To Compare the Effects on Blood Glucose of Two Different Carbohydrate Beverages Taken by Elite Triathletes During Triathlon Time Trials

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1. BACKGROUND AND STATEMENT OF THE PROBLEM.

Fluid and carbohydrate replacement is an important factor during prolonged exercise, since performance may be limited by glycogen depletion, decreased blood sugar and dehydration.

Many studies Costill and Hargreaves (1,2,3) have already clearly demonstrated that carbohydrate feeding in the form of a drink solution will improve exercise performance. These studies have focused on fluid carbohydrate replacement during exercise of a single mode, usually prolonged running or cycling. Owen et al (4) found no adverse effects on circulatory function while consuming carbohydrate beverages during a standard bout of prolonged running at 65% V o2 Max. in the heat. Davis et al (5) and Murray et al (6) Reported improved cycling performance with moderately concentrated carbohydrate beverages within the range of 5-7%.

The effect of carbohydrate beverage replacement during Multi-Modal exercise such as the triathlon, which combines swimming, cycling and running, has not been studied extensively. The current literature is limited and only provides descriptive evidence of hypoglycemia, hyponatremia and dehydration following Ironman competition (7,8) which take top competition 8-11 hours to complete and are only raced 2-3 times annually by top athletes. Milliard et al. (9) Have carried out studies using a Simulated Triathlon Protocols. This is one of a very limited number of projects using multi modal exercise.

In addition very little data exists from research using intensity of exercise above 60-70% Vo_2 Max.. This study provide rare data at paces above 80-85% Vo_2 Max..

The more widely popular triathlon is the standard distance of 1.5km swim, 40km bike, and 10km run. Competitions of this distance take experienced highly trained triathletes about 1 hour 45 minutes to 2 hour 15 minutes to complete. The sprint distance of 750 Mt. swim, 20km bike and 5km run is also wide spread and raced frequently by both experienced and novice athletes. The standard and sprint distance are frequently raced by junior athletes of 15 to 20 years of age.

Although carbohydrate administration has been observed to improve cycling and running performance in the single mode. It might not have a similar effect on standard or sprint distance triathlon performance since muscle groups are used for a relatively short duration in each of the three exercise modes. Also, no research has concentrated on the performance of junior athletes. All research to date has used exclusively adult subjects. This study will provide totally new information both in respect of using race pace simulated triathlon (i.e. 80-85% Vo_2 Max) and in it's use of junior subjects.

Therefore, the purpose of this study was to determine the effects of 2 different carbohydrate beverages during a 1km swim, 27km bike, 7km run distance triathlon using junior triathletes. Specifically, we sought to examine whether the blood glucose levels and performance of junior triathletes would benefit more by using either a 100% glucose solution or a glucose polymer-'Polycal' solution carbohydrate beverage during a simulated competition.

The results obtained will be of great value to endurance athletes from many sports and to athletes of all ages and abilities. The results will enable athletes and coaches to choose the optimum type of carbohydrate for each individuals needs.

2. METHODS:

Subjects: 6 Male elite junior triathletes from the Hong Kong National Squad served as subjects. 5 were Asian and 1 Caucasian. The differences in race were insignificant. Their physical characteristics are summarized in table I. The raw date is presented as appendix i.
Mean weekly training distances for these subjects as a group were 7,578.28 Mt. swimming,94.04 km cycling, and 23.97 km running.

As individuals the mean weekly training distances were.

Subject :	Swim(Mt.)	Bike(km)	Run(km)
D	11,319	164.11	30.18
A	5,648	70.54	14.25
JE	6,243.24	93.67	20.17
K	6,278.47	56.52	20.73
F	6,469	67.70	16.52
J	9,514.55	93.87	14.20

Their mean best performance time in a standard, 40k,10k triathlon race was 2 hour 14 min. and in the sprint 750 Mt., 20k, 5k triathlon race was 1 hour 8 min. All subjects had competed in triathlon for at least 2 years and 5 of the individuals had come from a competitive swimming background since child hood. Subjects were fully informed of all aspects of the study, and each signed a statement of informed consent approved by the institutional review board. Those subjects under 18 years of age also had a parent sign the consent from. See appendix ii.

Table 1. Physical Characteristics And Maximal Physiological Date of Subjects. (N=6)

VARIABLE	MEAN(±SD)
Age(yr.)	17.17
Height(cm)	172.33
Weight(kg)	65.67
% Body Fat	5.49
Vo2 Max. (ml-kg^{-1} min^{-1})	
Swimming	-
Biking	64.27
Running	66.71
Heart Rate Max.(beats "Min")	
Swimming	193
Biking	190.5
Running	196.6

Raw data refer to appendix i.

After the initial S.T.T. one subject was injured. The data of this subject was not statistically analysised but was analyzed subjectively outside the context of the study. For the remaining trials (S.T.T.) 5 subjects were tested.

Maximal And Sub-Maximal Test Protocols:

During preliminary sessions, maximal oxygen uptake (Vo2 Max.) was assessed during progressive cycling and running test .

The maximal treadmill running test utilized a continuous grade incremented protocol.

The maximal cycle ergometer test also used a continuous incremented protocol with the watts increased by 25 every 1 minutes to exhaustion or watts output could no longer be maintained.

During cycling and running tests, oxygen uptake (Vo2) and other metabolic 'Measures were continuously sampled every 30 seconds. The gas-collection system utilized the Gould 2900 Energy Measurement system (West Carollton, Ohio,USA).

The sub- maximal tests or step test protocol followed a 'interrupted' incremental protocol, were subjects had one minutes rest between progressively harder stages see figure 2.

For swimming, maximal heart rates, lactate, speed, and perceived effort were established using a 4 x 400 Mt. swim in an interrupted format i.e. rest of 2 minutes between each progressively harder stage.

Maximal Vo2 and Heart Rate data (H.R.) data for bike and run are presented in Table 1. Raw data is presented in appendix i.
For both the maximal tests and the sub-maximal tests the running was carried out on a treadmill control series 1825, (marqvelte Gectronics Inc.Mil Wankee WI, USA) and the bike tests used the athletes own racing bike fixed an a Cateye Cyclosimuator cateye CS-1000 (TSUYAMA MFG. CO. LTD, JAPAN).

Figure 2 of Outline Protocols of Triathlon MVO2 and Step Test

Running

Step Test

5 x 5 min; 1 min rest in between

Stage	Speed (mph)
1	7*
2	7.5
3	8
4	8.5
5	9

*starting speed 6.5 - 9, depends on individual

MVO2

	Time (min)	Speed (mph)	Gradient (%)
Warm Up	5	5	0
Exercise	2	7.5 - 8	0
	2	7.5 - 8	2.5
	2	7.5 - 8	5

↓

same speed with gradient increment of 2.5% for each 2 min to exhaustion

	Time (min)	Speed (mph)	Gradient (%)
Recovery	5	3	0

Biking

Step Test

5 x 5 min; 1 min rest in between (70-100watt)

Stage	Power (watt)
1	100
2	200
3	250
4	300
5	350

MVO2

Time (min)	Power (watt)
3	100
1	125
1	200
1	225

↓

25 watt increment for each 1 min to exhaustion

PHYSIOLOGICAL MEASURES

A heart rate monitor (Polar Model 3000) was worn on the chest throughout the S.T.T., perceived exertion (R.P.E.) was rated using the 15-point Borg Scale. See appendix iii. The Borg Scale was presented in Chinese characters for the Asian Athletes and in English for the Caucasian.

Heart rate, R.P.E. were taken at regular intervals throughout the S.T.T. see appendix iv for physiological and blood chemistry timetable and figure 1 for schematic diagram. Nude dry body weight was recorded before and after the S.T.T. changes in weight were used to assess whether a subject had become dehydrated a subject had become dehydrated during the S.T.T..

Blood Analysis

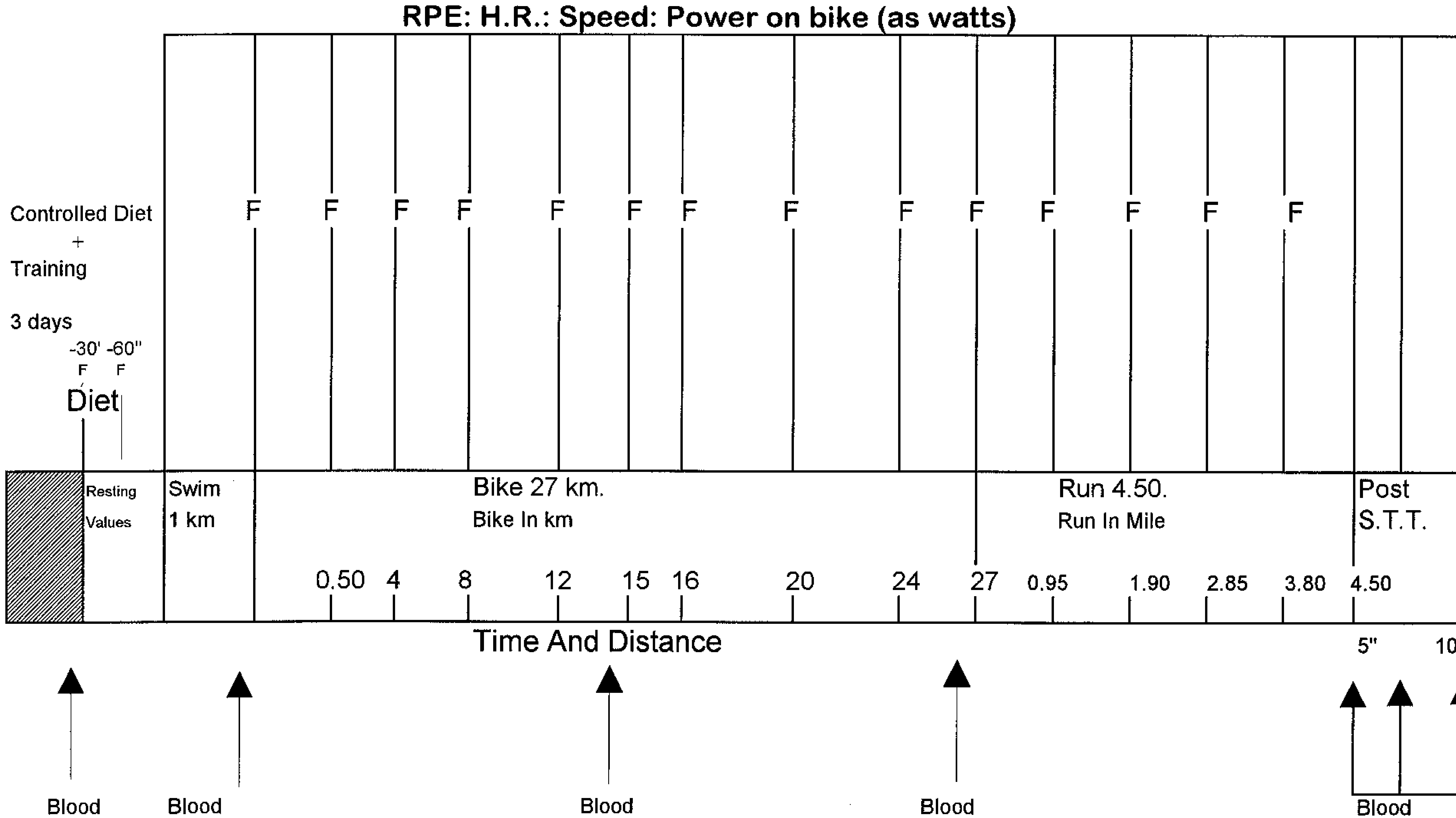
Blood samples were obtained from Finger Tip puncture using Soft touch lancet throughout the S.T.T.. The Pre-Exercise (Or Resting Levels) blood test was taken 10 minutes before commencing the warm-up protocol. Subsequent blood tests were taken at immediately post swim, 15 and 27 km in the bike, immediately at the end of the 4.50 mile run and then at 5 and 10 minutes Post-Exercise(end of S.T.T.). Blood lactate was measured by the Yellow Springs Instrument or Y.S.I. model 1500 Analyzer. (Yellow Springs Instruments OH,USA) Glucose, and urea was measured by the reflotron IV analyzer.(Model IV by Boehringer Mannheim, Germany)

Blood Lactate is measured as units of m,mol.

Blood Glucose as Mg/dl and Blood Urea as units of Mg/dl.

The 'normal' ranges for Blood Glucose are 80 - 120 (levels of up to 160 can be found during exercise) and 35 - 55 for Blood Urea. Blood Lactate ranges from as low as 1.0 at rest to up to 20 during extremely intense exercise. The Anaerobic Threshold is taken as around 4 mmol. For sprint to Olympic Distance Triathron 5 - 8 mmol would be considered the 'optimal' range.

Figure 1. Schematic diagram of the simulated triathlon testing protocol



F = C.H.O. Solution Feed

Beverage Administrations

Each subject completed a Simulated Triathlon Trial S.T.T. under two carbohydrate fluid regimens, in which either a 9% carbohydrate solution of Glucose or a 9% carbohydrate solution of Glucose Polymer - 'Polycal' is administered. Glucose being a short chain 'fast acting' carbohydrate and Glucose Polymer being a long-chain more complex, 'slower acting' carbohydrate. This study seeks to clarify which of the 2 carbohydrate types is most effective at maintaining blood glucose though the S.T.T. at self regulated race pace. The 9% carbohydrate solution % was based on the recommendations of Wilber R.L. and Moffat R.J. (11) who recommend "during moderate and high intensify exercise, a carbohydrate solution containing up to 10% glucose has a gastric emptying rate similar to water".
1.2gm of carbohydrate per kilogram of body weight. Per hour was used (that is 2.49 CHO/kg BW for the 90'-120' S.T.T.). This figure was based on the 11.5 + g of CHO per kilogram of body weight per hour suggested by Clark. N. et al (14).

Flavor colour and 'Texture' were adjusted so that both solutions appeared the same. The beverage will be prepared and given in a double-blind, randomized order, with a period of 5-6 weeks separating each triathlon trial.

A period of 14 days separating trials would have been preferable. However, owing to the junior status of the subjects, and the heavy race schedule it was felt a longer period of recovery was necessary. To eliminate the possible changes in physiology i.e. training effect, the subjects training schedule and load was kept constant for both trials, In addition one subject was injured and we had to wait in order for the subject to fully recover and match previous levels of training and fitness.
Subjects consumed individualized amounts of the beverage at 30 minutes and 1 minutes prior to trial start, after the swim and at 4,8,12,16,20,24 km during the bike at the end of the bike and at 0.95, 1.90, 2.85, 3.80 mile intervals during the run amounts shown on Table 2. The amount of fluid was calculated by the Hong Kong Sports Institute Sports Nutritionist based on kg of body wt the amount and gms of CHO are shown in table 2. Following each S.T.T. each subject will complete a Likert questionnaire concerning acceptability and palatability of the beverage. See Appendix v.

Subject Orientation

Subjects were fully familiar with the simulated Triathlon Trial, using the Hong Kong Sports Institute (HKSI) swimming pool, Cateye bike simulator and treadmill for running extensively in general training, and during the maximal and sub-maximal testing, protocols . During the week prior to each S.T.T., each subject was instructed to duplicate his training, in terms of intensity, duration and frequency, and to perform no exercise 24 hours before the S.T.T.

The National Coach structured a suitable training regimen for the week prior to the S.T.T. which was standardized as much as possible for all subjects. The subjects should be well rested and ready to perform to the best of their individual abilities. Moreover, each subject was requested to follow a 3 day diet regimen, which will be as close as possible between subjects, and duplicated for each individual subject prior to the S.T.T. The subject will report to the lab after feeding on a standardized pre-race breakfast of 1-2 Powerbars. Pre-S.T.T fluid will be water only to avoid any 'Insulin Spike' which may occur on the glucose test when administered prior to the onset of exercise.

The S.T.T.s were carried out at the same time and same venue for all subjects and for both tests. Tests were completed in the mornings to further control food and beverage intake.

Simulated Triathlon Protocol

Warm Up Protocol

1. Lactate at rest.

2. Bike 8 minutes at 70% Vo2 Max.
   Run 5 minutes at 70% Vo2 Max.
   Swim 150 meters at 70% Max. Heart Rate.

3. Drink solution before mounting bike.

4. Drink solution at end of swim warm up.

5. H.R. to return to 120 BPM. Before trial start.

Trial Protocol

The S.T.T. will comprise of a 1km swim in a 25 meters indoor pool, 27 km cycle using the subject's own bicycle mounted on a 'Cateye' simulator, 'tyre pressure', and a measured 'wheel stop' will be standardized amongst the subjects and duplicated for each trial, and 4.50 mile running on a treadmill. Treadmill was a Precor model C962 (U.S.A.). Miles had to be used as the measure of speed and distance as the treadmill only utilized the mile system. The subject will complete the S.T.T at a self-selected race pace, with incentives offered based on his combined performance in both S.T.T.s. Subjects will be given verbal motivation only in terms of the time splits during each event.
The swim phase will be a continuous 1km time trial. Blood, heart rate and other parameters will be taken at the end of the swim, before moving to the bike. The transition and testing time will be standardized and deducted from the overall performance time.

The bike will be mounted on the Cateye simulator and the subject will Time Trial at 0% gradient for 27 km. Before each test the bike is adjusted to the same tyre pressure and 'Roll-down' test measuring wheel stop time from 100 watts. Blood tests and feedings will occur at set intervals throughout the bike event. (See Tables 3+4) After another transition of about 5 minutes the 4.50 mile run will be performed at 1% grade. The subject can request that the speed be changed and given verbal feedback on the distance covered. Blood tests and feedings will occur at set intervals. See figure 1 for schematic diagram and appendices iv a, iv b, iv c.

Transitions times, between modes of the S.T.T will be held constant between trials for each subject and to vary less than 45 seconds between subject . The final S.T.T. time will not include the transition time.
Means of the environmental conditions for all trials will be taken dry, wet bulb and WBGT index and variations between trials minimized. Subjects will wear a swim suit for the entire S.T.T.. Swim suit, bike shoes and running shoes will remain constant between the 2 trials.

Statistical Analysis

Analysis of variance with repeated measures was used to determine differences between drinks trials for the variables measured during the S.T.T.. A Tukey post hoc test was used to determine significant mean differences. An Alpha level of .05 was used for all significance tests.
Due to the small subject pool statistical significance is for reference only. The graph patterns are of more importance.

Table 2 Carbohydrate Amount and Volume of Liquid Per Feed

Subject:	CHO(g)	Fluid (ml)	(CHO/ML)
J	135	1700	0.079 g/ml
D	152	1900	0.08 g/ml
K	152	1900	0.08 g/ml
F	168	2100	0.08 g/ml
JE	180	2200	0.81 g/ml

Volume of fluid (ml) to be consumed during S.T.T.

	CHO J	D+K	F	JE
30 min Pre (15% of Total Vol)	19g-240ml	23g-290ml	25g-310ml	22g-330ml
1 min Pre (5%)	7g-85ml	8g-95ml	8.4g-105ml	9g-115ml
End Swim (10%)	13g-170ml	15g-190ml	17g-210ml	19g-230ml
Every 4k Bike (7% x 7)	9g-120ml	10g-130ml	12g-150ml	12g-150ml
Every 1.5k Run (4% x 4)	6g-70ml	6g-80ml	6g-80ml	7g-90ml
Total (15 Feeds)	Total: 1,700ml	1,9000ml	2,1000ml	2,200ml

RESULTS

TEST A - SOLUTION A USED CHO SOLUTION 100% GLUCOSE.
TEST B - SOLUTION B USED CHO SOLUTION GLUCOSE POLYMER (POLYCAL).

Individual Result:

Refer to table 3 for statistical differences and graphs 13 - 16.

Subject J.E.:

The total S.T.T. time (Minus transition time) was 176 seconds slower in test B than test A. (although there is no statistical difference)
The swim section in test B was significantly slower (44") than test A.

The % H.R. Max. of both cycling tests were at a high endurance level. The % H.R. Max. of the cycling section in test B was higher than test A, but the total cycle time was 89 seconds slower over the 27km T.T. The % H.R. Max. of the test run were higher than test A while the speed was about the same.

Lactate Acid levels for both tests were low. Expected values for elite juniors working at the S.T.T. intensity should be between 5-8 MMol. Very low, below normal range, pre-exercise blood glucose levels could be a limiting factor on subject J.E., in that his energy levels are too low to work at a high enough work level. J.E. had the highest level of power output amongst the subjects, although it could be argued that it would be even higher if there were not limiting factors.

The H.R. and lactate stability was good in test A, but decreased in test B (levels dropping at the end half of the S.T.T.). This indicates greater fatigue in test B.

The data shows that both heart rate and blood lactate concentration were not high enough to produce peak performance and that the S.T.T. performance was limited in both tests, although test A produced better performance than test B.
Urea - levels were statistically the same.
R.P.E. - statistically the same.
Palatability - approximately same.

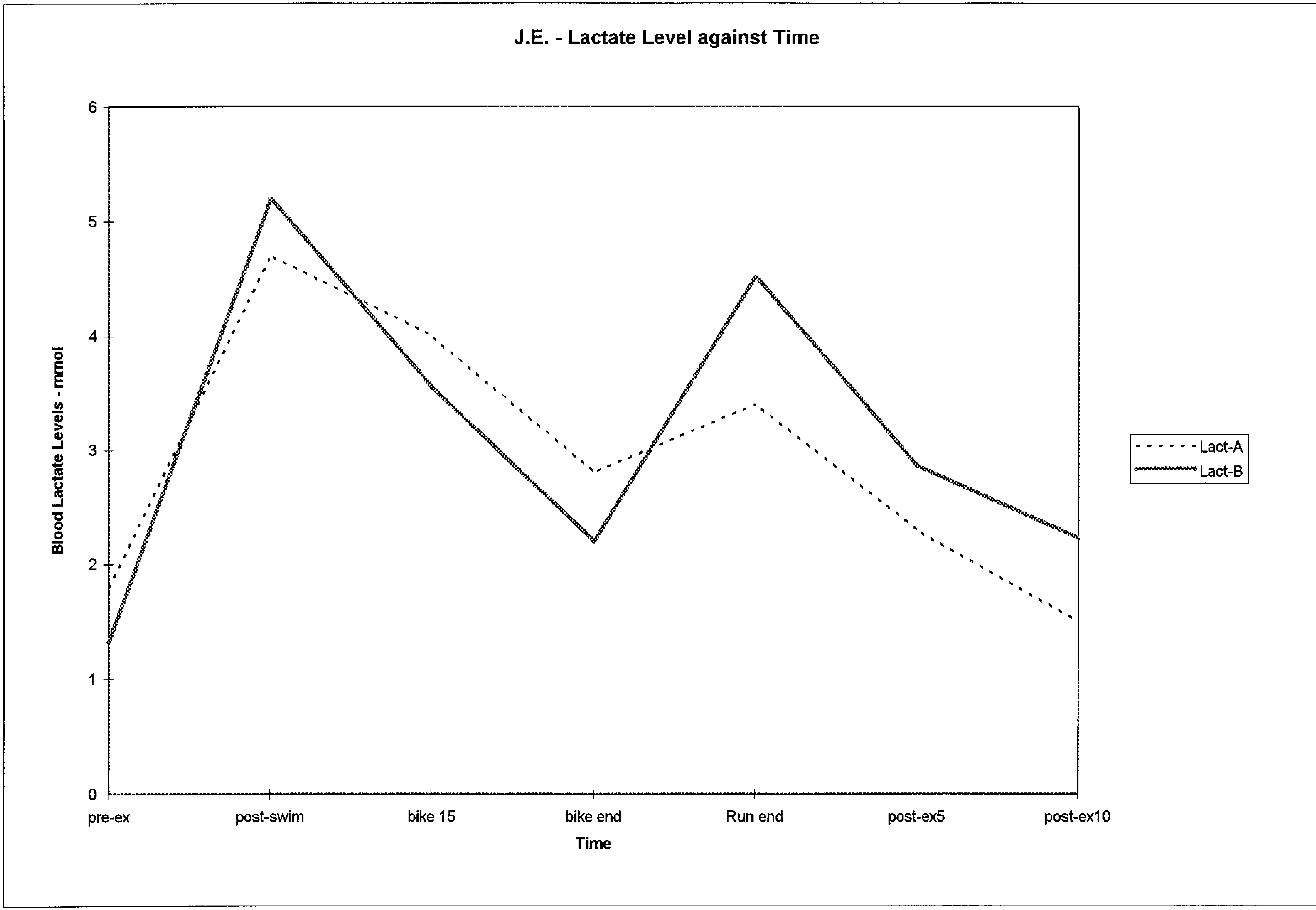
Glucose - Blood glucose was similar between both tests. These findings in association with the decreased performance in test B. Indicate that neither glucose or glucose polymer was more efficient at maintaining blood glucose and consequently performance, the decrease in performance in test B must be due to other limiting factors other than blood glucose.

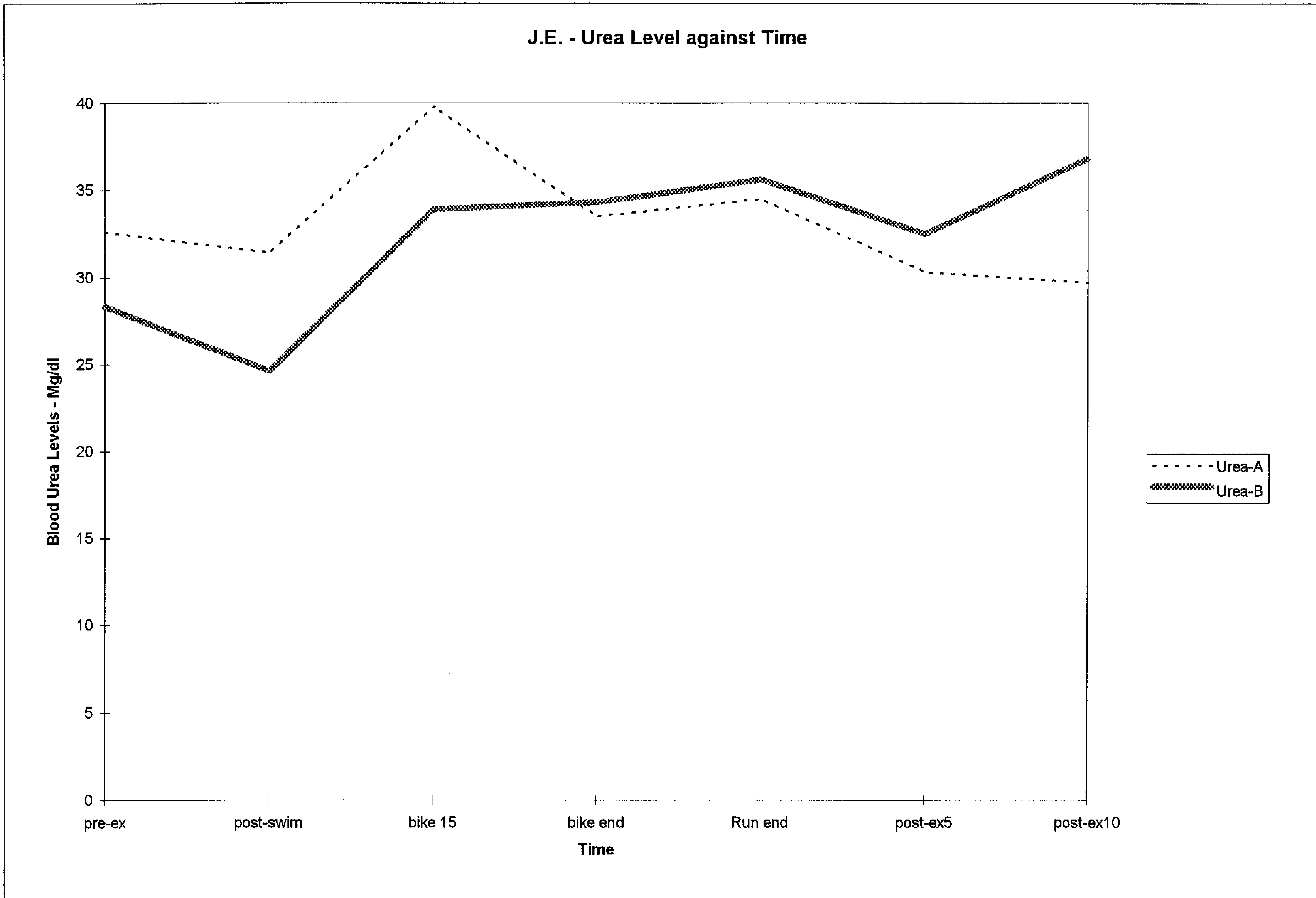
The Likert scale indicated similarities of preference for solution A and B. The only difference being a preference to use Glucose Polymer during training and competition (question 2).

