy of manual methods when compared with electronic methods would be further decreased. This is due to an expected larger decrease in heart rate during the 10/30 second monitoring period. Further studies into this area would be of benefit.

During the trials, a number of problems associated with both the manual and electronic methods of determining heart rate became apparent. Problems associated with the manual method include the following:

- the need to dismount to take each reading. This reduced the practicality of this method
- at lower heart rates it is sometimes difficult to hear the heart beat, particularly in windy condition
- measurements sometimes need to be re-started if the horse moves, interfering with the ability to hear the heart rate
- Using the BPM10 method , an error of one beat in recording translates to an error of 6bpm. Only multiples of 6 are able to be calculated

- Using the BPM30 method, an error of one beat in recording translates to an error of 2bpm

Problems associated with the electronic method of obtaining heart rate include the following:

- some measurements are not recorded due to drop out or interference
- it is sometimes difficult to gain a reading, necessitating manipulation of the position of the electrodes. This problem mainly occurs in cold weather, when the horse is not sweating, creating difficulties in maintaining conduction with the electrode

6. Conclusion

The main advantage of manual methods of obtaining heart rates will always be the accessibility of this method to the largest number of people, due to its inexpensive nature, and ease of use in terms of the limited knowledge required. The results of this study indicate however, that it is not a suitable method for serious competitors wishing to maximise performance.

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8.0 APPENDICES

8.1 Raw Data

Bpm for 10sec Sample	Bpm for 30sec Sample	Bpm for Polar HRM
66	58	61
72	60	125
60	52	68
42	46	56
42	44	54
36	42	48
36	42	45
42	46	31
54	54	82
66	60	79
60	54	74
48	40	50
48	48	35
42	38	18
48	40	50
42	44	.
54	52	.
66	56	97
48	46	.
48	44	50
48	44	51
42	42	47
48	42	46
42	40	52
48	50	71
54	52	.
54	50	69
48	44	54
48	48	50
42	36	48
42	44	52
42	42	51
30	26	72
36	36	48
42	30	53
36	26	46
36	30	46

	36	28	49
	42	34	46
	42	36	25
	42	48	75
	60	60	122
	60	50	83
	54	54	77
	54	52	74
	60	54	70
	48	48	68
	54	52	66
	66	48	95
	66	52	121
	54	44	79
	48	52	71
	54	52	64
	48	52	63
	54	50	64
	54	50	66
	54	52	71
	60	50	94
	48	48	64
	48	46	60
	48	46	61
	48	44	53
	42	42	51
	42	42	49
	60	48	88
	60	50	95
	60	52	77
	54	50	59
	54	50	54
	48	46	52
	48	46	47
	48	44	53
	54	42	77
	66	56	90
	48	52	64
	54	50	57
	42	44	55
	48	46	54
	48	44	54
	48	46	52
Mean	**50**	**46**	**63**

8.2 1F dressage test

Preliminary 1F

Average Time: 6 mins

		TEST
1	A X	Enter working trot Halt- Immobility- Salute Proceed at working trot
2	C B E	Track right Turn right Turn left
3	AC	Serpentine 3 loops each loop a half 20m circle
4	C HXF	Working trot Change rein
5	A KR R	Medium walk Change rein in free walk on a long rein Medium walk
6 between	M C&H	Working trot Working canter left lead
7	S SR	Circle left 20m Half circle 20m diameter and straight on
8	C HXF	Working trot Change rein showing a few lengthened strides
9 between	F A&K	Working trot Working Canter right lead
10	V VP	Circle right 20m Half circle 20m diameter and straight on
11	A KXM M	Working trot Change rein showing some lengthened strides Working trot
12	CHE EX X G	Working trot Half circle left 10m Down centre line Halt- Immobility- Salute

(Test taken from James, 1998)