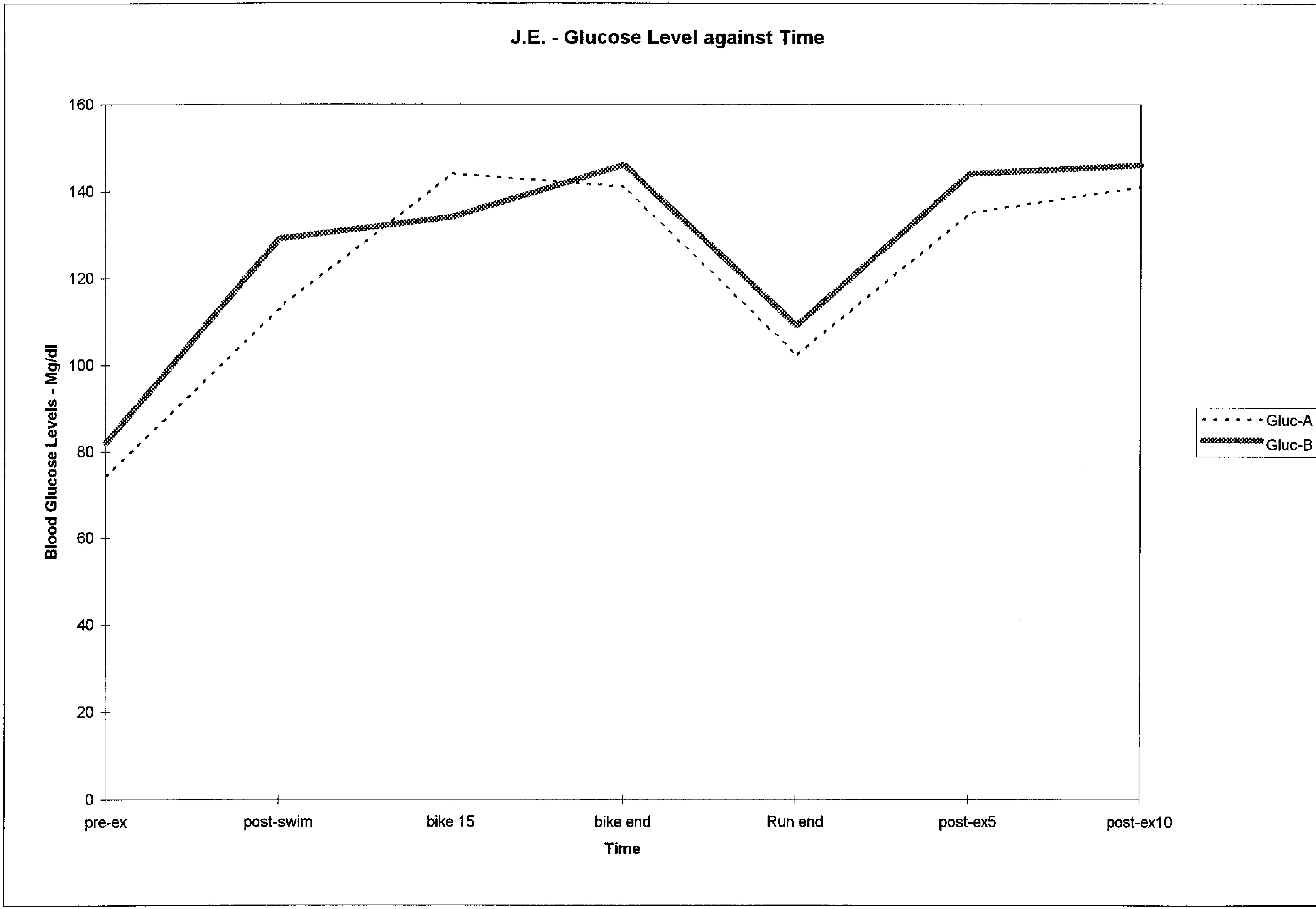
It is therefore recommended subject J.E. uses a sports drink with a equal ratio of glucose to glucose polymer. Also J.E. may need to consider a greater intake of pre-exercise CHO in the form of a complex CHO as well as glucose immediately prior to the onset of exercise.

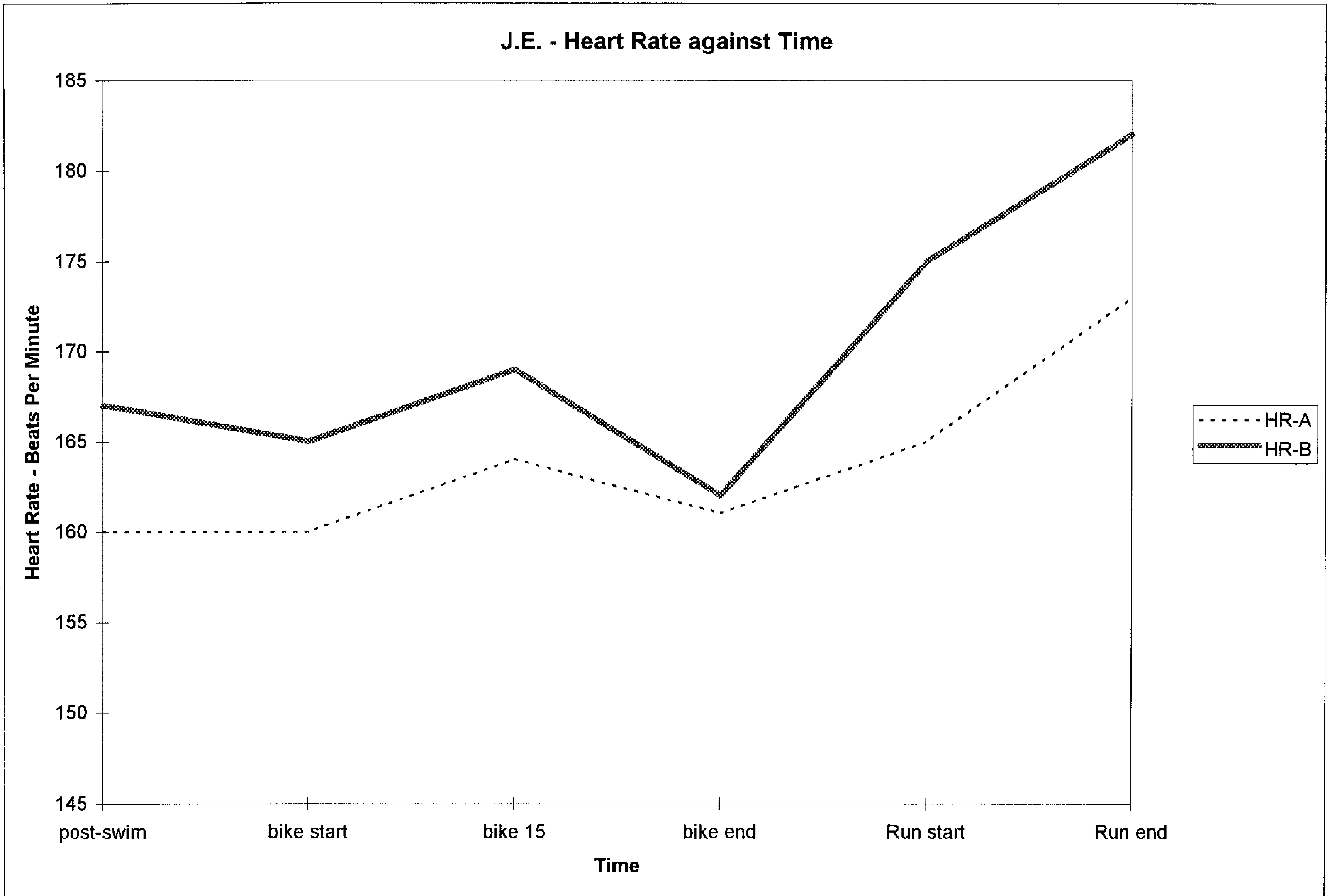
Solution	A	B	A	B	A	B	A	B	A	B	A	B	A	B
STAGE	LACT	LACT	UREA	UREA	LUCOS	LUCOS	H.R.	H.R.	R.P.E.	R.P.E.	SPEED	SPEED	WATT	WATTS
PRE-EXERCISE	1.8	1.32	32.6	28.3	74.1	82								
POST SWIM	4.7	5.2	31.4	24.6	11	129	160	167	16	15	15'15"	15'59"		
START BIKE							160	165	16	15	42	41	350	323
BIKE 15KM	4	3.55	39.8	33.9	144	134	164	169	16	16	44.1	431	360	339
END BIKE 27KM	2.8	2.2	33.5	34.3	141	146	161	162	16	16	44.2	41.1	362	301
0.95 MILE RUN							165	175	15	15	9.5	9.7		
END RUN 4.50 MILE	3.4	4.52	34.5	35.6	102	109	173	182	16	16	9.5	9.7		
END TEST II 5 MINUTES	2.3	2.86	30.3	32.5	135	144								
END TEST III 10 MINUTE	1.5	2.23	29.7	36.8	141	146								

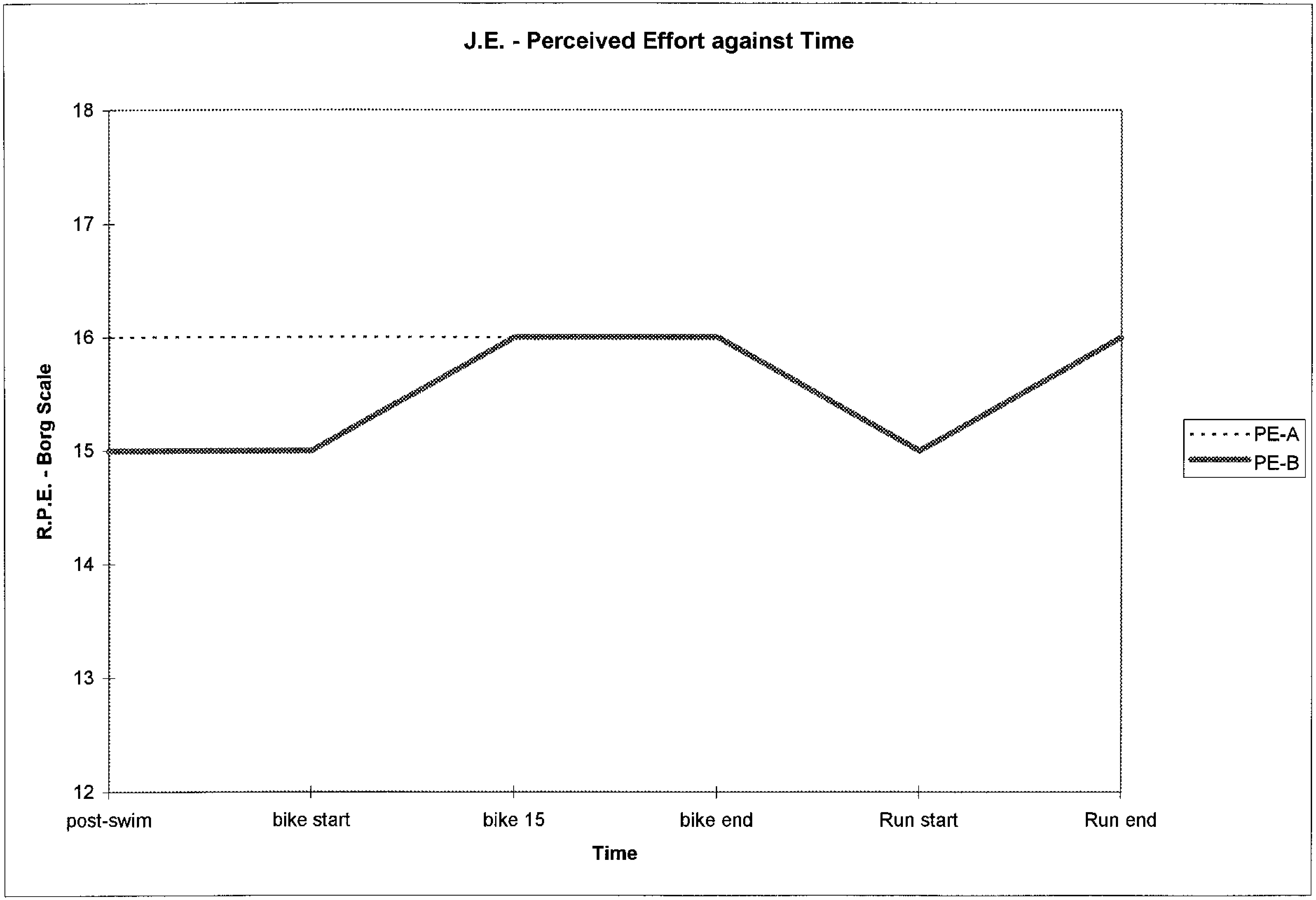
TOTAL FINISH TIME : A - 1 HOUR 19 MIN 09 SEC B - 1 HOUR 22 MIN 05 SEC

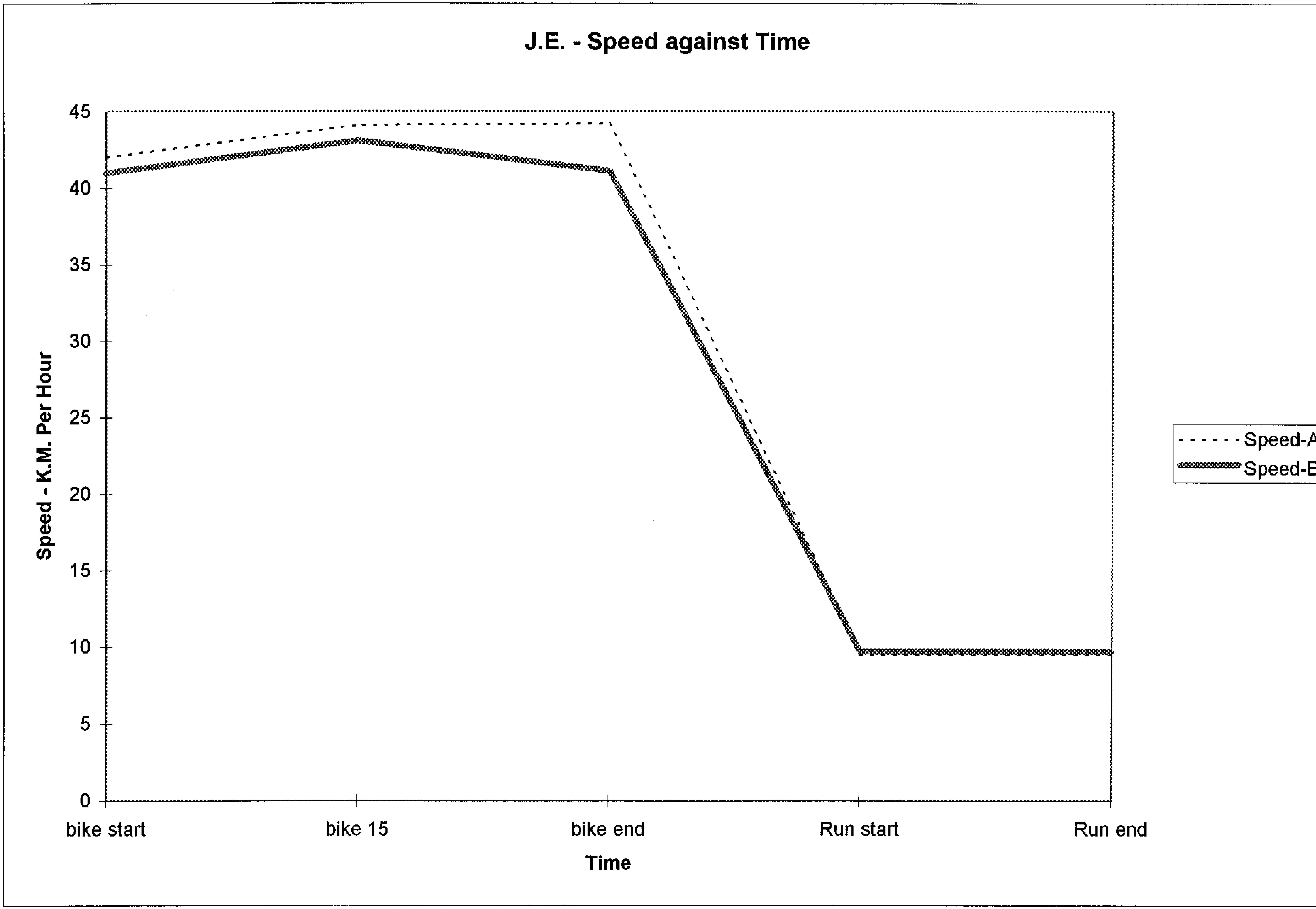

J.E. - Lactate Level against Time
Blood Lactate Levels - mmol
0
1
2
3
4
5
6
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Lact-A
Lact-B

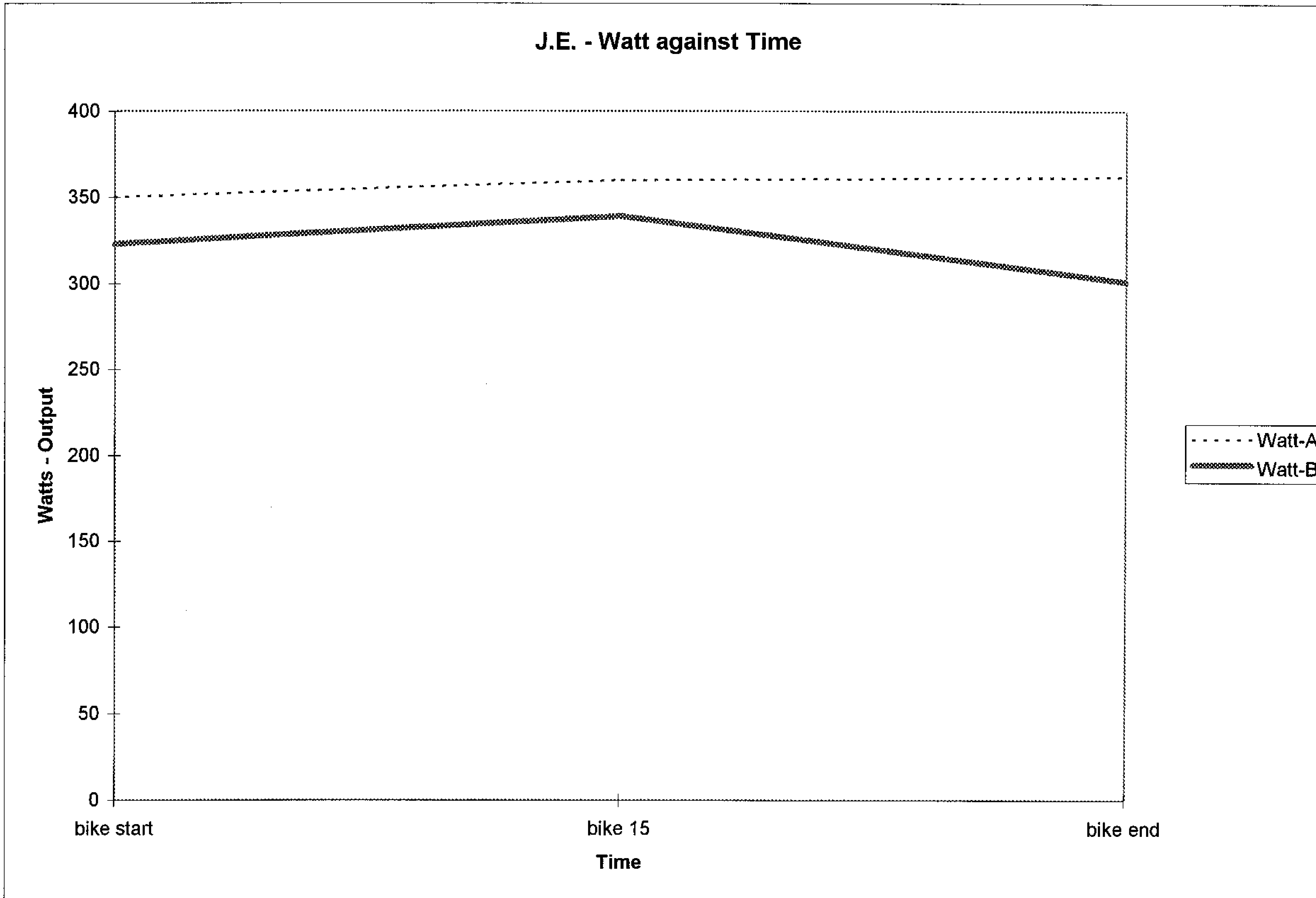

J.E. - Urea Level against Time
40
35
30
25
20
15
10
5
0
Blood Urea Levels - Mg/dl
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Urea-A
Urea-B


J.E. - Glucose Level against Time
Blood Glucose Levels - Mg/dl
160
140
120
100
80
60
40
20
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Gluc-A
Gluc-B


J.E. - Heart Rate against Time
Heart Rate - Beats Per Minute
185
180
175
170
165
160
155
150
145
post-swim
bike start
bike 15
bike end
Run start
Run end
Time
HR-A
HR-B


J.E. - Perceived Effort against Time
R.P.E. - Borg Scale
18
17
16
15
14
13
12
post-swim
bike start
bike 15
bike end
Run start
Run end
Time
PE-A
PE-B


J.E. - Speed against Time
Speed - K.M. Per Hour
0
5
10
15
20
25
30
35
40
45
bike start
bike 15
bike end
Run start
Run end
Time
Speed-A
Speed-B


J.E. - Watt against Time
400
350
300
250
200
150
100
50
0
Watts - Output
bike start
bike 15
bike end
Time
Watt-A
Watt-B

Subject D:

For result data refer to table 4 ii.

Final S.T.T. time (Minus) transition was 32 seconds faster in test B than test A. For most of the S.T.T. subject D was able to maintain a heart rate of 95% of his Max. for well over an hour.

The blood lactate was in the normal range for this work intensity (5-8 MMOL) and similar between the 2 trials. Power output, heart rate and lactate is good in both tests, but has low stability during the 27km bike T.T.. This may be due to lack of pacing experience, rather than - physiological factors. See graph.

Blood glucose levels were slightly lower in test B than test A throughout the S.T.T. especially at the 15km point of the bike trial.

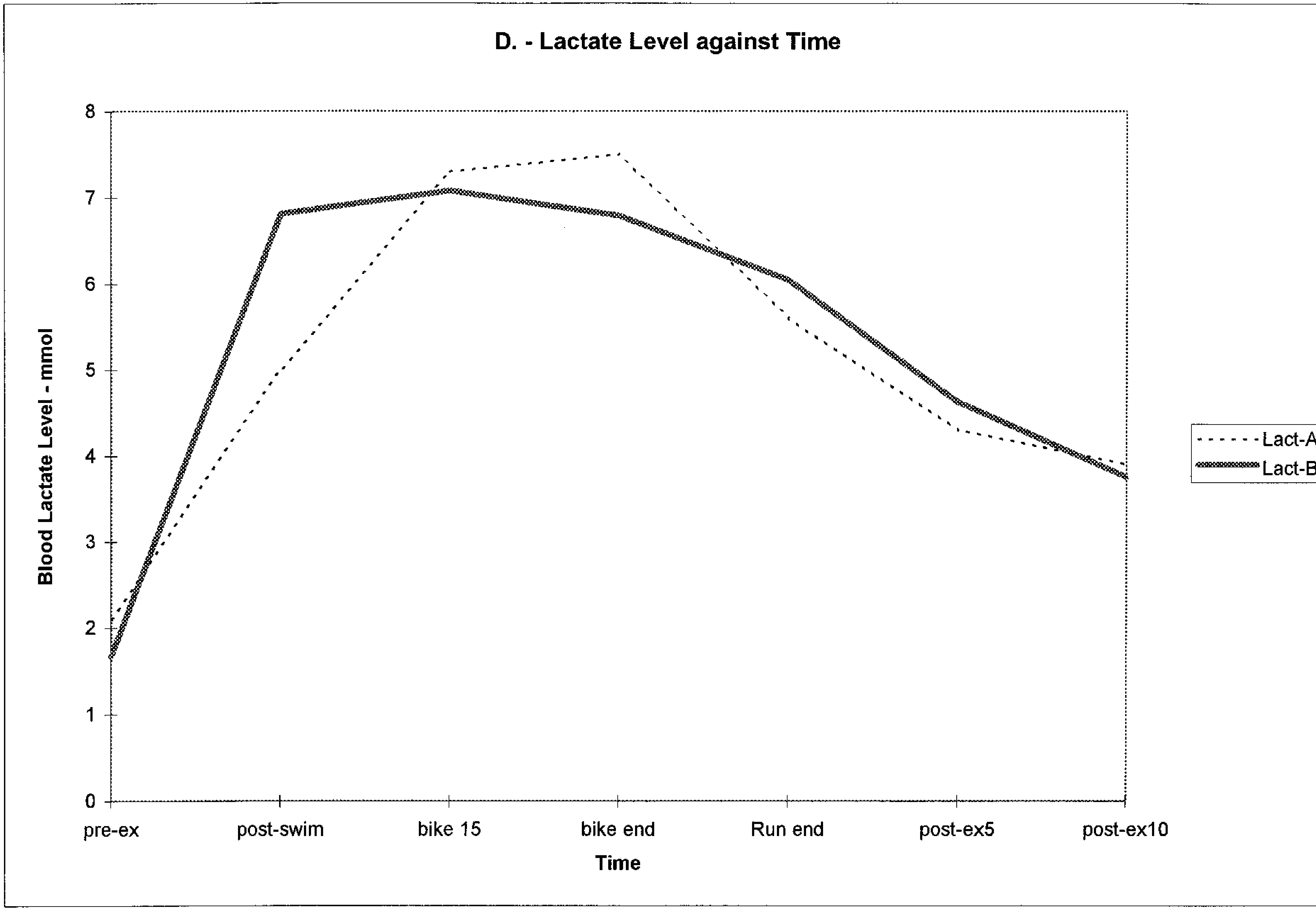
Urea was similar between both trials. R.P.E. - Subject D perceived effort was greater using solution B than A.

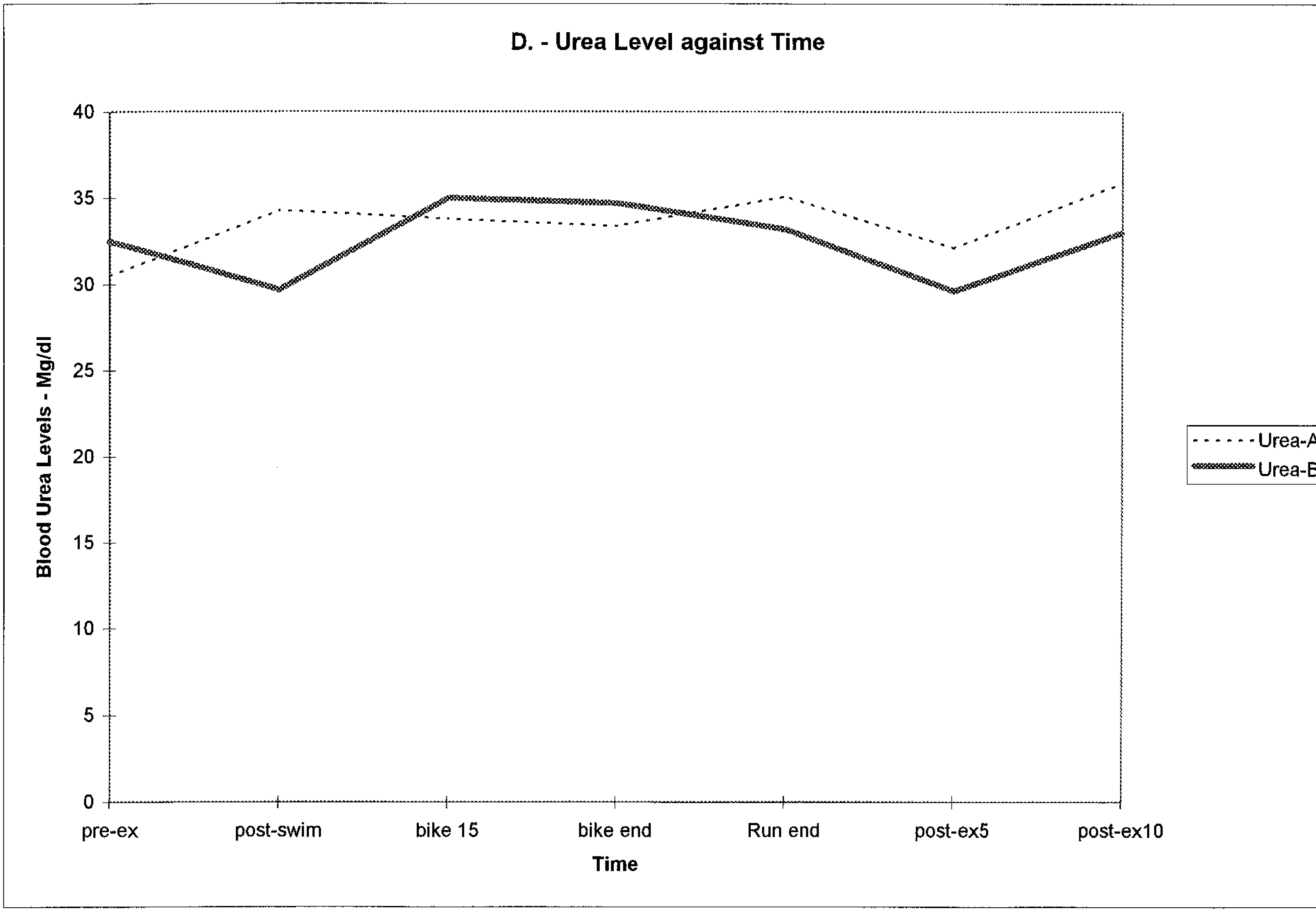
Likert scale showed an equally positive response to both solutions.

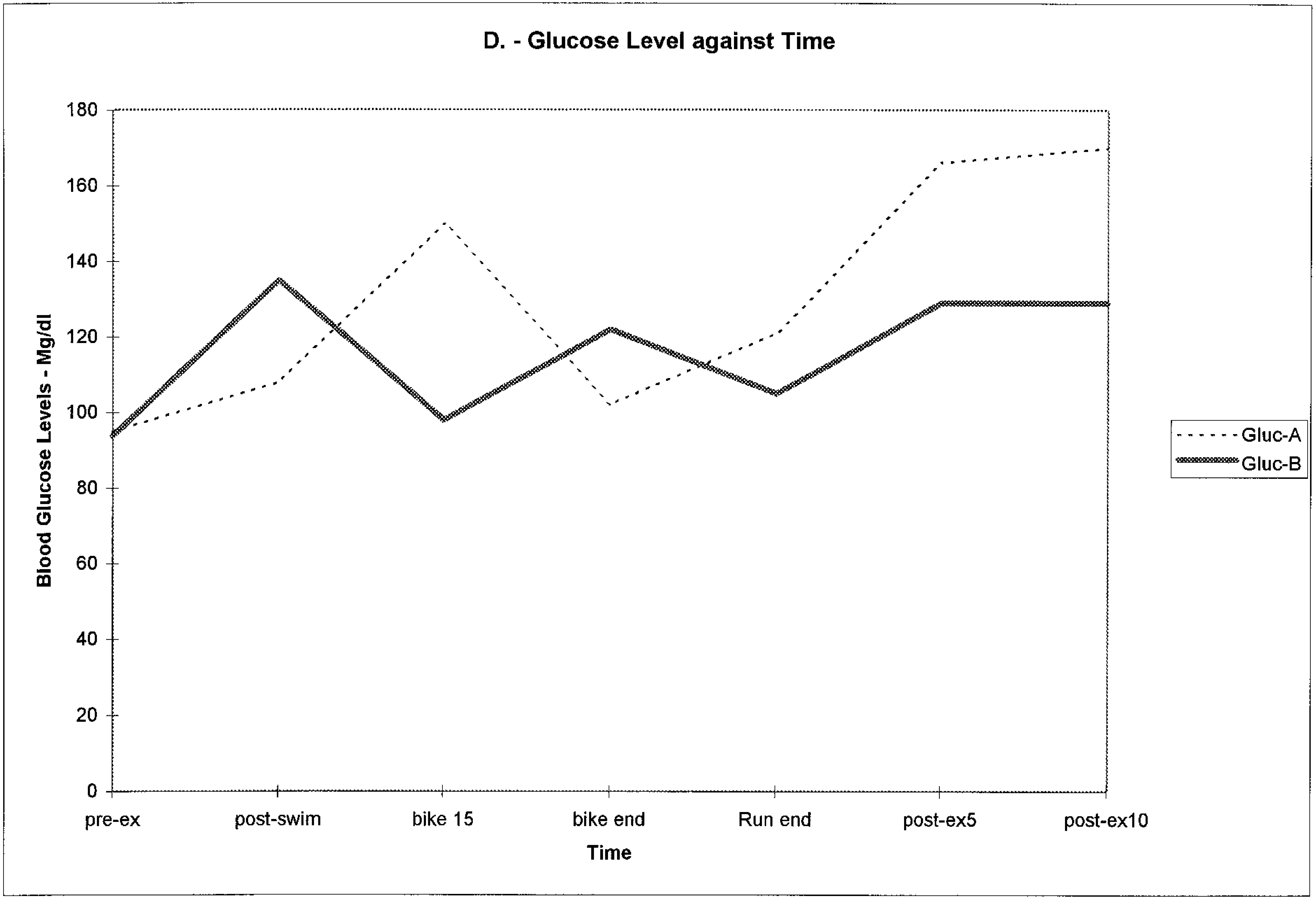
The slightly lower levels of blood glucose (not statistical significant) in test B in relation to an improved level of performance indicates that the relationship between blood glucose and performance is not clear. (See discussion section).

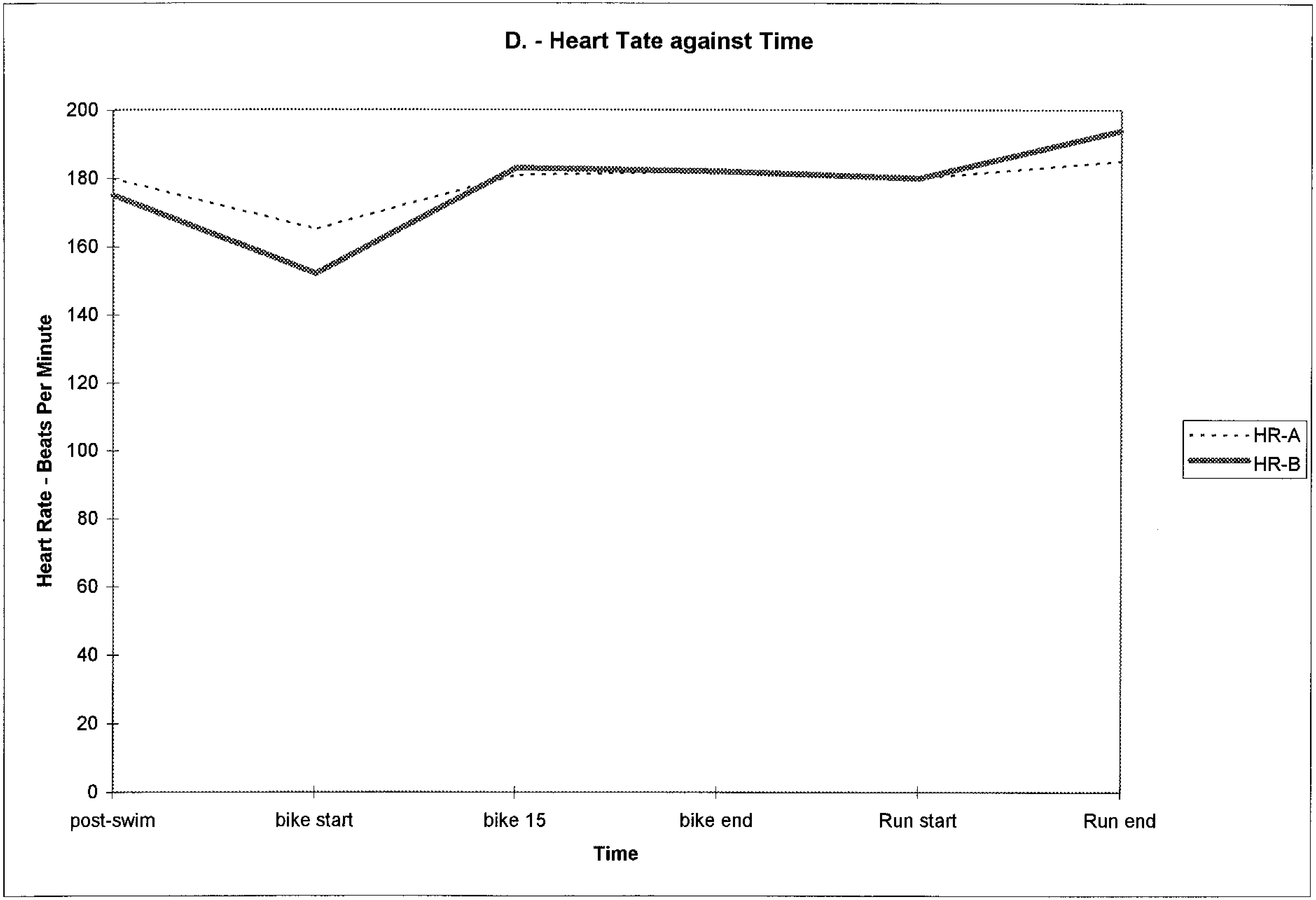
Solution	A	B	A	B	A	B	A	B	A	B	A	B	A	B
STAGE	LACT	LACT	UREA	UREA	LUCOS	LUCOS	H.R.	H.R.	R.P.E.	R.P.E.	SPEED	SPEED	WATT	WATTS
PRE-EXERCISE	2.1	1.67	30.5	32.5	95	93.9								
POST SWIM	5	6.81	34.3	29.7	108	135	180	175	15	15	13'21"	13'33"		
START BIKE							165	152	14	16	40	40	282	270
BIKE 15KM	7.3	7.08	33.8	35	150	97.9	181	183	15	16	42	43	315	341
END BIKE 27KM	7.5	6.79	33.4	34.7	162	122	182	182	16	17	44	44	360	368
0.95 MILE RUN							180	180	15	16	9.8	10		
END RUN 4.50 MILE	5.6	6.04	35.1	33.2	121	105	185	194	16	16	9.8	11		
END TEST II 5 MINUTES	4.3	4.62	32.1	29.6	166	129								
END TEST III 10 MINUTE	3.9	3.75	35.9	33	170	129								

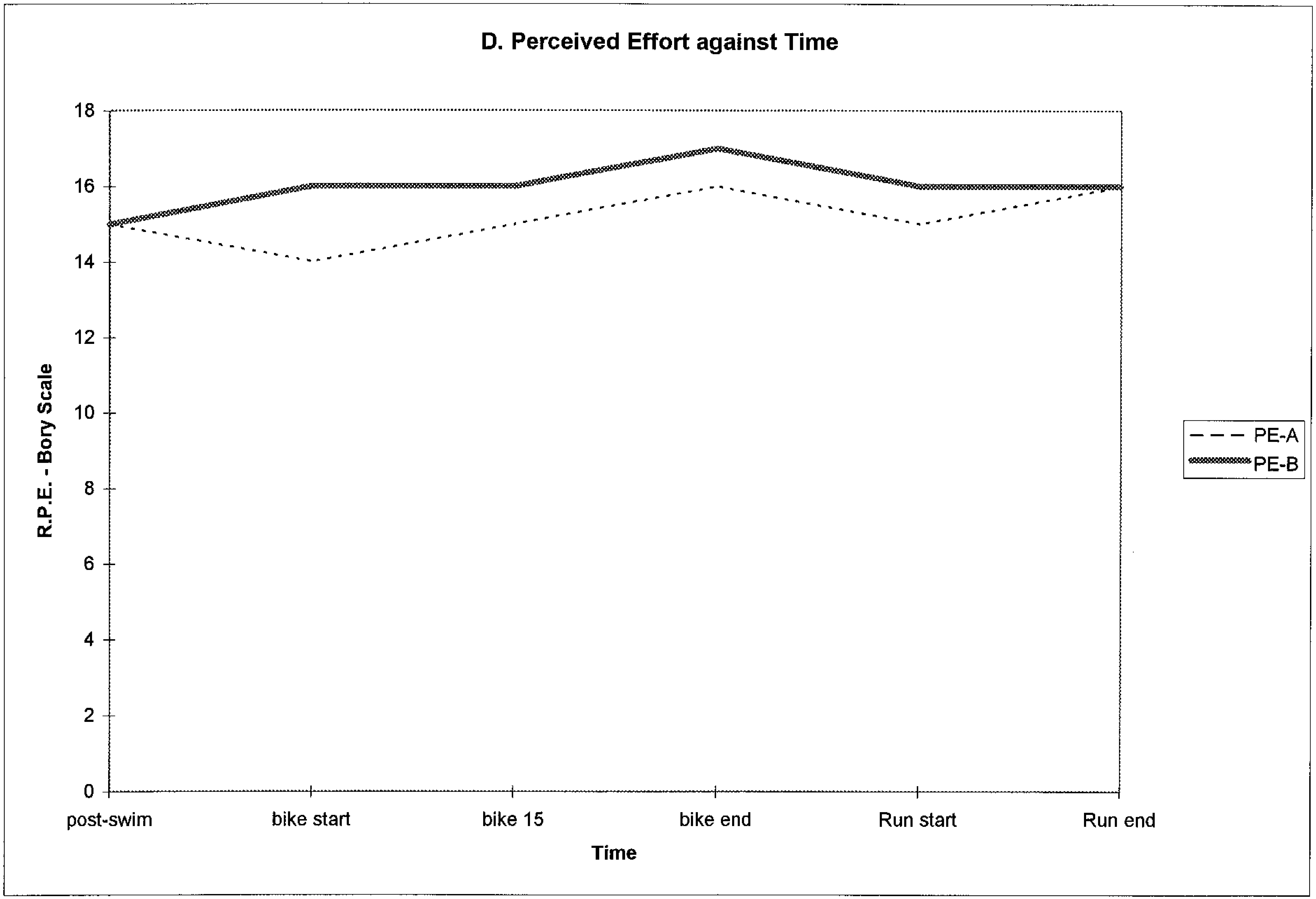
TOTAL FINISH TIME : A - 1 HOUR 19 MIN 53 SEC B - 1 HOUR 18 MIN 25 SEC

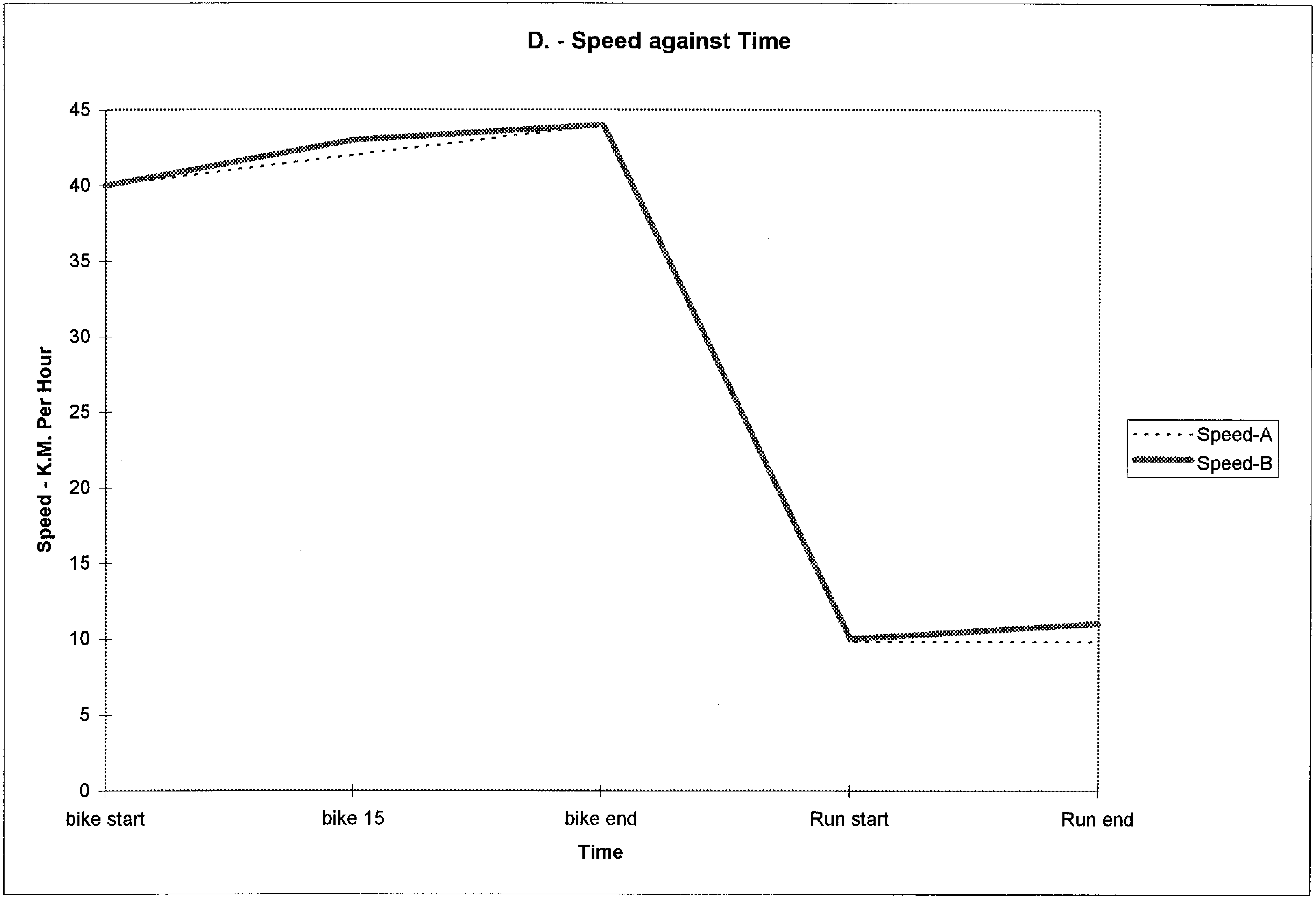

D. - Lactate Level against Time
Blood Lactate Level - mmol
8
7
6
5
4
3
2
1
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Lact-A
Lact-B

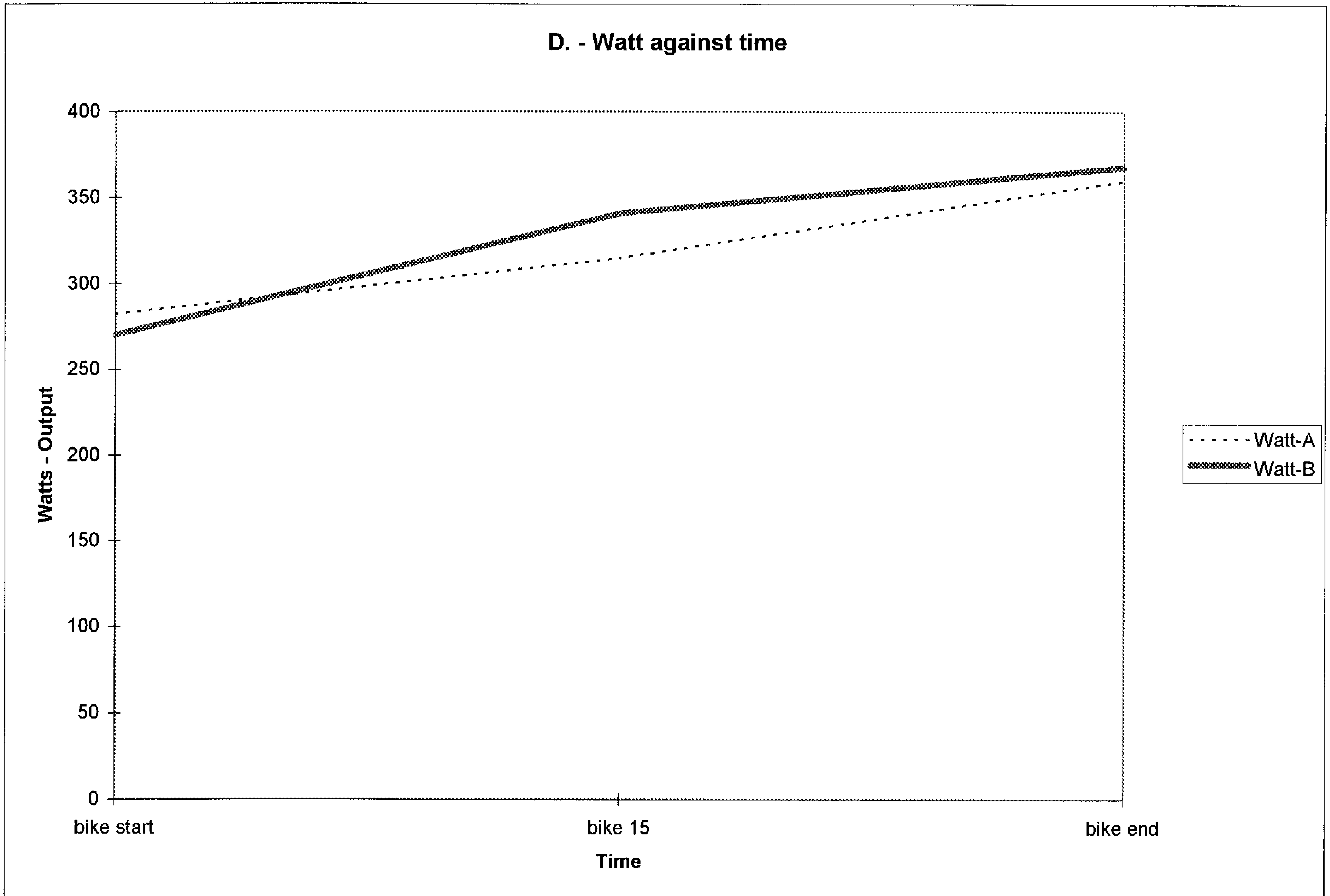

D. - Urea Level against Time
Blood Urea Levels - Mg/dl
40
35
30
25
20
15
10
5
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Urea-A
Urea-B


D. - Glucose Level against Time
Blood Glucose Levels - Mg/dl
180
160
140
120
100
80
60
40
20
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Gluc-A
Gluc-B


D. - Heart Tate against Time
Heart Rate - Beats Per Minute
200
180
160
140
120
100
80
60
40
20
0
post-swim
bike start
bike 15
bike end
Run start
Run end
Time
HR-A
HR-B


D. Perceived Effort against Time
R.P.E. - Bory Scale
18
16
14
12
10
8
6
4
2
0
post-swim
bike start
bike 15
bike end
Run start
Run end
Time
PE-A
PE-B


D. - Speed against Time
Speed - K.M. Per Hour
45
40
35
30
25
20
15
10
5
0
bike start
bike 15
bike end
Run start
Run end
Time
Speed-A
Speed-B


D. - Watt against time
400
350
300
250
200
150
100
50
0
Watts - Output
bike start
bike 15
bike end
Time
Watt-A
Watt-B

Subject F :

Swim speed decreased progressively in both trials, indicating a lack of pacing awareness or a diminishing of energy.

Subject F had a medium level of power output on the bike and good stability of power and heart rate. However, subject F was working at a lower % of H.R. Max.. The possible reasons for this are numerous, including muscle glucose depletion, insufficient muscle strength, or lack of conditioning. In the run the % of heart rate Max. was held at a very high level.

Blood glucose - levels were slightly higher in test B than in test A, but showed no significant difference. In both tests blood glucose levels were reasonable high. Blood lactate - levels were higher in test A than test B.

Urea - levels were lower in test A than test B.
R.P.E. - was slighter higher in test B, but not statistically significant.
The swim was slower in test B as was the bike, the run however, was faster.

The Likert scale showed a preferable response to both solutions with a marginal preference to solution A.

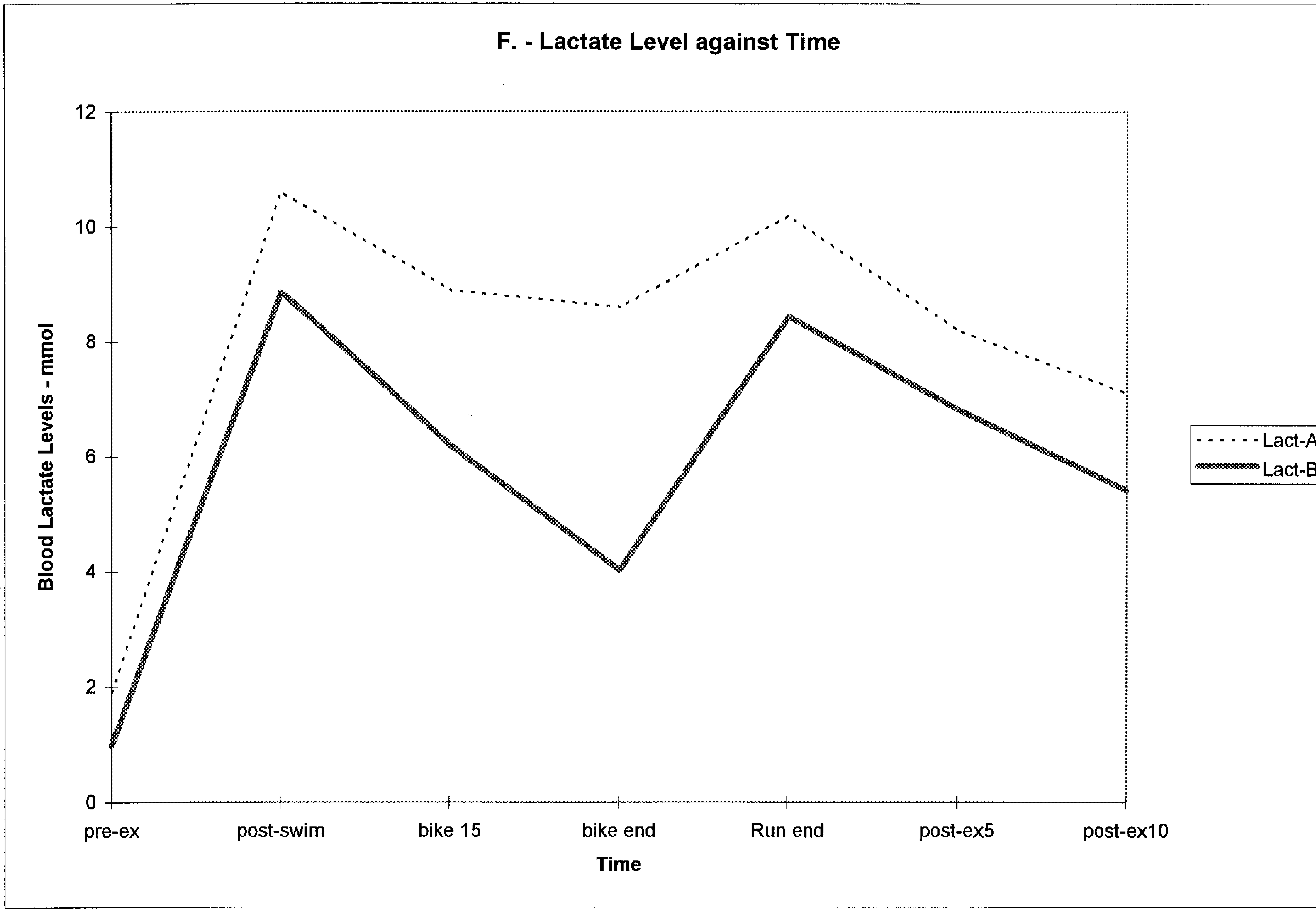
For subject F there appears to be little difference in use of Glucose or Glucose Polymer performance was generally better in test A, but it is unclear if this is due to the difference of CHO solution . (See discussion).

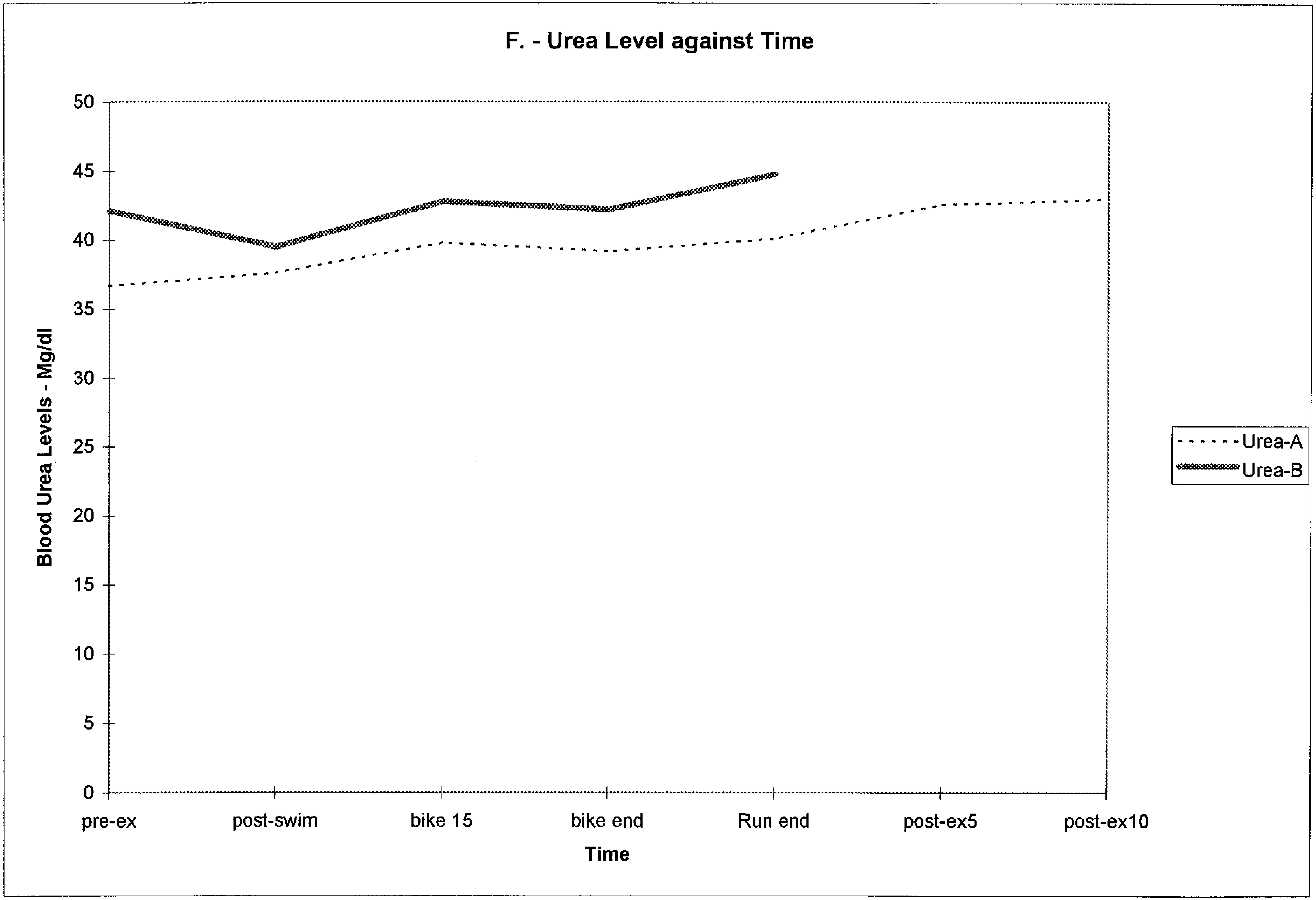
For result data refer to table 4 iii.

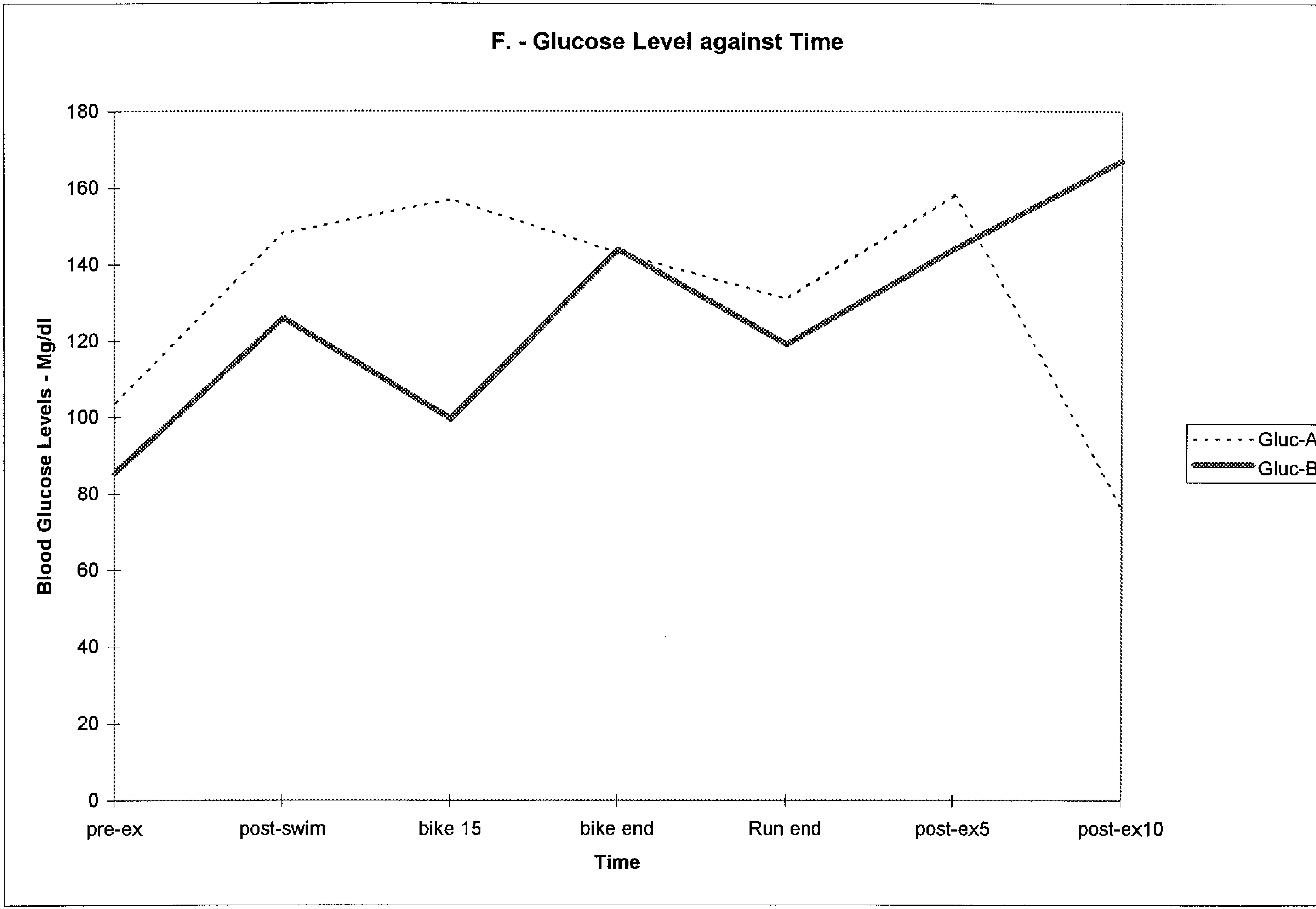
SUBJECT F

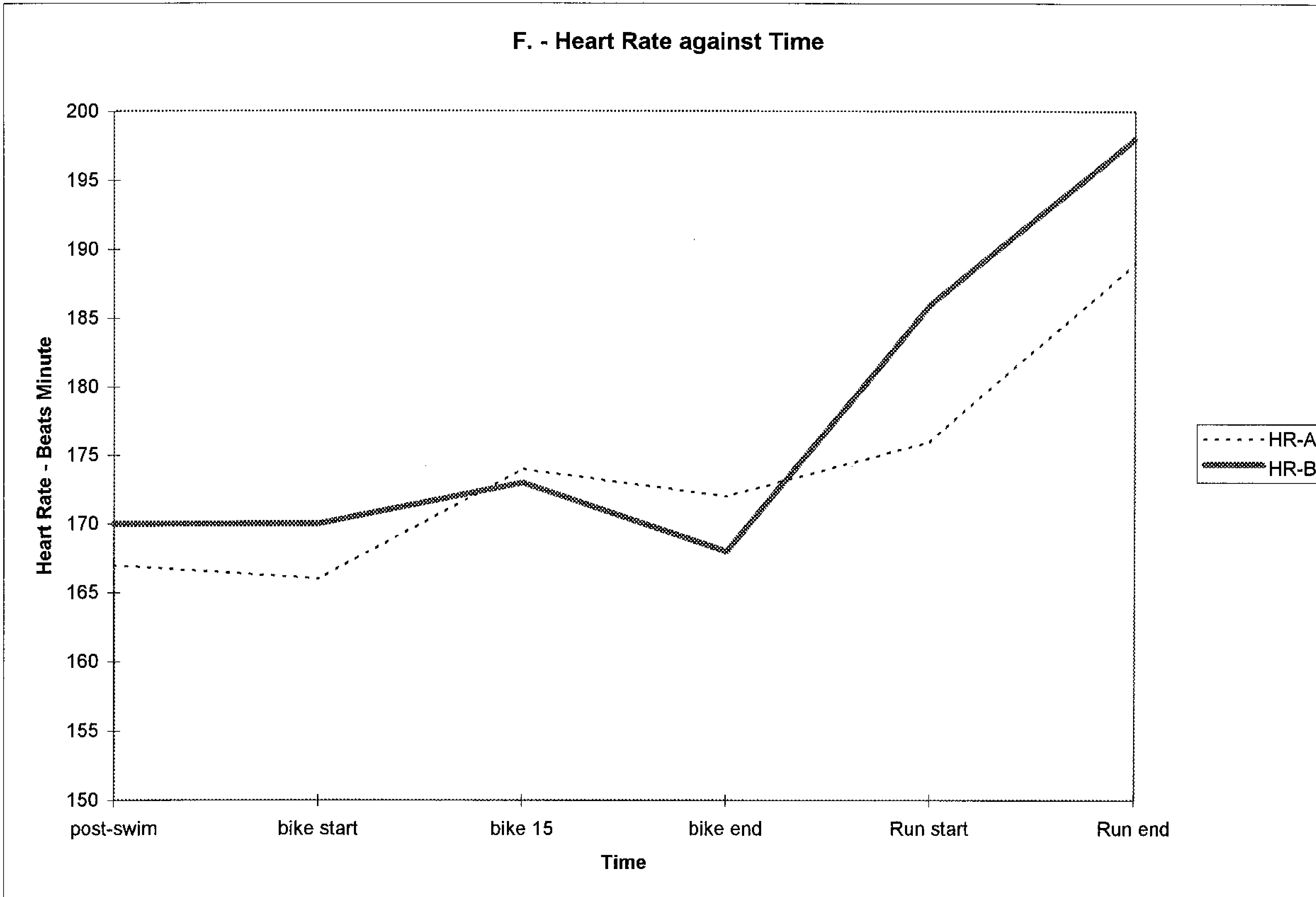
Solution	A	B	A	B	A	B	A	B	A	B	A	B	A	B
STAGE	LACT	LACT	UREA	UREA	LUCOS	LUCOS	H.R.	H.R.	R.P.E.	R.P.E.	SPEED	SPEED	WATT	WATTS
PRE-EXERCISE	1.9	0.99	36.7	42.1	104	85.4								
POST SWIM	10.6	8.87	37.6	39.5	148	126	167	170	16	17	17'14"	17'32"		
START BIKE							166	170	17	17	40	30	270	NO DATA
BIKE 15KM	8.9	6.19	39.8	42.8	157	99.6	174	173	19	19	40	35.7	265	NO DATA
END BIKE 27KM	8.6	4.01	39.2	42.2	143	144	172	168	17	18	39	37.9	265	NO DATA
0.95 MILE RUN							176	186	17	17	8.4	8.6		
END RUN 4.50 MILE	10.2	8.44	40.1	44.8	131	119	189	198	18	19	8.4	8.6		
END TEST II 5 MINUTES	8.2	6.82	42.6	NO DATA	158	144								
END TEST III 10 MINUTE	7.1	5.41	43	46.8	76.2	167								

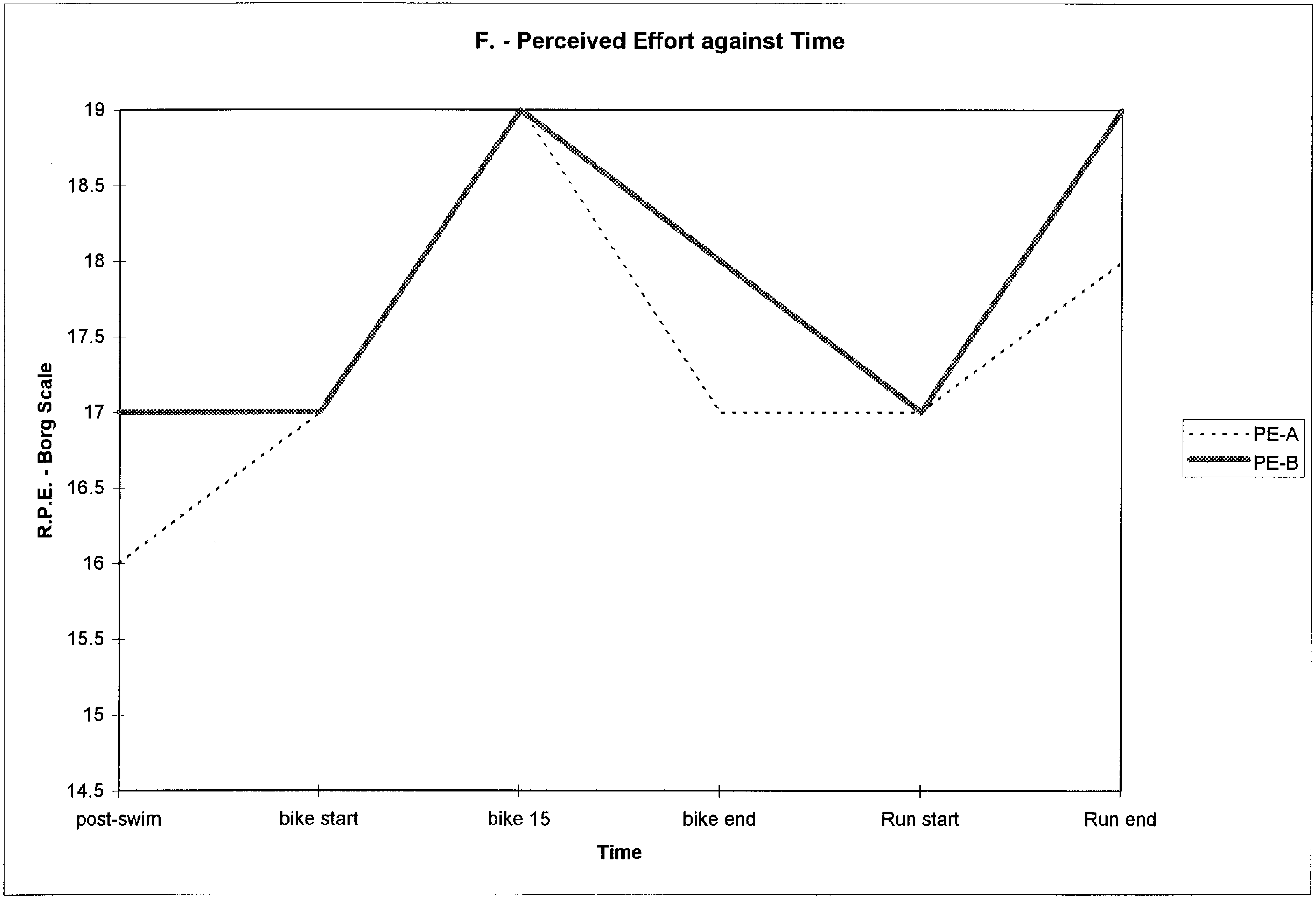
TOTAL FINISH TIME : A - 1 HOUR 32 MIN 39 SEC B - 1 HOUR 33 MIN 19 SEC

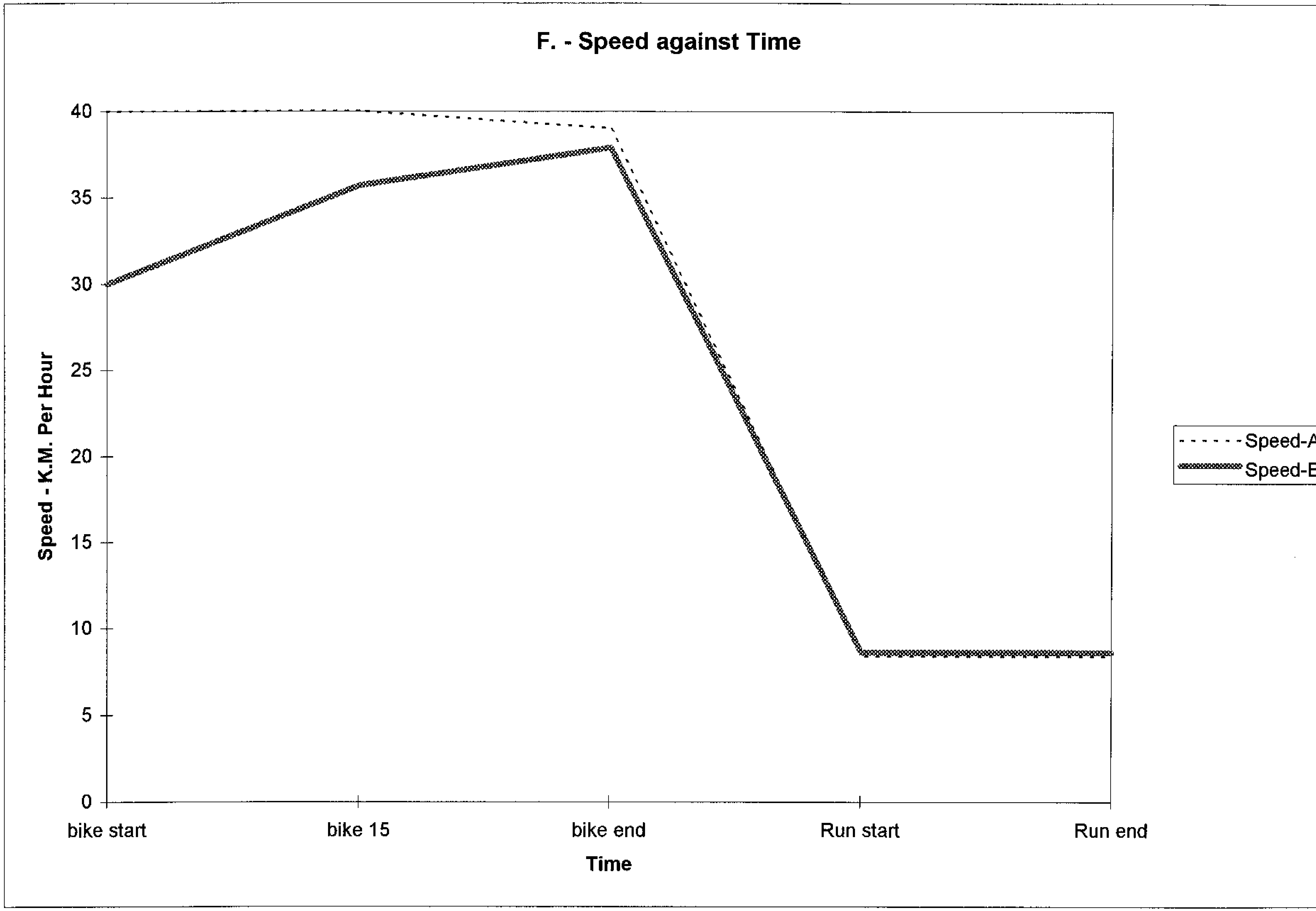

F. - Lactate Level against Time
Blood Lactate Levels - mmol
0
2
4
6
8
10
12
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Lact-A
Lact-B


F. - Urea Level against Time
Blood Urea Levels - Mg/dl
50
45
40
35
30
25
20
15
10
5
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Urea-A
Urea-B


F. - Glucose Level against Time
Blood Glucose Levels - Mg/dl
180
160
140
120
100
80
60
40
20
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Gluc-A
Gluc-B


F. - Heart Rate against Time
Heart Rate - Beats Minute
200
195
190
185
180
175
170
165
160
155
150
post-swim
bike start
bike 15
bike end
Run start
Run end
Time
HR-A
HR-B

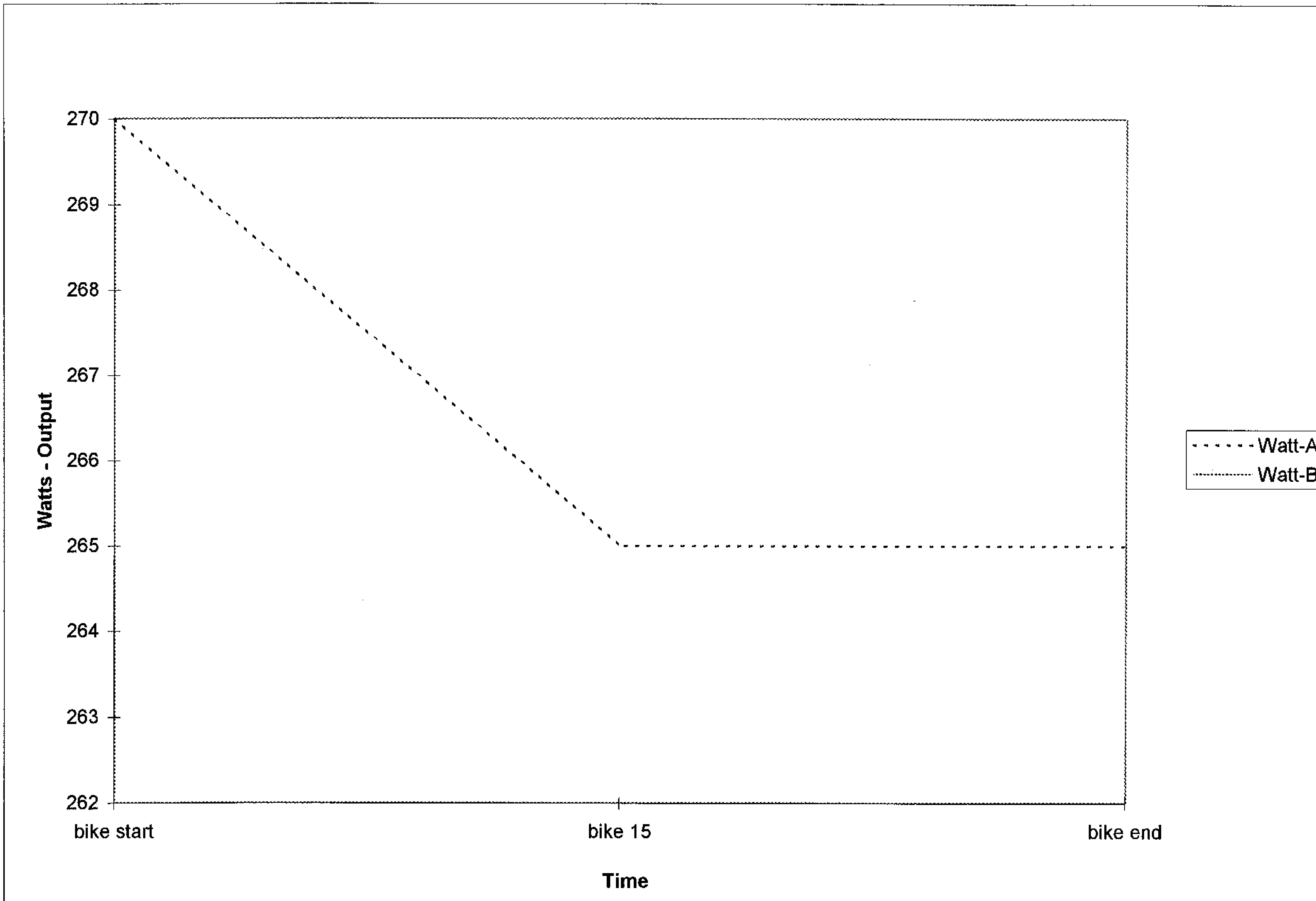

F. - Perceived Effort against Time
R.P.E. - Borg Scale
19
18.5
18
17.5
17
16.5
16
15.5
15
14.5
post-swim
bike start
bike 15
bike end
Run start
Run end
Time
PE-A
PE-B



F. - Speed against Time
Speed - K.M. Per Hour
40
35
30
25
20
15
10
5
0
bike start
bike 15
bike end
Run start
Run end
Time
Speed-A
Speed-B

F. - Watt against Time

N.B. No Data For Test B. Due to Machine Malfunction.



Subject K:

Swimming speed decreased progressively in both tests. Pacing inadequacy being the prime cause. The total swim time was slightly slower in test B.

The heart rate using the glucose solution in test A was 84.99% of Max.. In the Glucose Polymer test B the heart rate was at 94.70% of H.R. Max.. This is reflected in the faster bike speed. The heart rate and lactate values were not within the expected optimal range in the glucose test A. This indicates the subject was limited by low blood glucose, or other variables including lack of fitness or motivation. The generally low blood glucose values under both CHO solutions may suggest individual variation of norm values, or the need for higher levels of CHO supplement. The value of heart rate and lactate were within the 'normal' optimal range in test B and thus, a faster time was produced in bike and run and overall.

Urea was higher in test A than test B suggesting test A may have been more stressful on the subjects metabolism.

R.P.E. was the same for both tests A and B.

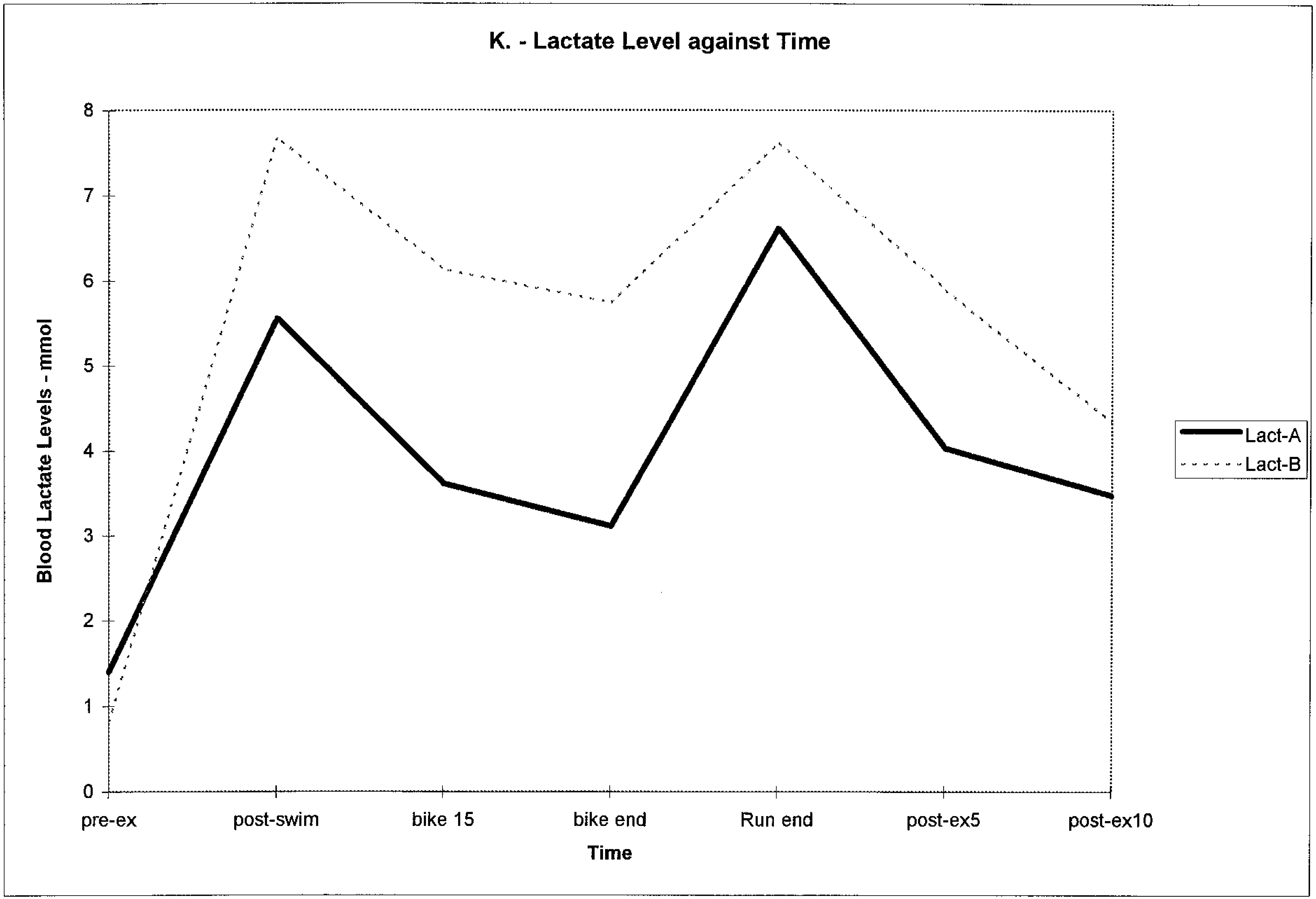
It seems the Glucose Polymer enabled the subject to perform at higher levels. Again the blood glucose levels were not statistically significantly different, therefore other limiting factors must be operating. (See discussion). In terms of personal preference this subject responded positively to both solutions on the Likert scale, but with a slight preference to solution A.

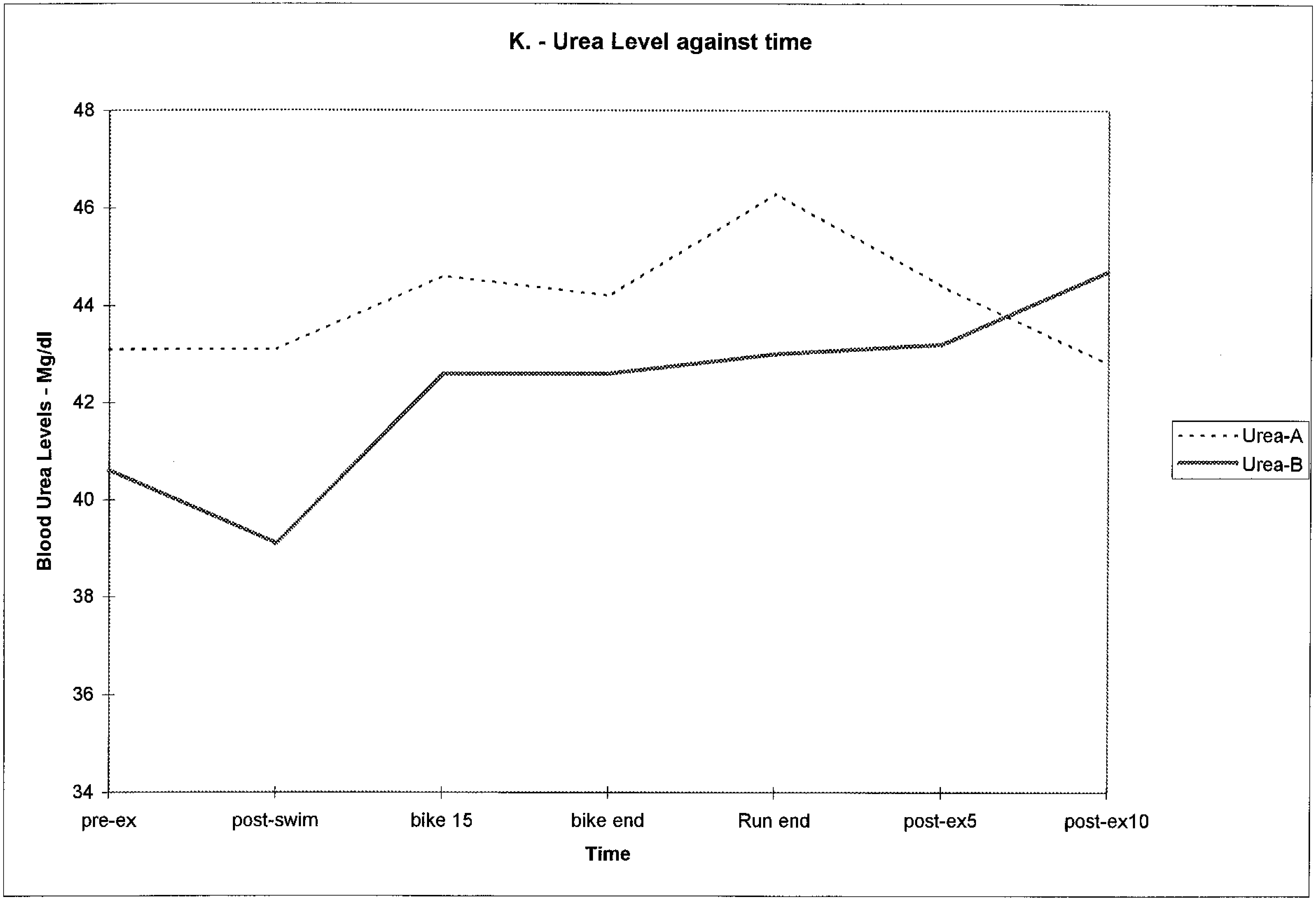
Result data refer to table 4 iv.

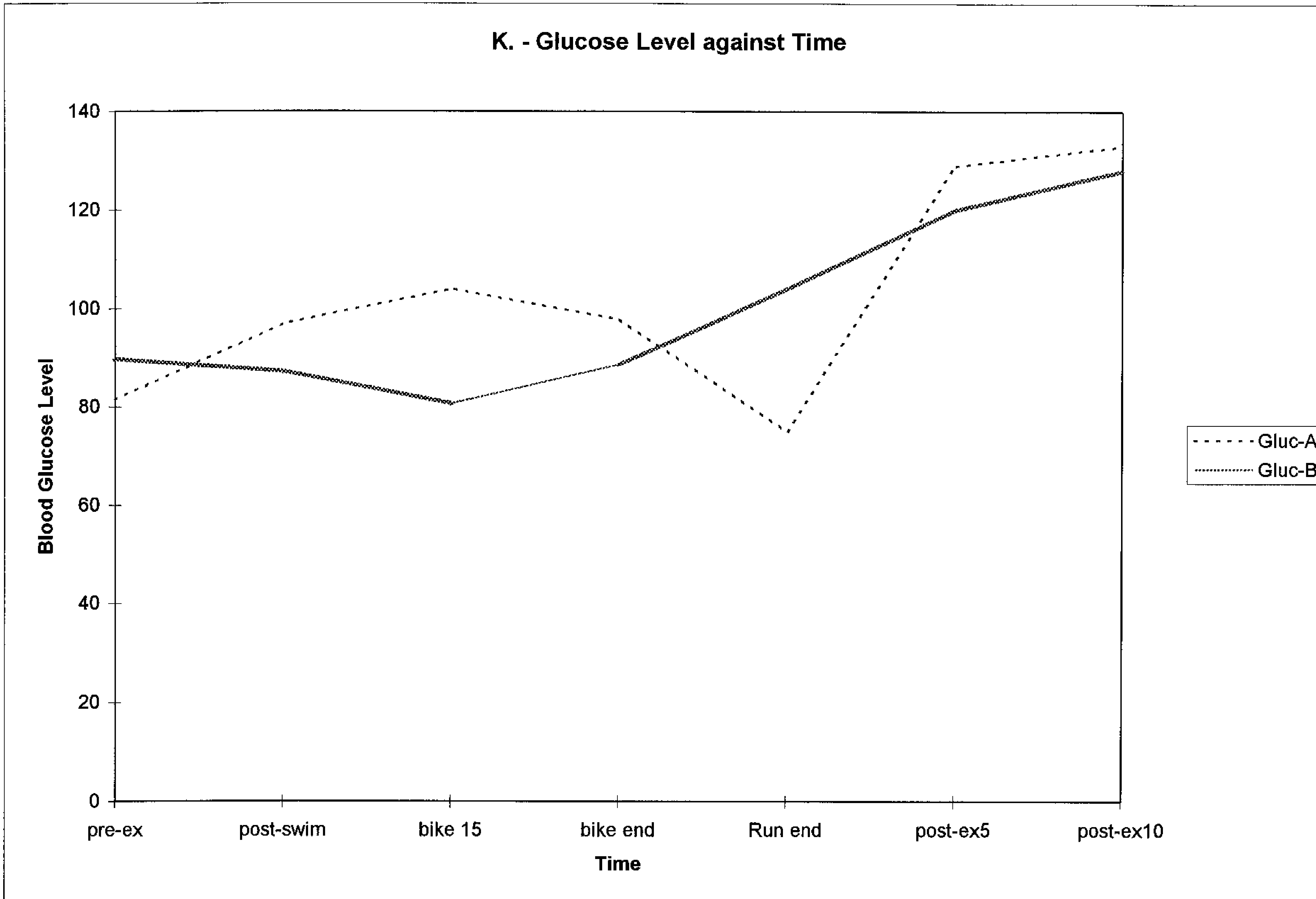
SUBJECT K

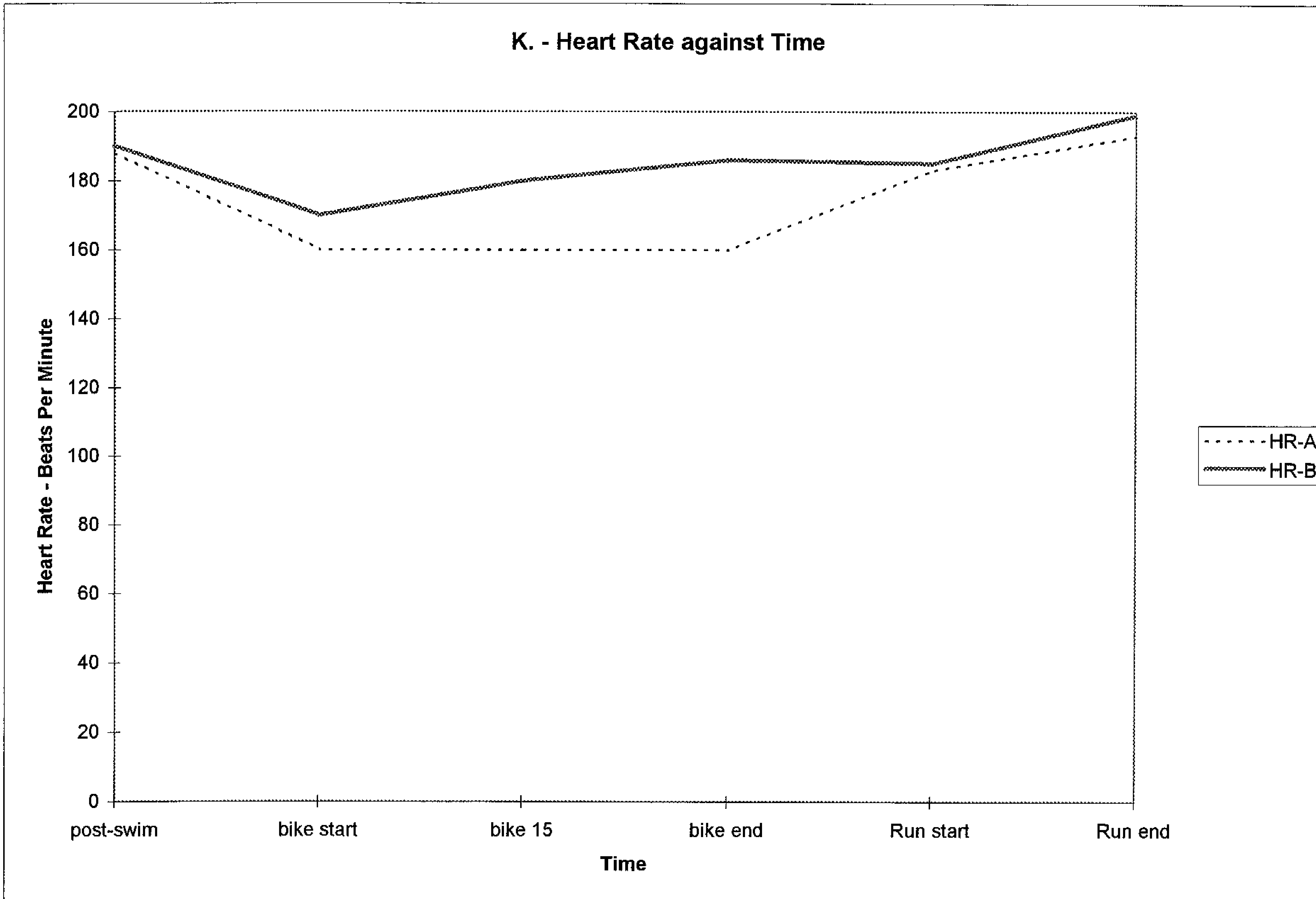
Solution	A	B	A	B	A	B	A	B	A	B	A	B	A	B
STAGE	LACT	LACT	UREA	UREA	LUCOS	LUCOS	H.R.	H.R.	R.P.E.	R.P.E.	SPEED	SPEED	WATT	WATTS
PRE-EXERCISE	1.4	0.81	43.4	40.6	81.5	89.7								
POST SWIM	5.56	7.68	43.1	39.1	96.9	87.2	188	190	14	17	15'23"	15'35"		
START BIKE							160	170	15	15	36	36	216	216
BIKE 15KM	3.61	6.13	44.6	42.6	104	80.7	160	180	16	15	36.8	38.8	242	260
END BIKE 27KM	3.11	5.74	44.2	42.6	97.8	88.7	160	186	15	17	38.5	40	259	282
0.95 MILE RUN							183	185	17	15	9	8.7		
END RUN 4.50 MILE	6.62	7.63	46.3	43	75	104	193	199	18	17	8.2	9.1		
END TEST II 5 MINUTES	4.03	5.9	44.4	43.2	129	120								
END TEST III 10 MINUTE	3.47	4.33	42.8	44.7	133	128								

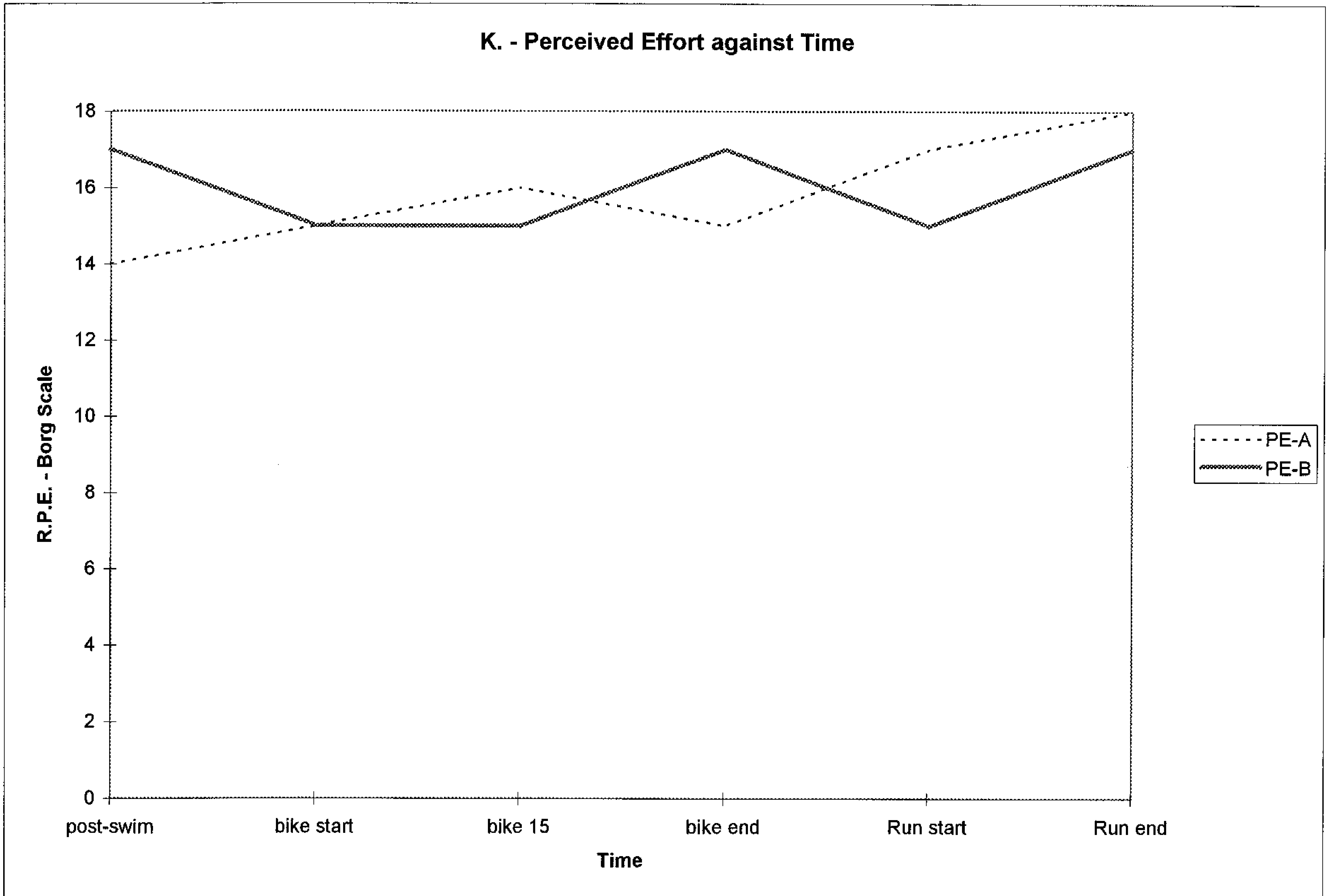
TOTAL FINISH TIME : A - 1 HOUR 30 MIN 18 SEC B - 1 HOUR 28 MIN 36 SEC

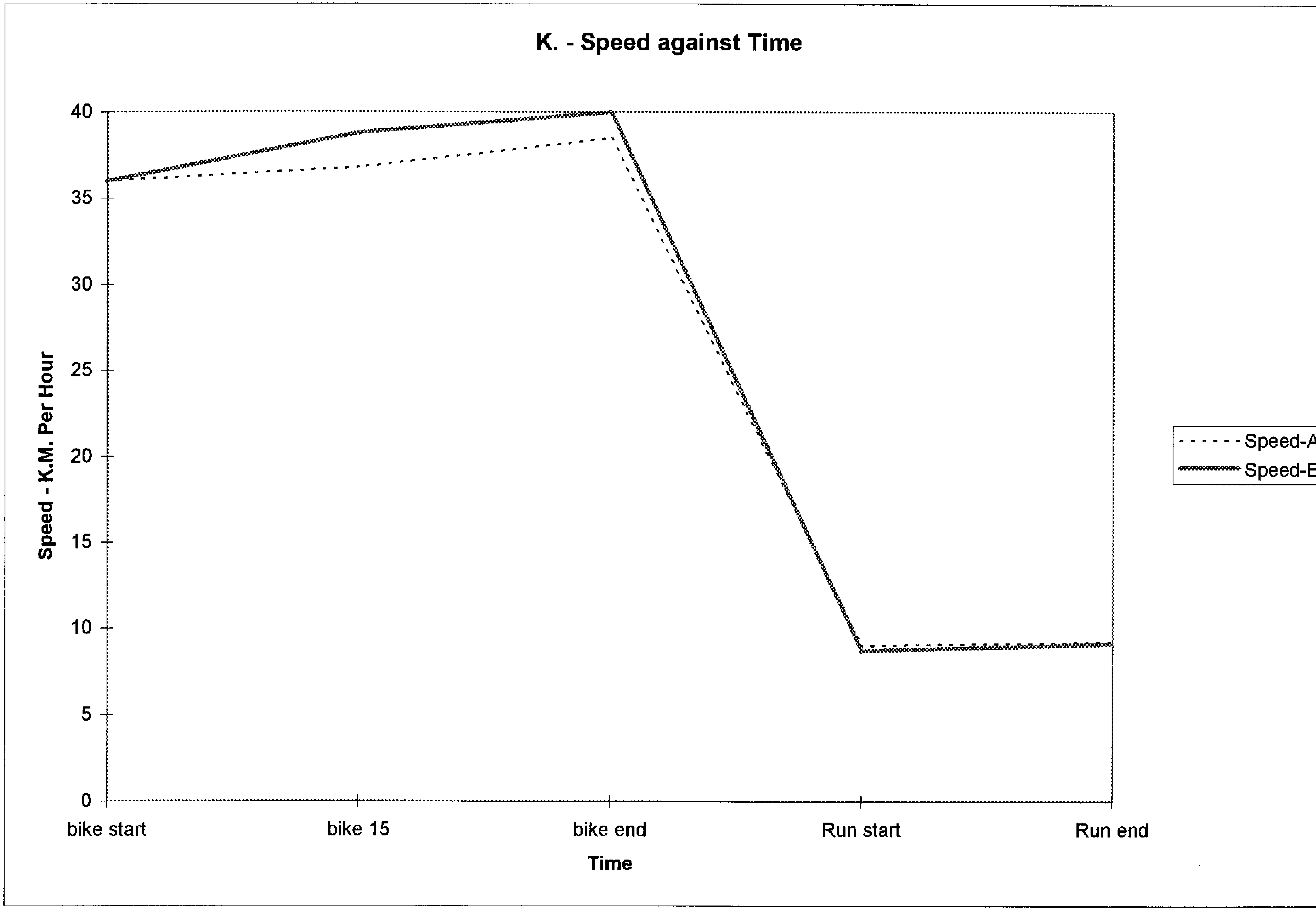

K. - Lactate Level against Time
Blood Lactate Levels - mmol
8
7
6
5
4
3
2
1
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Lact-A
Lact-B

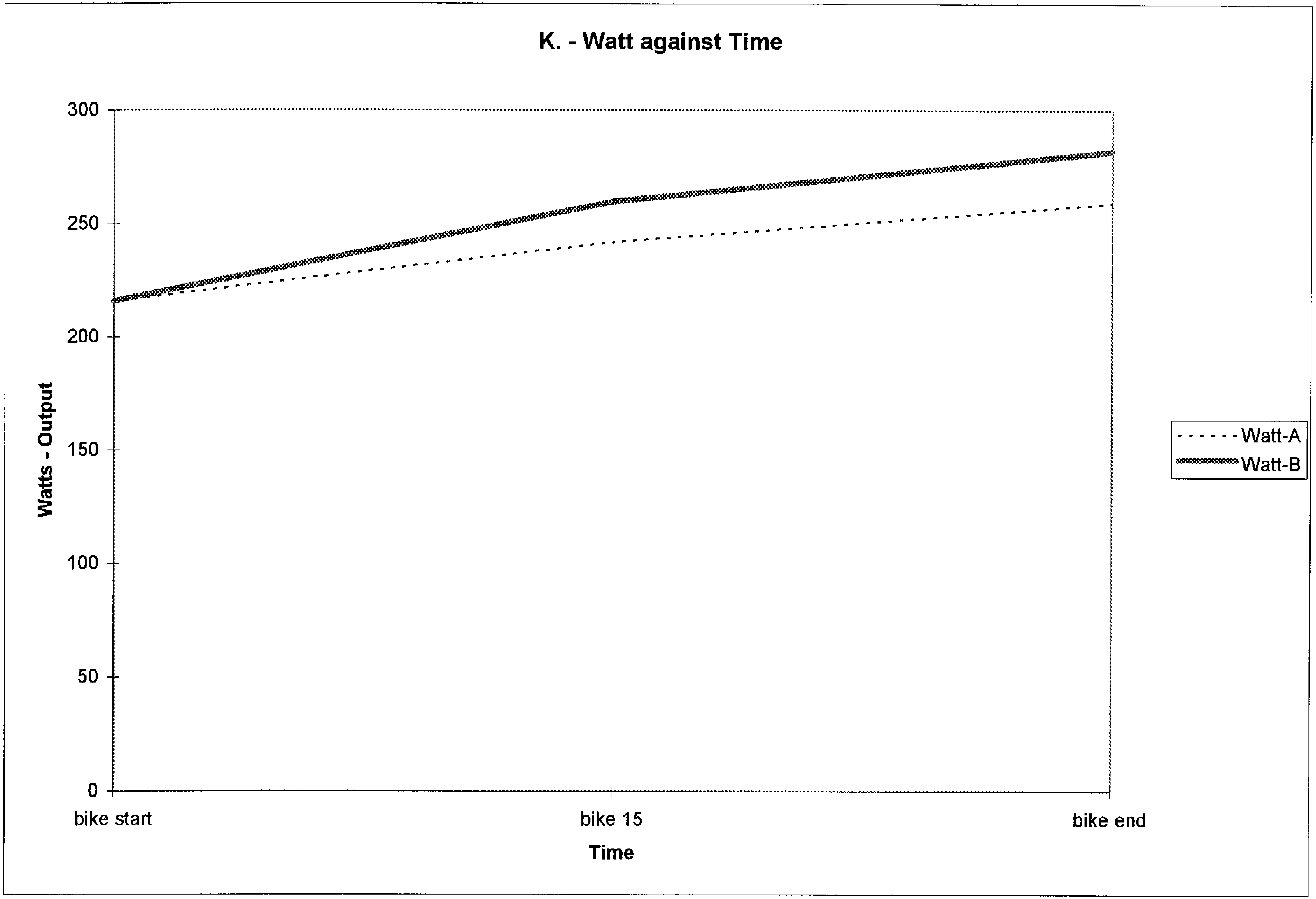

K. - Urea Level against time
Blood Urea Levels - Mg/dl
48
46
44
42
40
38
36
34
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Urea-A
Urea-B


K. - Glucose Level against Time
Blood Glucose Level
140
120
100
80
60
40
20
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Gluc-A
Gluc-B


K. - Heart Rate against Time
Heart Rate - Beats Per Minute
200
180
160
140
120
100
80
60
40
20
0
post-swim
bike start
bike 15
bike end
Run start
Run end
Time
HR-A
HR-B


K. - Perceived Effort against Time
R.P.E. - Borg Scale
18
16
14
12
10
8
6
4
2
0
post-swim
bike start
bike 15
bike end
Run start
Run end
Time
PE-A
PE-B


K. - Speed against Time
Speed - K.M. Per Hour
40
35
30
25
20
15
10
5
0
bike start
bike 15
bike end
Run start
Run end
Time
Speed-A
Speed-B


K. - Watt against Time
Watts - Output
300
250
200
150
100
50
0
bike start
bike 15
bike end
Time
Watt-A
Watt-B

Subject J:

The time for the test B - Glucose Polymer solution was much slower than test A. The stability in power, speed and heart rate was adequate, but the output was lower.

The speed was slower in all 3 disciplines. Blood Glucose - levels were low for both trials with little difference between Glucose and Glucose Polymer solutions.

Urea - Levels were lower in test A than test B.
R.P.E. - Was similar for both test.
Lactate - Levels were slightly lower in test A suggesting speed was limited. Coupled with low blood glucose it appears subject J performance in test B was limited by blood glucose to a certain level and other contributing factors.

The Likert scale showed indifference to both solutions, but a slight preference to solution A.

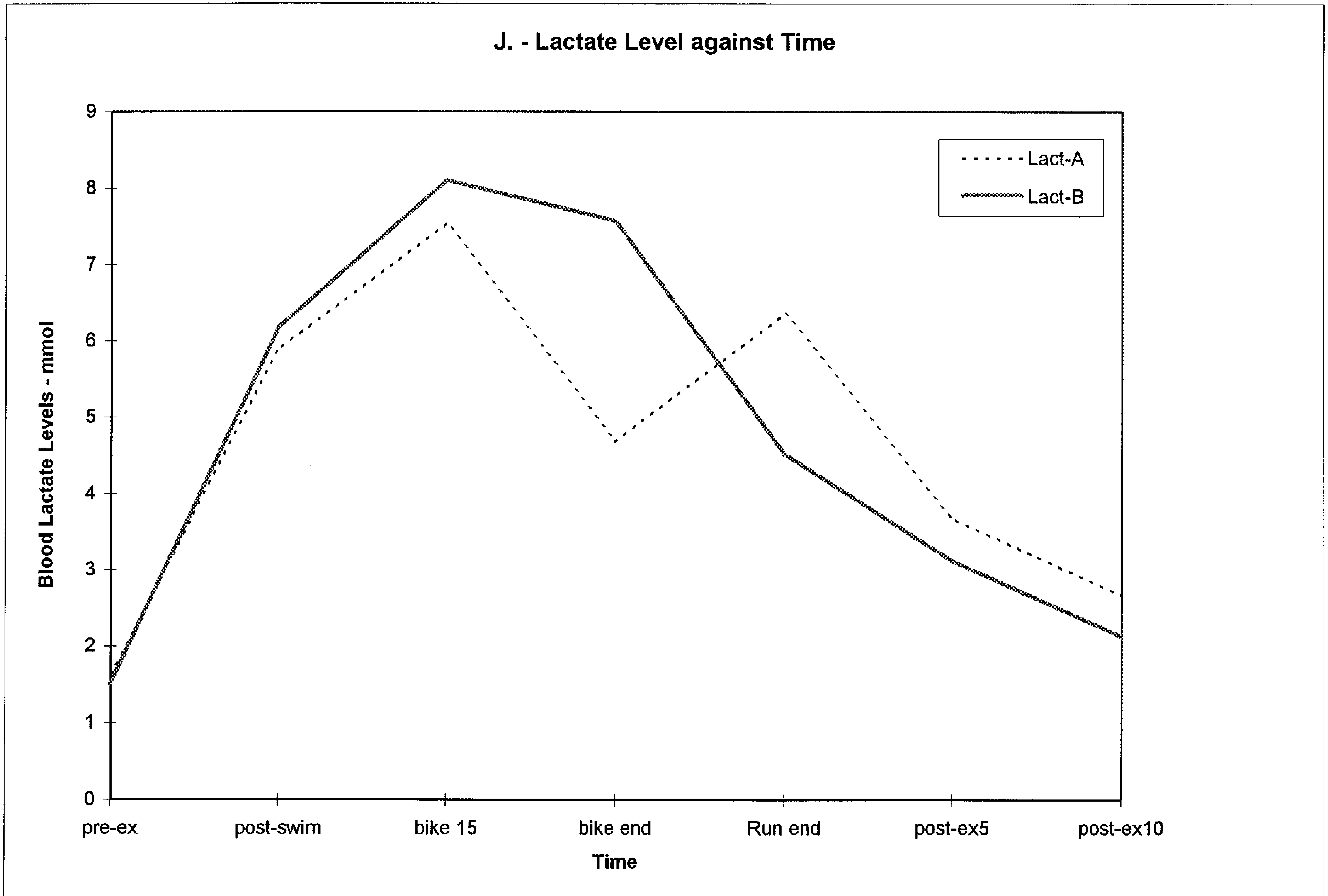
The glucose solution appears to be very slightly more effective for maintaining performance. Although there are minimal differences in the blood glucose levels between the 2 CHO solutions.

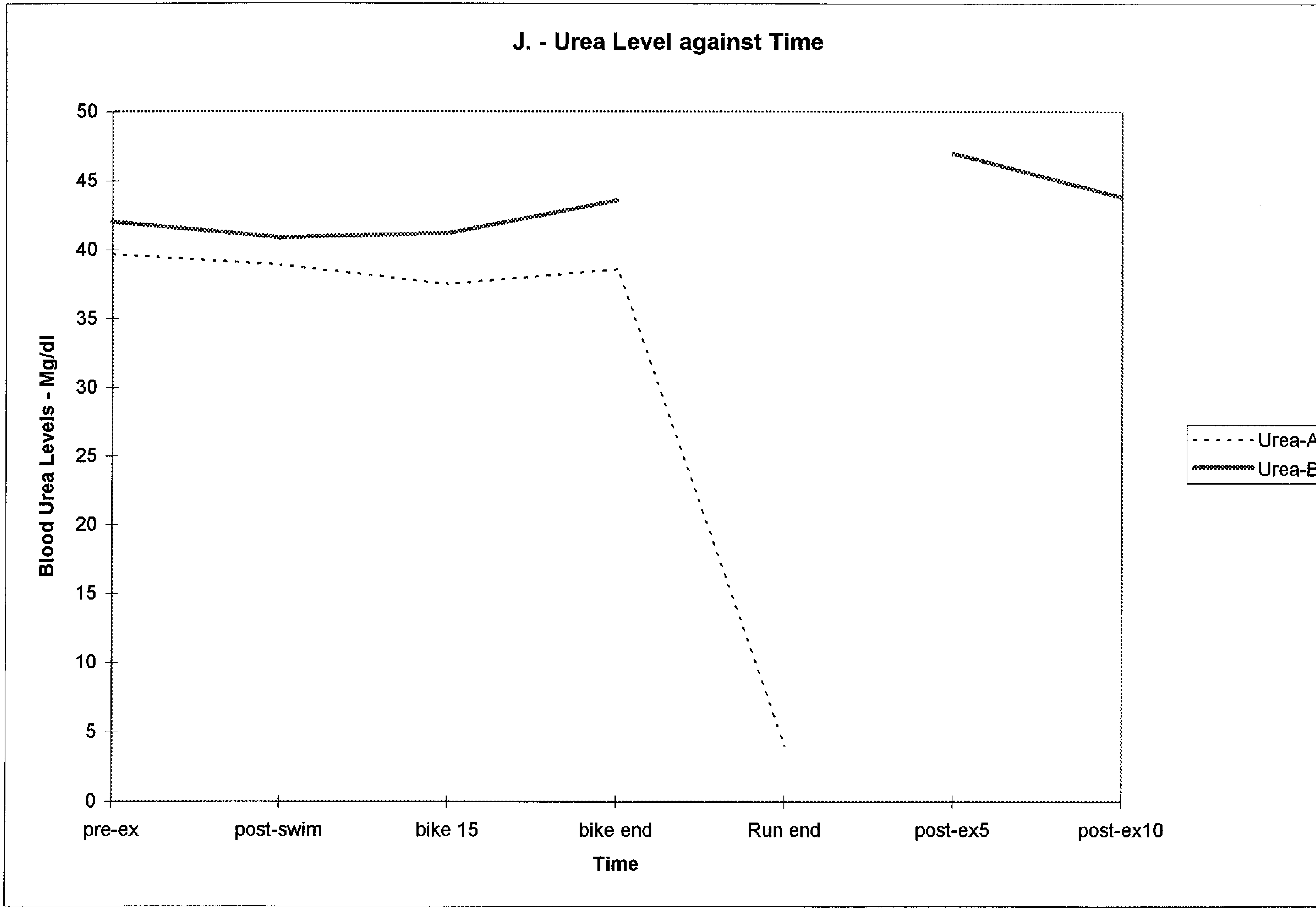
Individual statistical difference are presented in table.

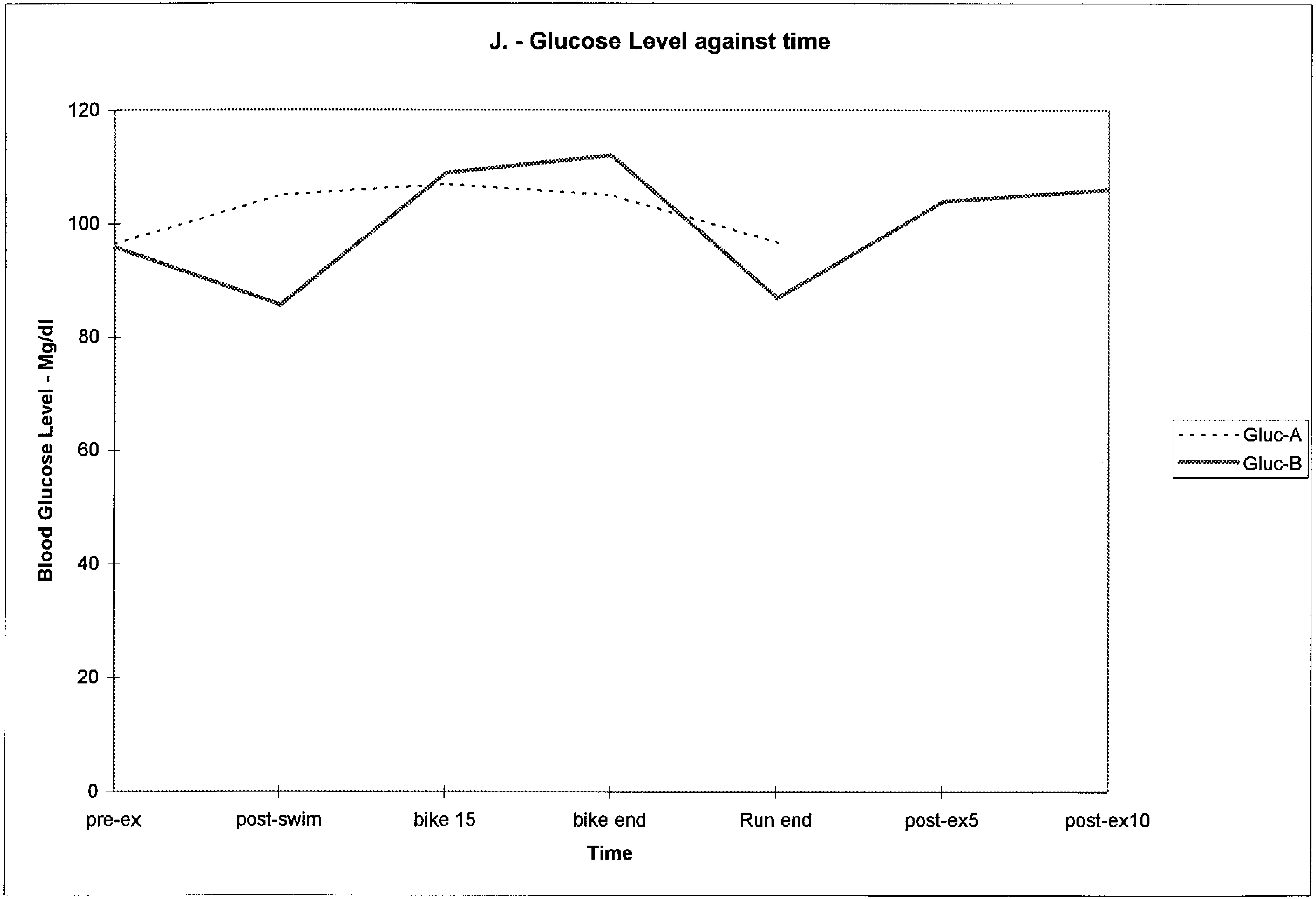
SUBJECT J

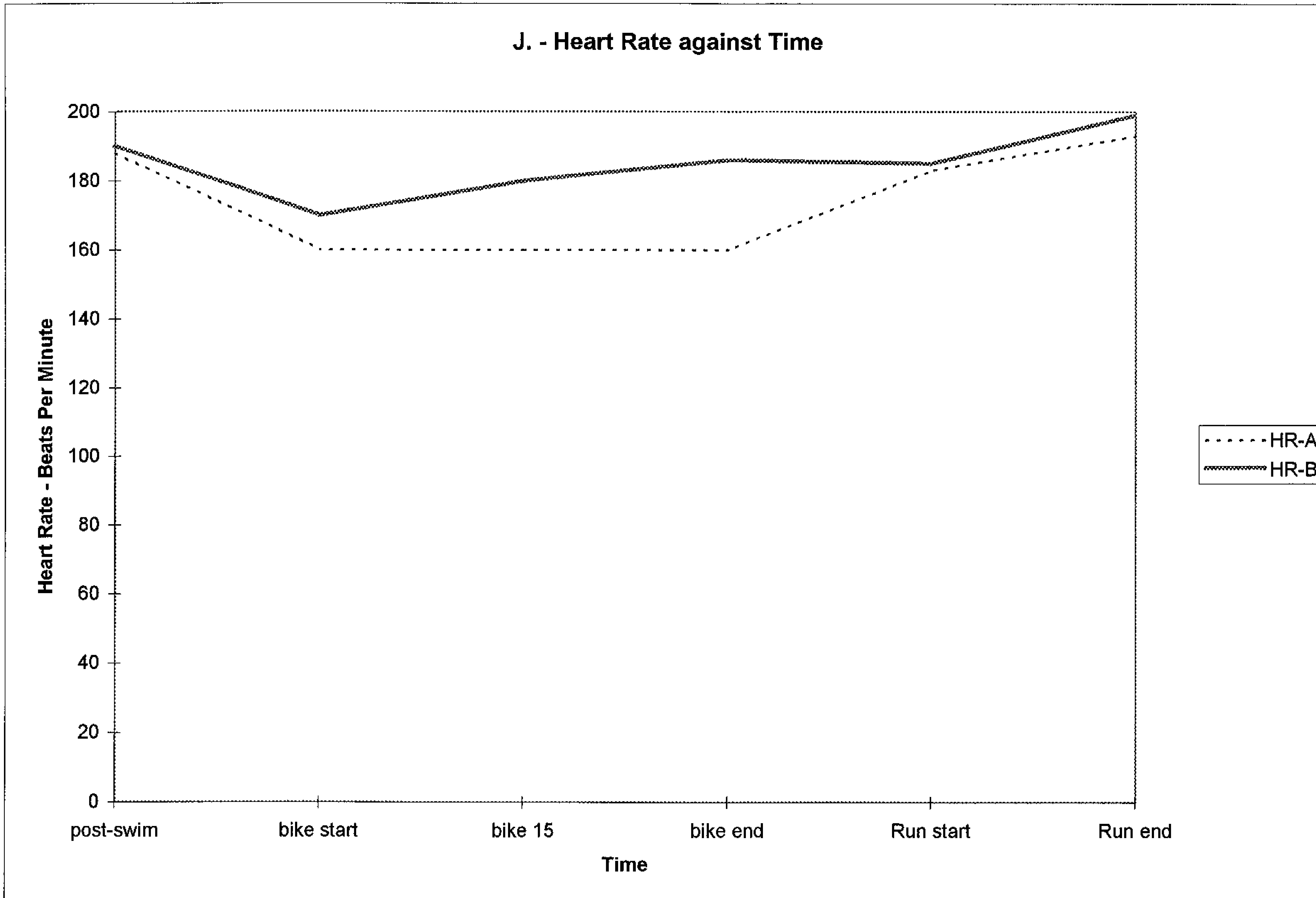
Solution	A	B	A	B	A	B	A	B	A	B	A	B	A	B
STAGE	LACT	LACT	UREA	UREA	LUCOS	LUCOS	H.R.	H.R.	R.P.E.	R.P.E.	SPEED	SPEED	WATT	WATTS
PRE-EXERCISE	1.63	1.51	39.7	42	96.5	95.9								
POST SWIM	8.59	6.18	38.9	40.9	105	85.7	190	195	11	13	15'14"	15'59"		
START BIKE							170	155	13	13	34	31	216	182
BIKE 15KM	7.54	8.1	37.5	41.2	107	109	182	186	15	15	36	36	224	219
END BIKE 27KM	4.68	7.57	38.6	43.6	105	112	176	184	16	15	34.3	36	201	221
0.95 MILE RUN							173	184	14	16	8.5	8.1		
END RUN 4.50 MILE	6.36	4.51	40.2	NO DATA	96.7	86.9	185	183	17	15	9.3	8		
END TEST II 5 MINUTES	3.67	3.11	NO DATA	47	NO READING	104								
END TEST III 10 MINUTE	2.65	2.12	41.8	43.8	110	106								

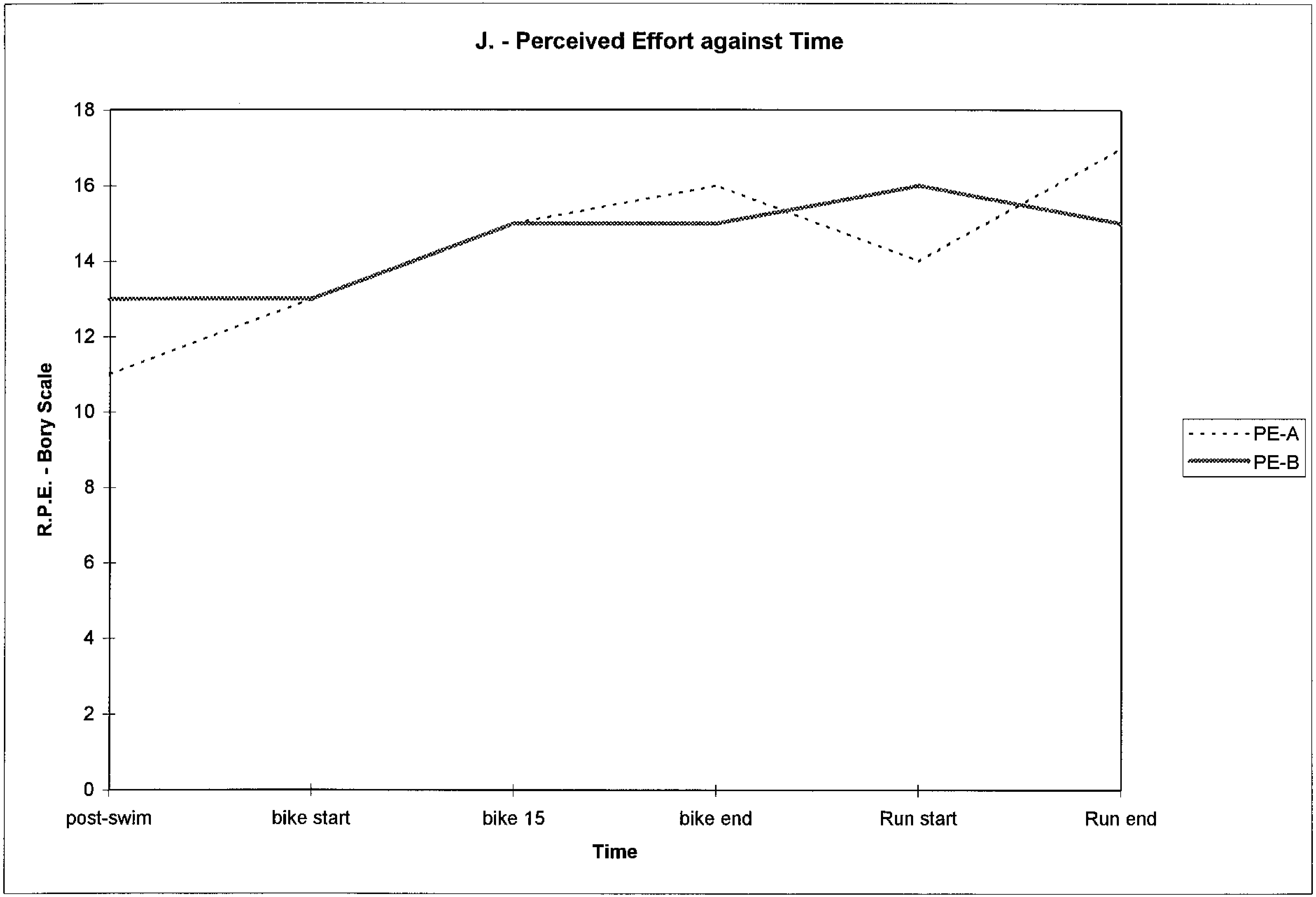
TOTAL FINISH TIME : A - 1 HOUR 30 MIN 38 SEC B - 1 HOUR 36 MIN 23 SEC

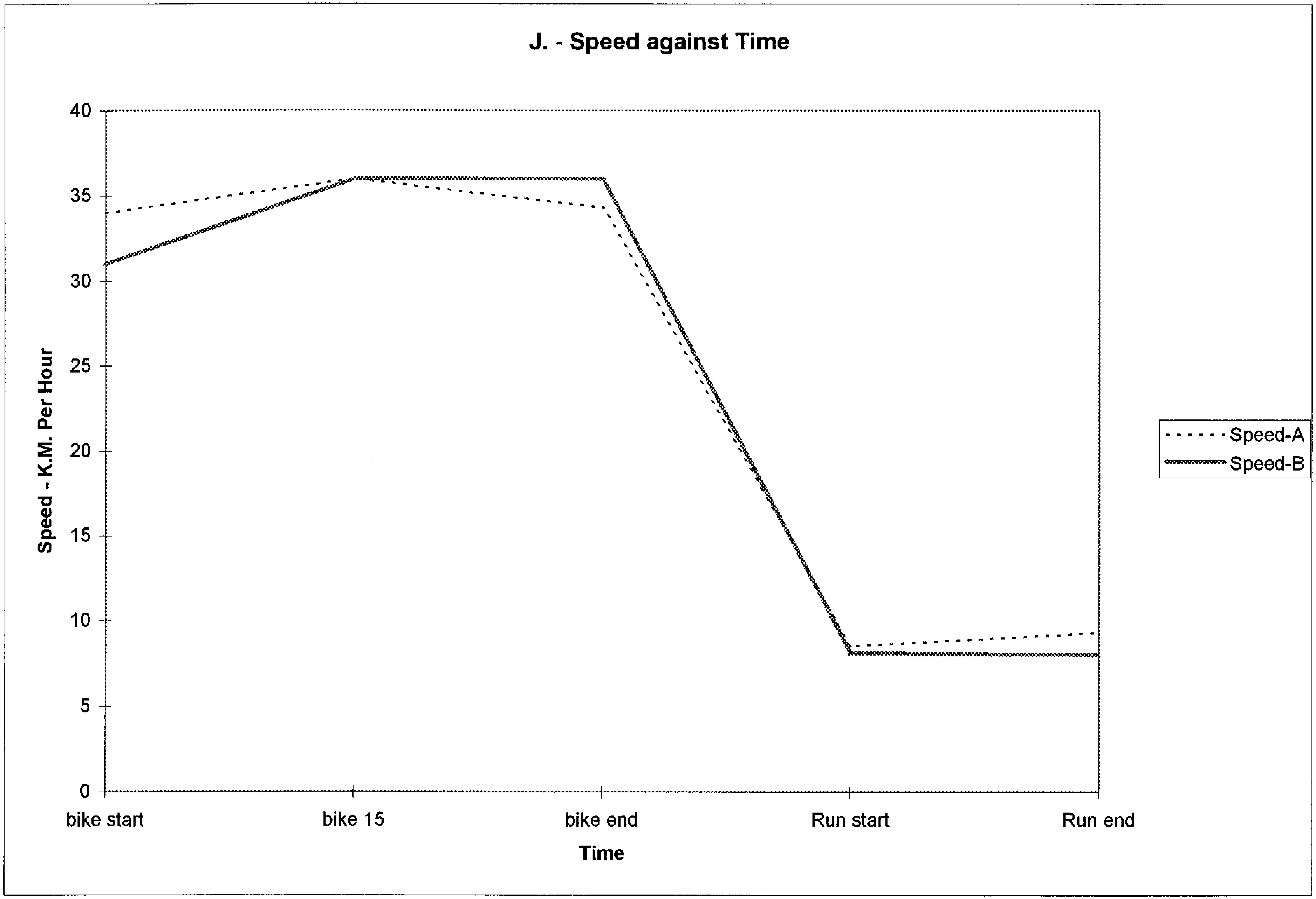

J. - Lactate Level against Time
Blood Lactate Levels - mmol
0
1
2
3
4
5
6
7
8
9
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Lact-A
Lact-B

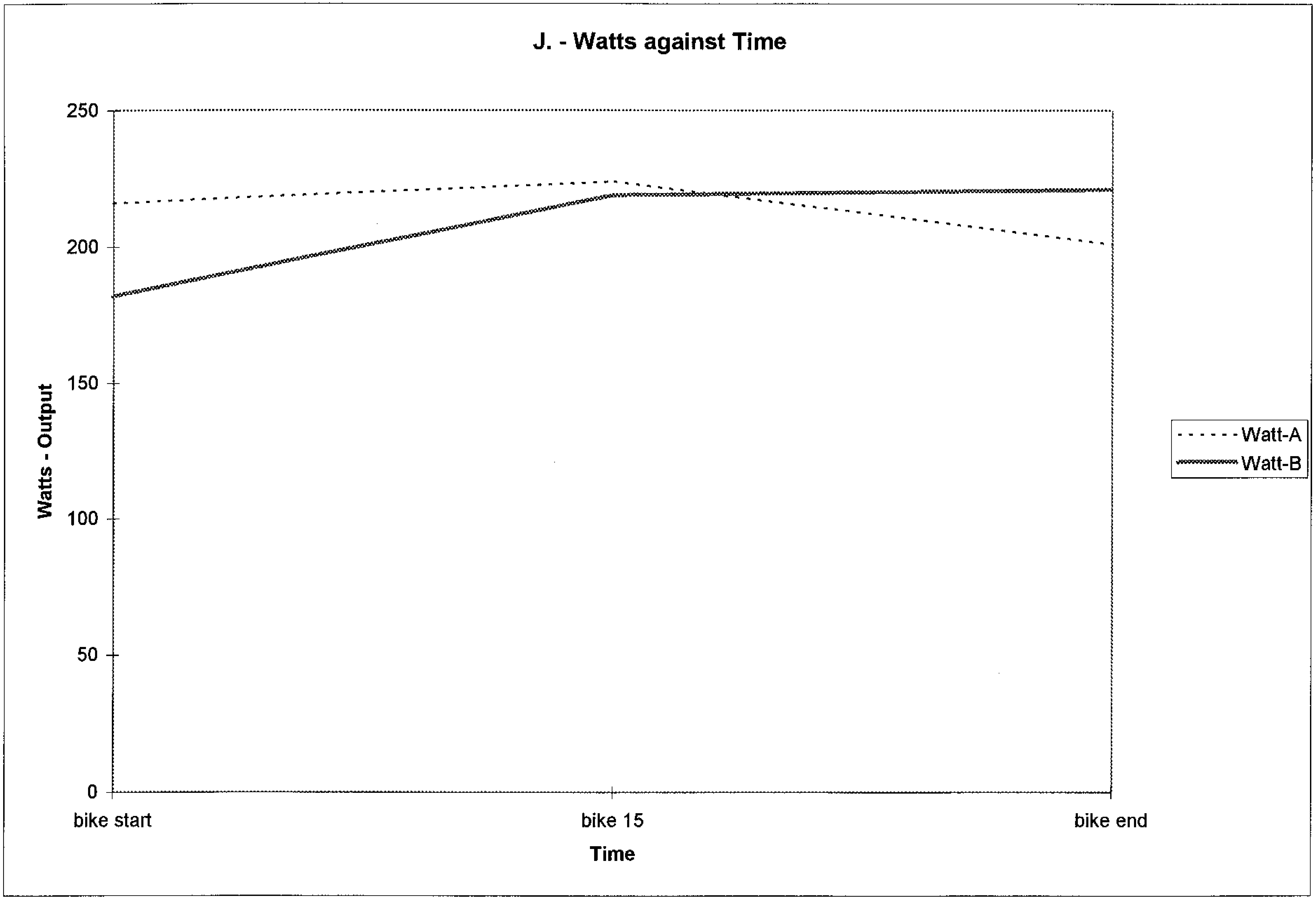

J. - Urea Level against Time
Blood Urea Levels - Mg/dl
50
45
40
35
30
25
20
15
10
5
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Urea-A
Urea-B


J. - Glucose Level against time
Blood Glucose Level - Mg/dl
120
100
80
60
40
20
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Gluc-A
Gluc-B


J. - Heart Rate against Time
Heart Rate - Beats Per Minute
200
180
160
140
120
100
80
60
40
20
0
post-swim
bike start
bike 15
bike end
Run start
Run end
Time
HR-A
HR-B


J. - Perceived Effort against Time
R.P.E. - Bory Scale
0
2
4
6
8
10
12
14
16
18
post-swim
bike start
bike 15
bike end
Run start
Run end
Time
PE-A
PE-B


J. - Speed against Time
Speed - K.M. Per Hour
40
35
30
25
20
15
10
5
0
bike start
bike 15
bike end
Run start
Run end
Time
Speed-A
Speed-B


J. - Watts against Time
250
200
150
100
50
0
Watts - Output
bike start
bike 15
bike end
Time
Watt-A
Watt-B

Group - Mean Results

Statistical Differences Are Presented in Table 3.

Group results are presented in graphs 6 to 12 and 13 to 16.

It is clear from table 3 that these are few statistical differences for the group analysis:

The only significant difference was in Heart Rate . Heart Rates for the group were higher in Teat B than Test A. Which may indicate that Test B was more 'stressful' in a physiological sense than Test A, or that the subjects were not limited in their performance in Test B. From the time differences it would appear the former is more likely.

Blood Lactate level show very little differences between test A and B. Blood glucose appears to be generally higher in test A than test B. Indicating that glucose maintains blood glucose levels at a higher level than Glucose Polymer. Blood Urea levels are generally lower in test A than test B which may indicate that there is less metabolic stress with the higher glucose levels found in test A.

Perceived effort is higher in test B than in test A which may be the result of numerous limiting factors including muscle fatigue, lower blood glucose or conversely the athletes were able to work at a higher level. This is true of some individuals but not others and will be examined in the individual analysis.

Average speed for the group in the swim and bike was slower in test B. Running speeds were on average similar between test A and test B. The average for the overall S.T.T. time was lower for test B than test A. From individual analysis subjects D and K were the only subjects who performed to a higher level in test B. The group average is slower in test B than test A.

There are however, descriptive differences in both the mean and individual results.

TABLE 3 STATISTICAL DIFFERENCES

A.

Individual Analysis	GLUC	HR	LACT	PE	SPEED	UREA	WATT
JE	-	A<B	-	-	-	-	-
F	-	-	A>B	-	-	A<B	-
K	-	A<B	A<B	-	-	A>B	-
J	-	-	-	-	-	A<B	-
D	-	-	-	A<B	-	-	-
Overall	-	A<B	-	-	-	-	-

B. MEAN GROUP DIFFERENCES

S	A-827.4"	B-943.6"
B	A-2467.2"	B-2521.4"
R	A-1821"	B-1816.6"
OV	A-5115.6"	B-5281.6"

C

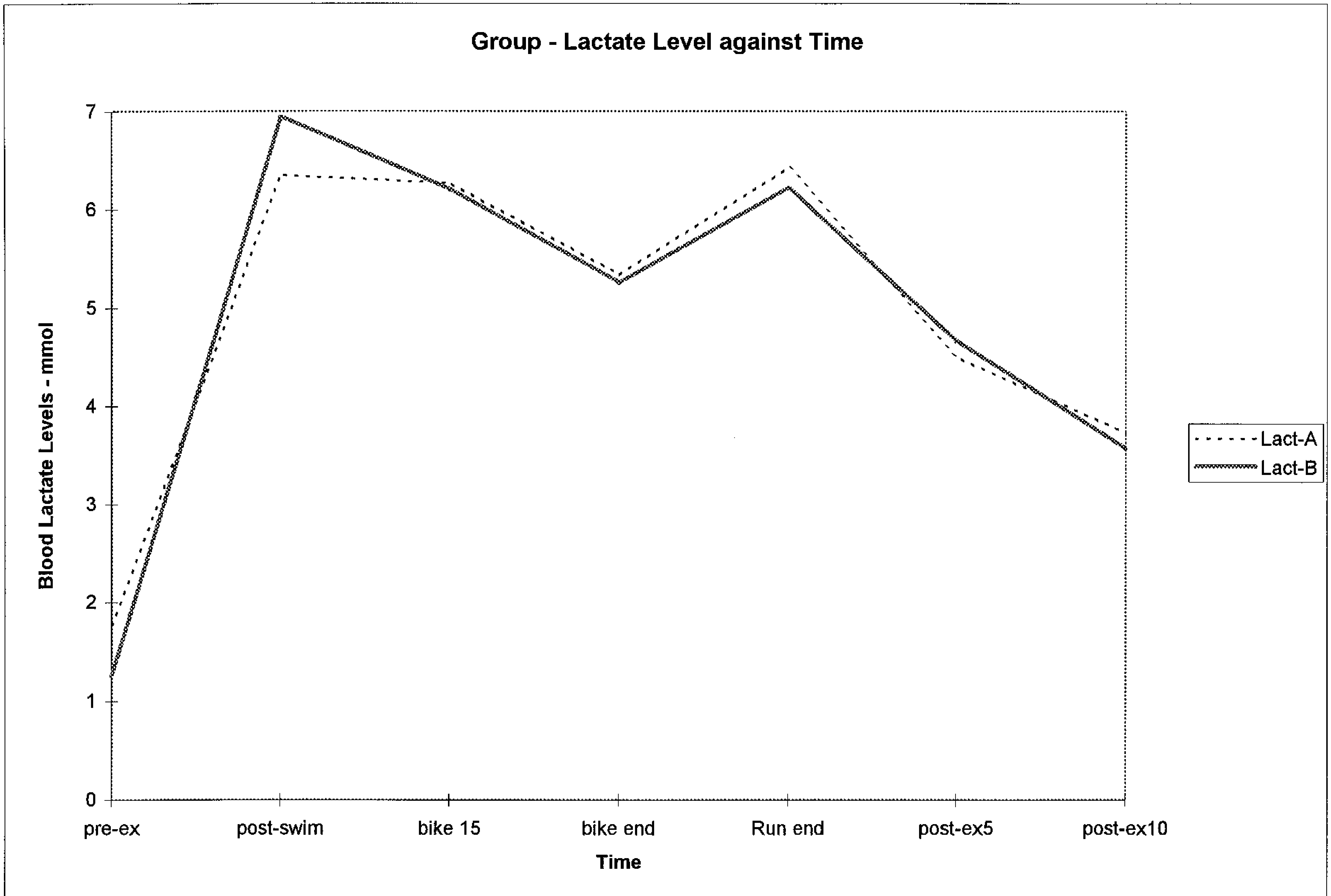
Group Analysis	Bike	Overall Time	Run	Swim
	-	-	-	-

< = LESS THAN

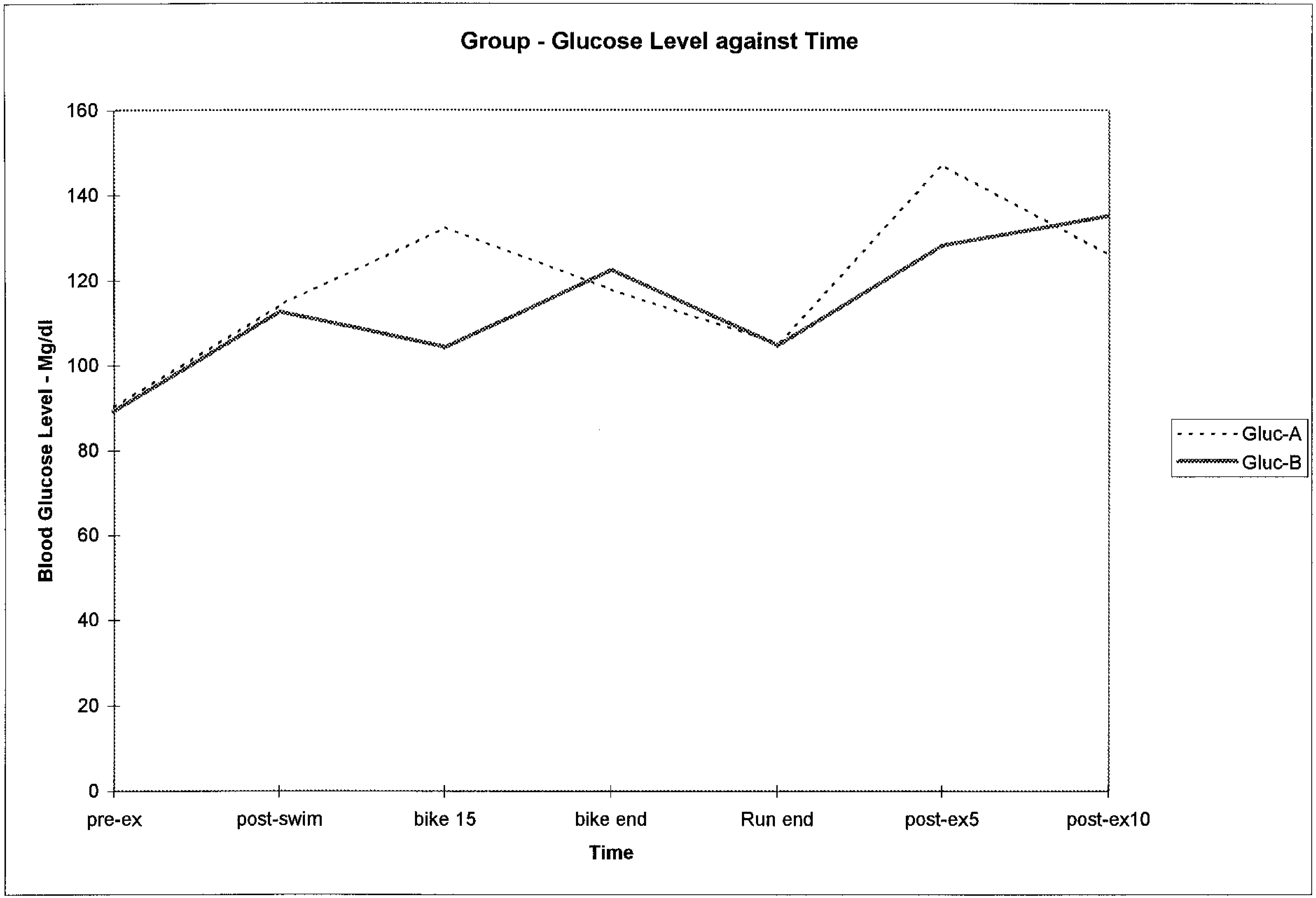
> = GREATER THAN

- = NO SIGNIFICANT DIFFERENCES

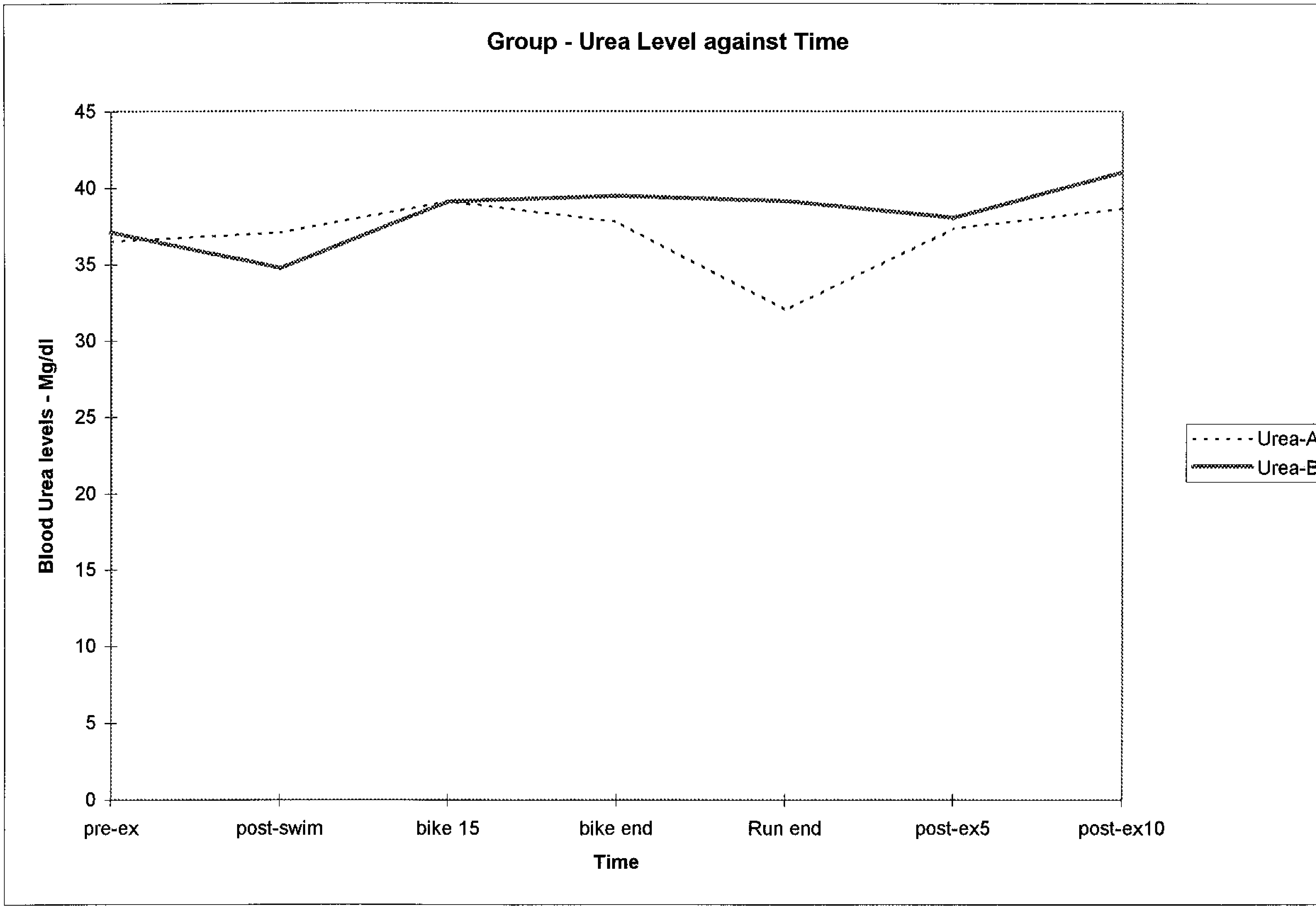
Graph 6


Group - Lactate Level against Time
Blood Lactate Levels - mmol
0
1
2
3
4
5
6
7
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Lact-A
Lact-B

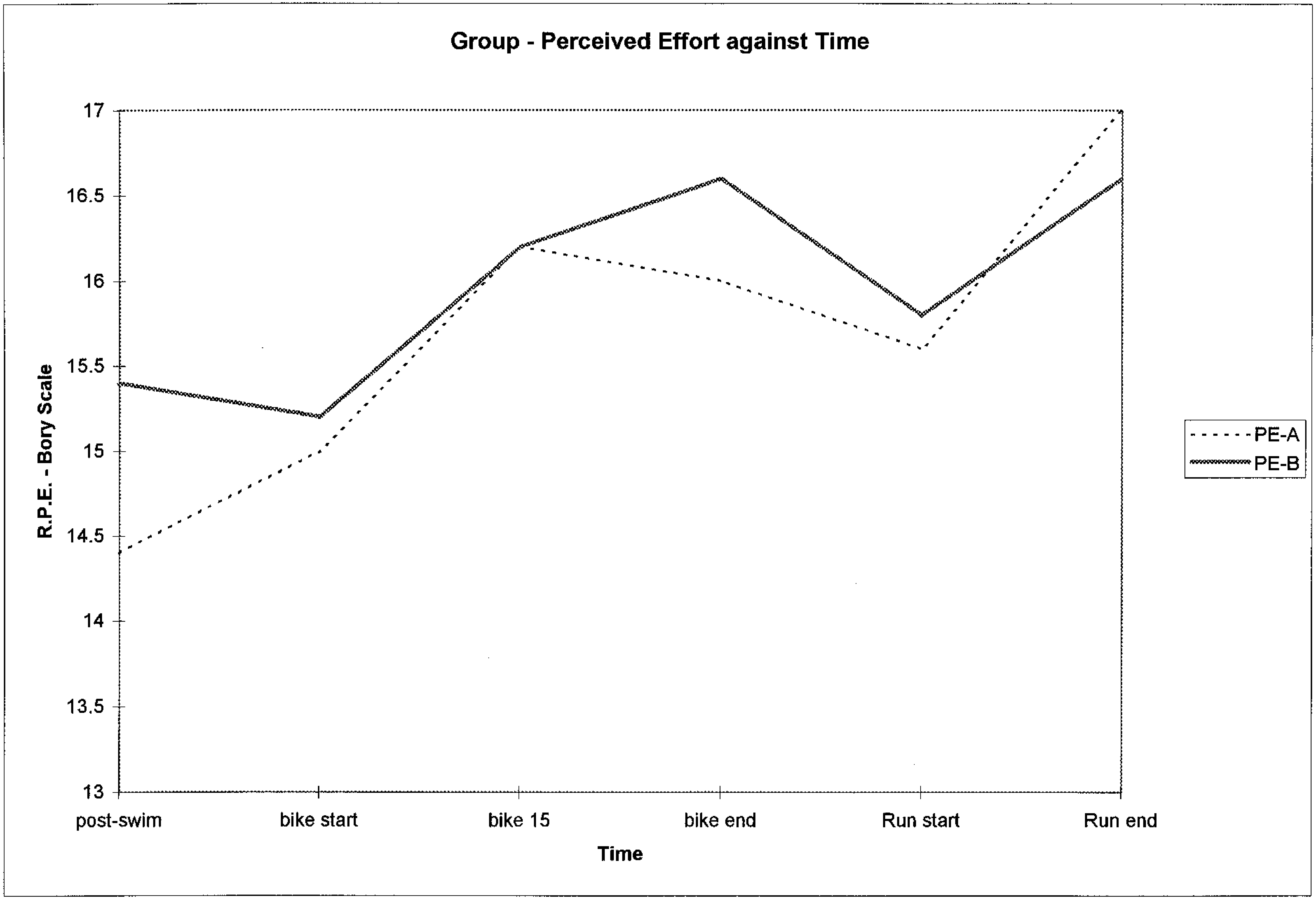
Graph 7


Group - Glucose Level against Time
Blood Glucose Level - Mg/dl
160
140
120
100
80
60
40
20
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Gluc-A
Gluc-B

Graph 8

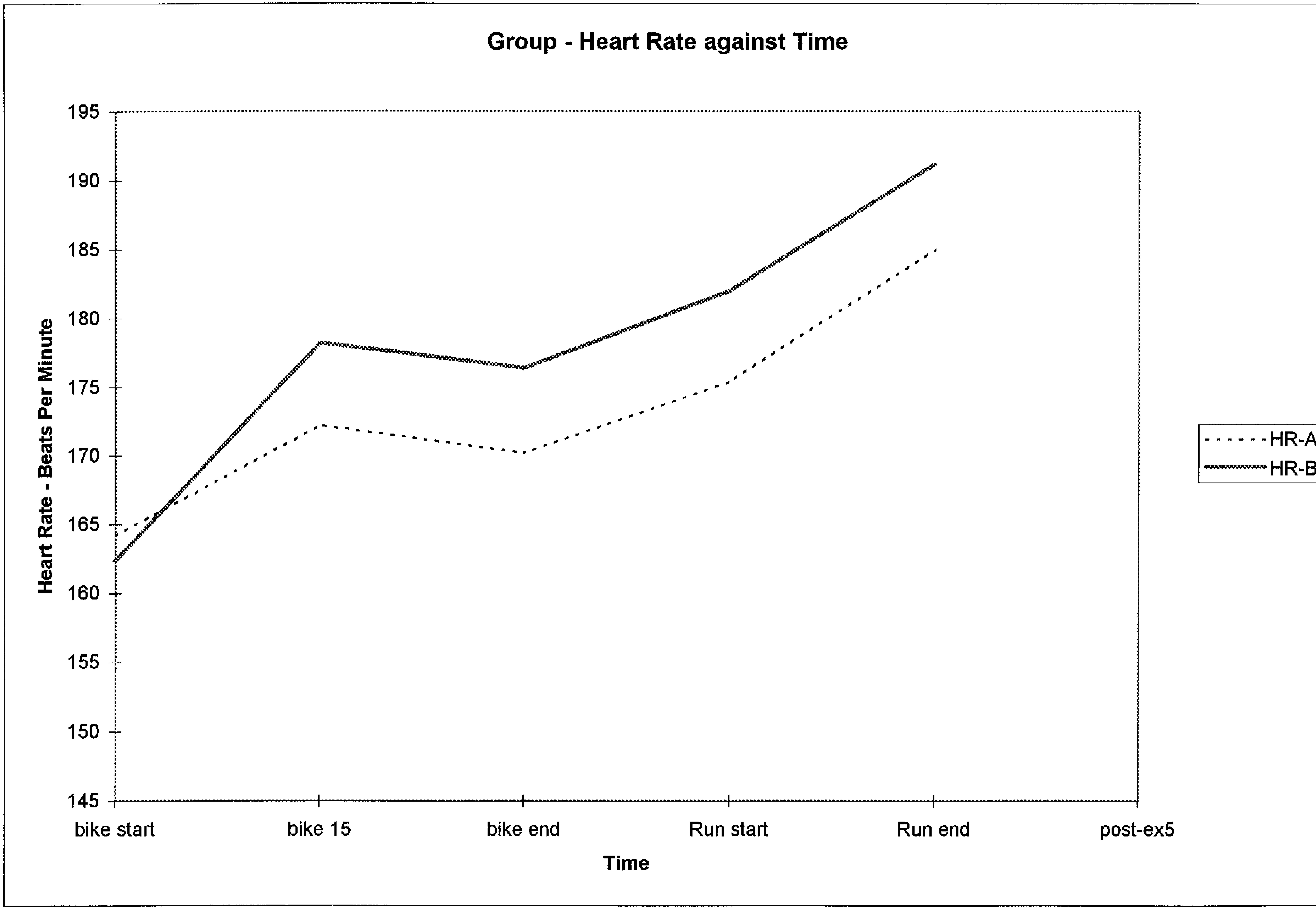

Group - Urea Level against Time
Blood Urea levels - Mg/dl
45
40
35
30
25
20
15
10
5
0
pre-ex
post-swim
bike 15
bike end
Run end
post-ex5
post-ex10
Time
Urea-A
Urea-B

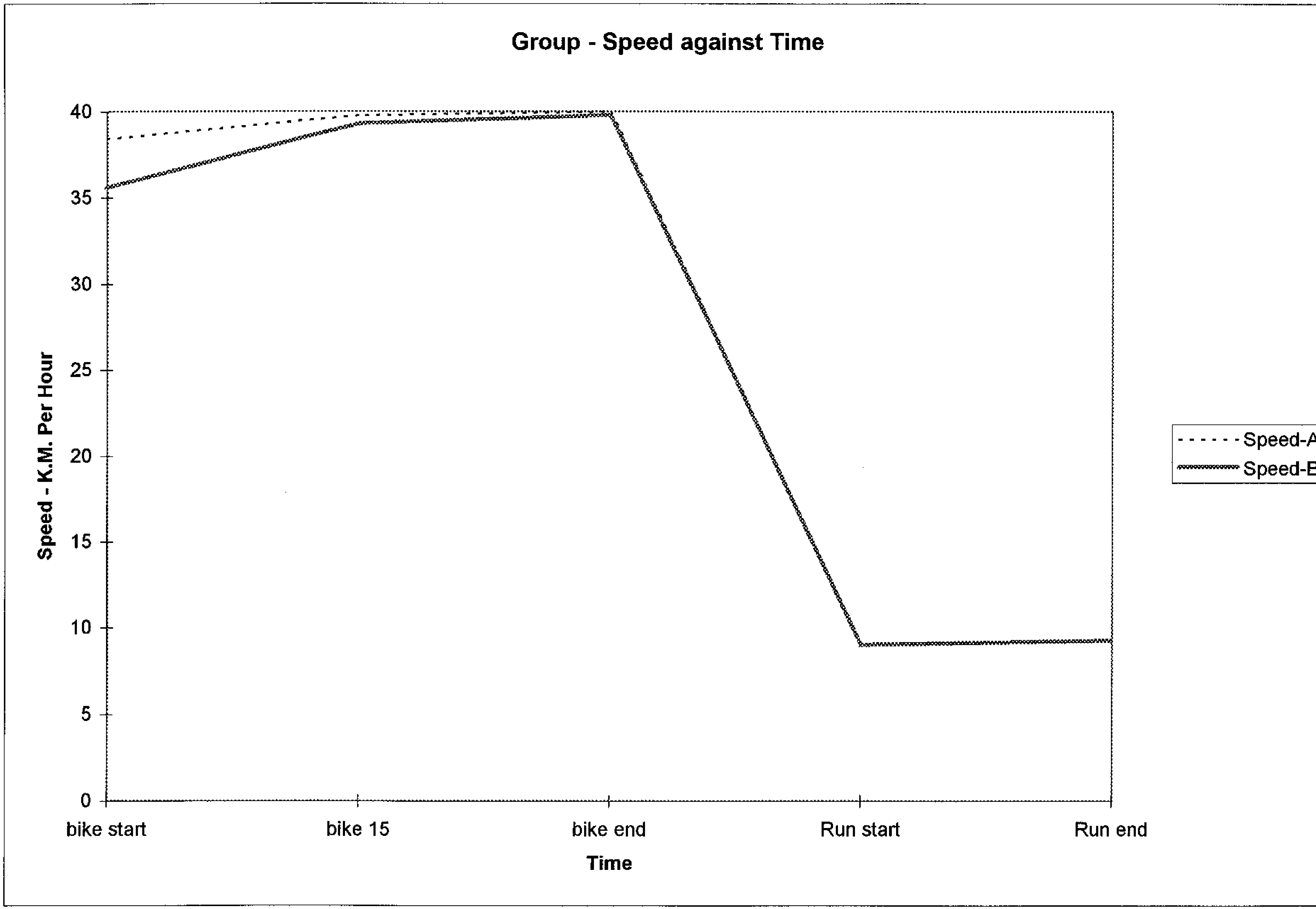
Graph 9



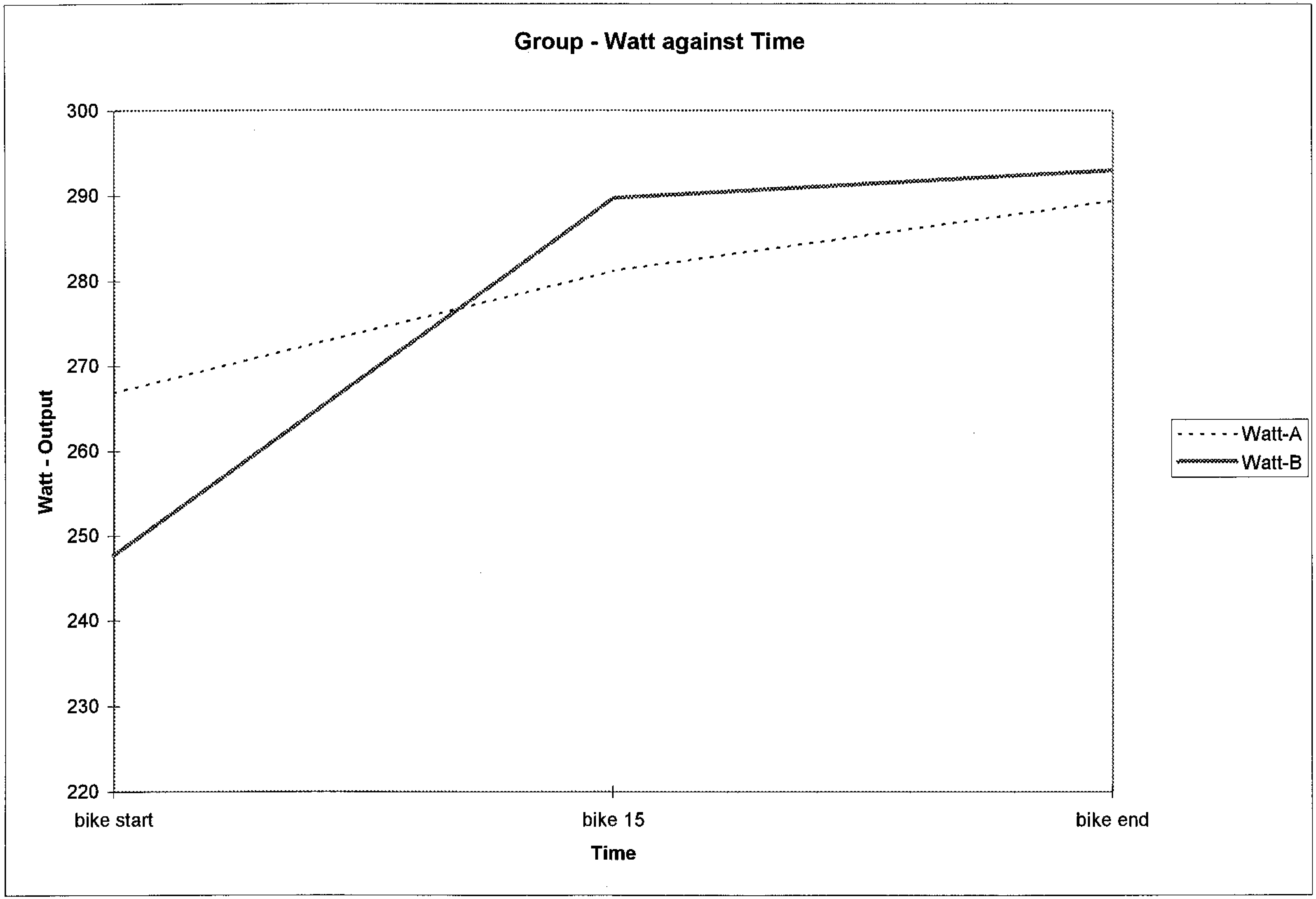
Group - Perceived Effort against Time
R.P.E. - Bory Scale
17
16.5
16
15.5
15
14.5
14
13.5
13
post-swim
bike start
bike 15
bike end
Run start
Run end
Time
PE-A
PE-B

Graph 10


Group - Heart Rate against Time
Heart Rate - Beats Per Minute
195
190
185
180
175
170
165
160
155
150
145
bike start
bike 15
bike end
Run start
Run end
post-ex5
Time
HR-A
HR-B


Group - Speed against Time
40
35
30
25
20
15
10
5
0
Speed - K.M. Per Hour
bike start
bike 15
bike end
Run start
Run end
Time
Speed-A
Speed-B

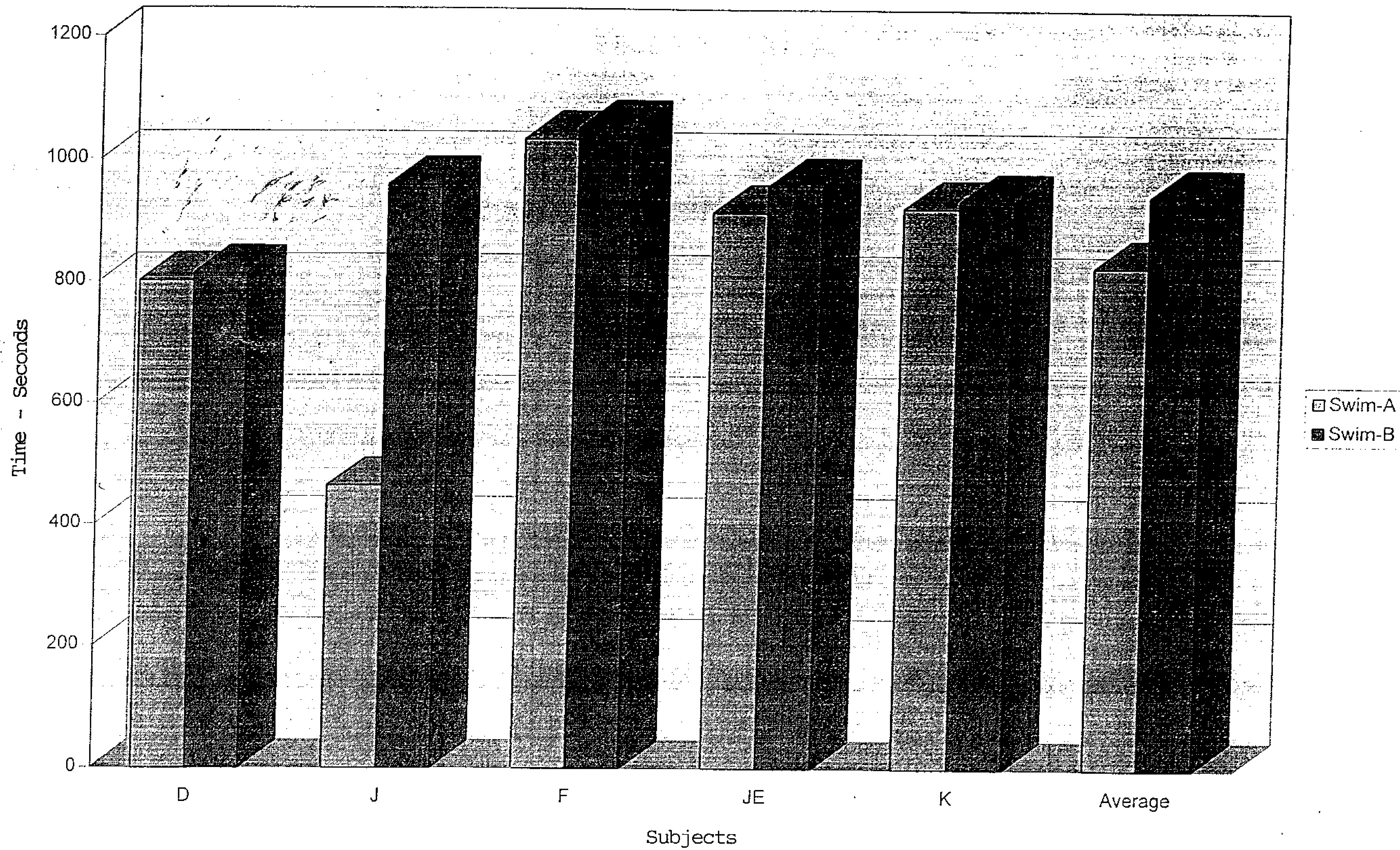
Graph 12


Group - Watt against Time
300
290
280
270
260
250
240
230
220
Watt - Output
bike start
bike 15
bike end
Time
Watt-A
Watt-B

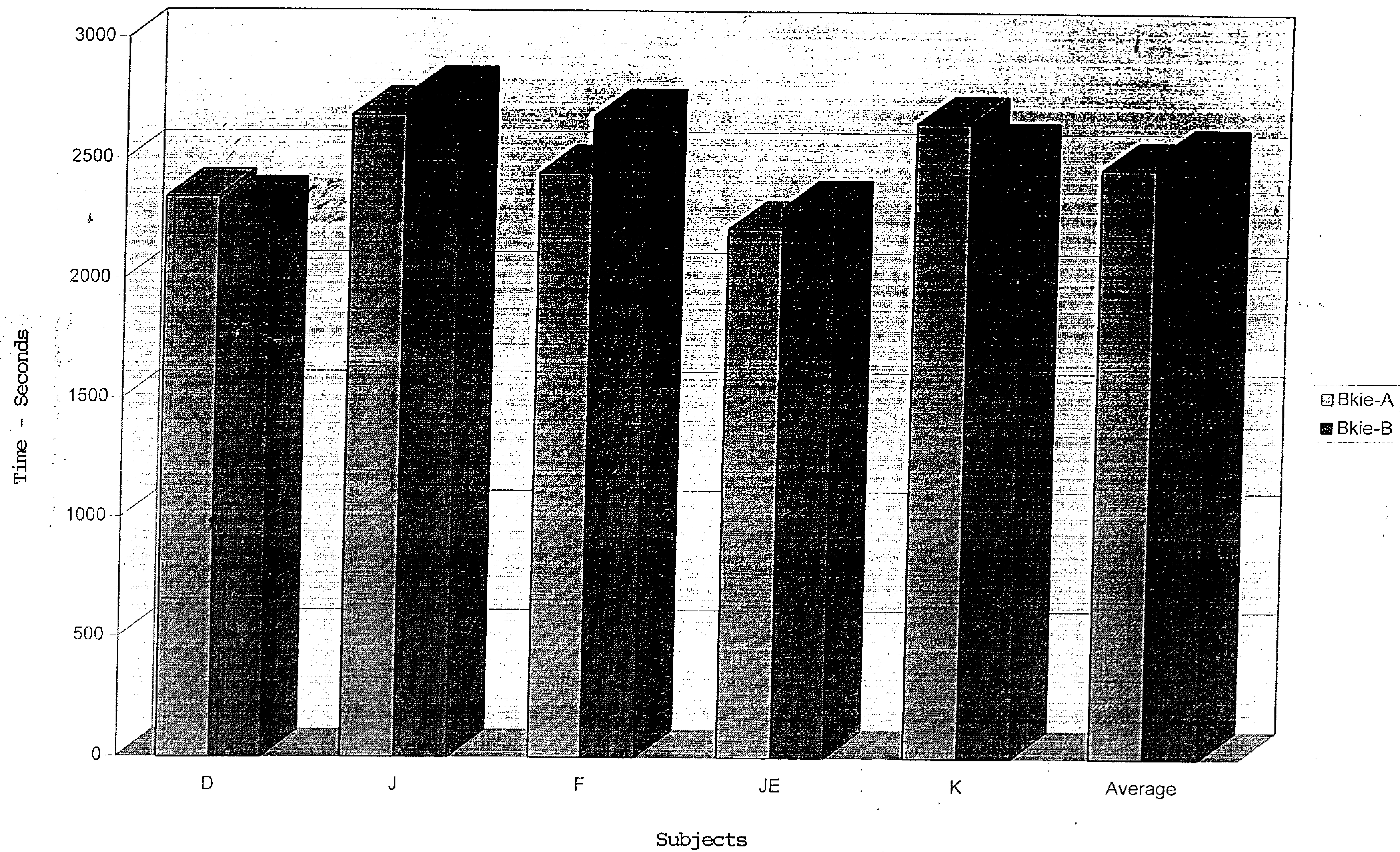
Graph 13

Result for Group Level analysis

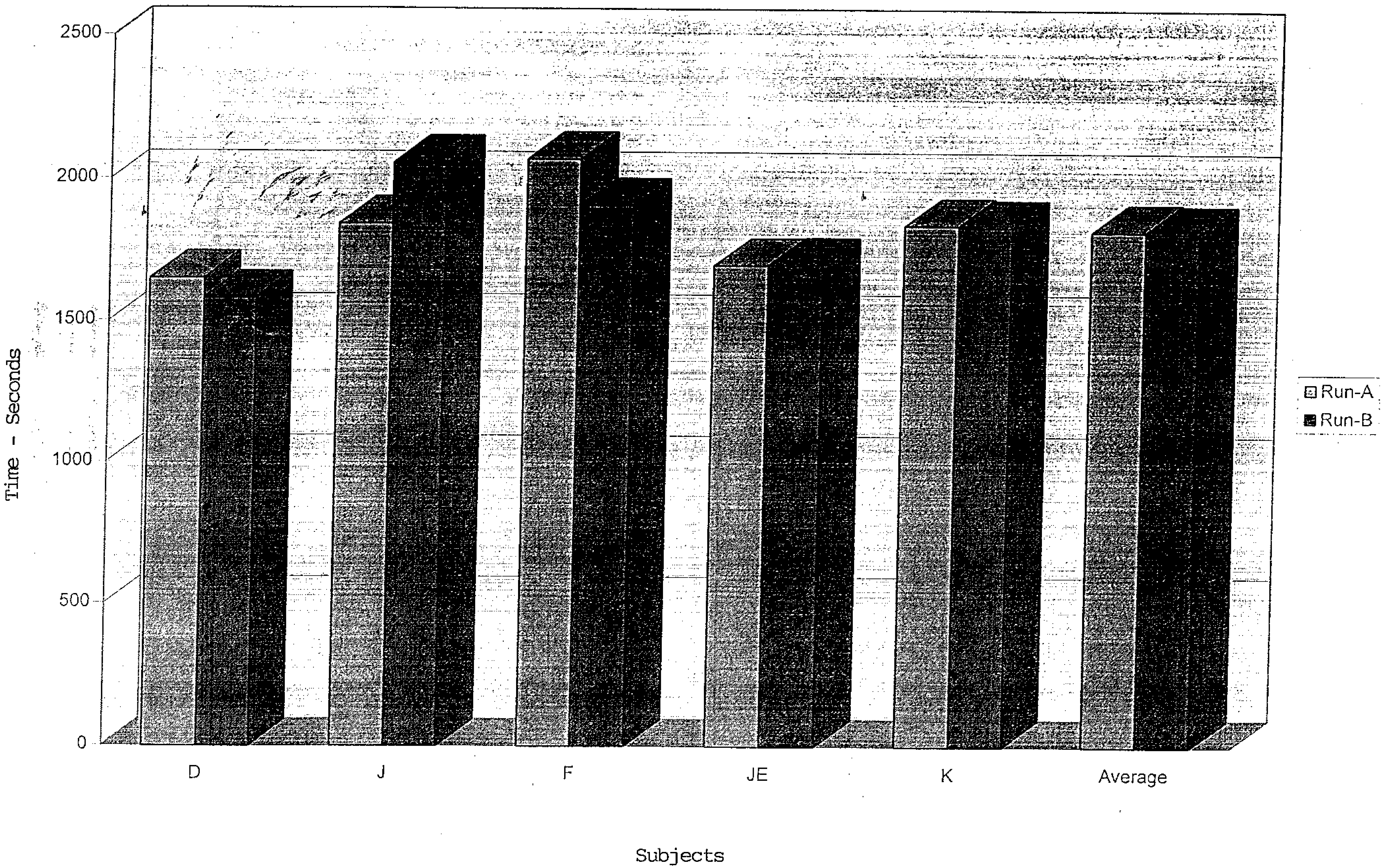
Swim - Time



Graph 14 Bike - Time

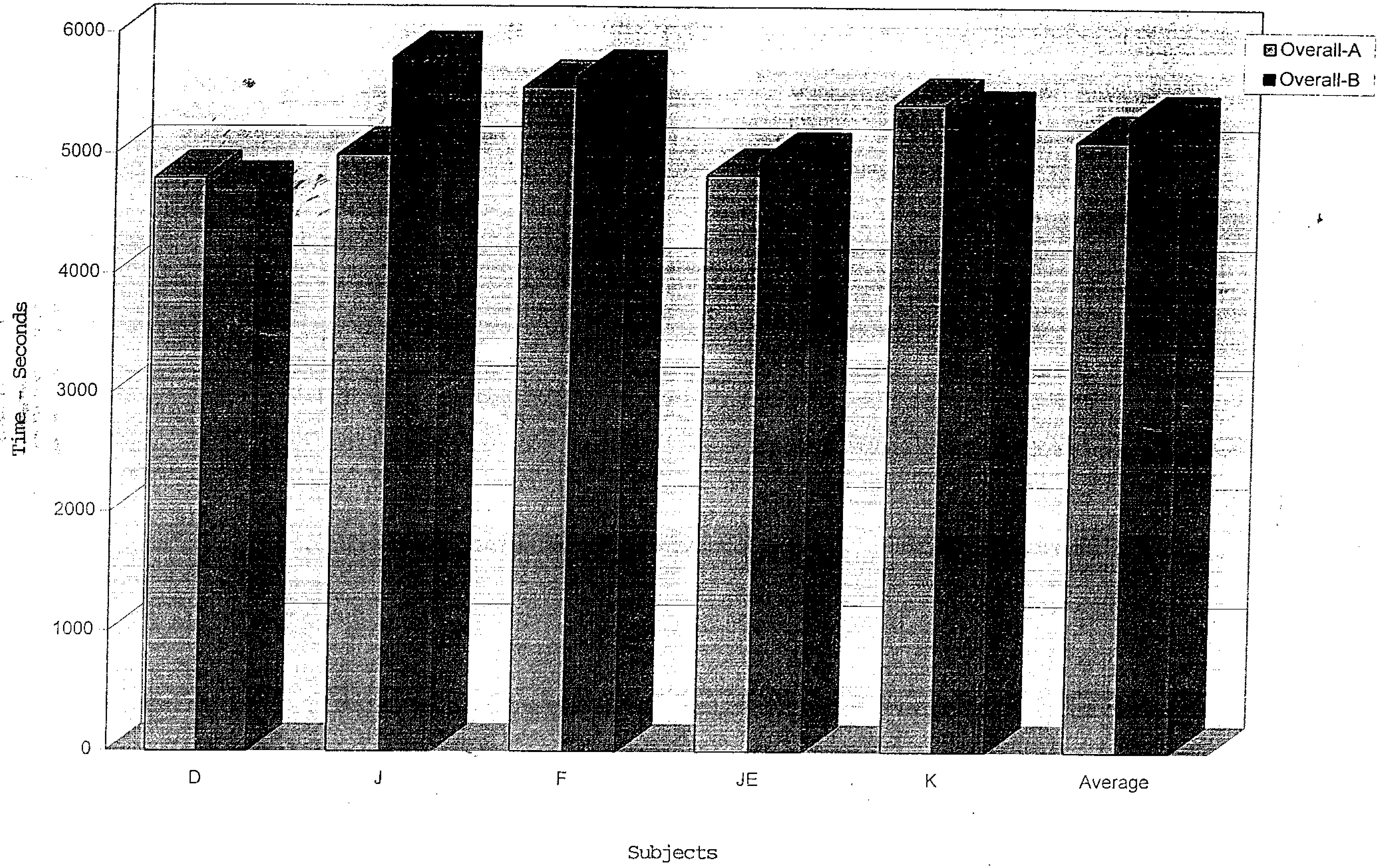


Graph 15 Run - Time



Graph 16

Overall - Time



Discussion

This investigation compared 2 different carbohydrate types on exercise performance and did not seek to compare carbohydrate feeding against a water placebo. Numerous existing studies have already clearly established that ingesting carbohydrate solution improves performance. This study seeks to clarify.

i. The influence of blood glucose on performance on a S.T.T. and ii. Whether there are differences in performance produced between types of carbohydrate used in the solutions.
i.e. The fast acting simple acting glucose or longer molecular chain slower acting Glucose Polymer. It has been argued (10) Howley. J.A. et al., the differences between the effectiveness of glucose and glucose polymer is related to rate and efficiency of gastric emptying as well as the differences in molecular structure.

i. Blood glucose increased under both the carbohydrate solution of solution A - 100% glucose and solution B. Glucose Polymer - (polycal) treatments during the S.T.T.. This is in agreement with Wilber and Moffat (1992) (11) who found "that time to exhaustion of high intensity treadmill exercise is delayed as a results of carbohydrate ingestion and that this effect is mediated by favorable alterations in blood glucose concentration and substrate utilization" and Coyle et al (12).Since the Simulated Triathlon trial was only around 80 to 90 minutes duration and utilized various muscle groups, it is doubtful that muscle glycogen depletion was the primary cause of fatigue. The increased blood glucose and availability of carbohydrate for oxidation, which has been associated with enhanced performance may be the factor (12).

Indeed elevated blood glucose might also prevent central nervous system dysfunction and delay the onset of fatigue. Certainly, during this research the 2 subjects who exhibited relatively low blood glucose levels under both the glucose and glucose polymer solution exhibited central nervous system dysfunction. Subject J complaining of lack of concentration and motivation which are classic signs of low blood glucose effecting the central nervous system. Subject K was even more extreme in that he because physically un-coordinated and made an error of judgment during the run section which resulted in the subject falling off the treadmill.

However, Millard (13) found in a study comparing carbohydrate treatment against a water placebo that "since neither blood lactate, heart rate or perceived effort were significantly different between the two groups the significance of elevated blood glucose remains obscure".

In light of the numerous studies, as quoted, and as a result of this research data our conclusion is that blood glucose levels effect performance at exercise levels of 85% and above and for exercise of up to 90 minutes duration. Further study is necessary to consider if blood glucose effects performance at lower exercise intensity and or for longer duration.

ii. From this results of the S.T.T. testing it appears that there is little difference in the maintaing of blood glucose and subsequent performance between glucose and glucose polymer.

This is in agreement with Howley J. et al (1992) (10). See conclusion.

Summary

The triathlon is a relatively new endurance sport, but has become very popular. It has recently been excepted as an Olympic Event for the 2000 games in Sydney.

Although characteristics of triathletes have been described and physiological responses during swimming, biking, and running performed separately have been studied, the physiological responses during a triathlon have been documented in only a a tew studies. e.g. Millard. M. (13).

The effect of carbohydrate ingestion during exercise and its effect on performance has been a subject of interest for many years. Carbohydrate supplement during exercise has been observed to maintain blood glucose levels, 'spare' muscle glucose, delay time to exhaustion, and improve work performance.

Since the advent of the glucose polymer carbohydrate there have been discussions an the relative effectiveness of the polymer versos 'ordinary' glucose. Therefore the question addressed in this study was to investigate which carbohydrate type (glucose-polymer or glucose) would be most effective at maintaining performance in a multi-modal triathlon at race pace.

More specifically how do glucose and glucose polymer effect metabolic, cardiorespiratory, substrate utilization, and perceptual during a simulated triathlon.

Results Summary

The findings of the study were as follows:

1. Glucose and Glucose polymer carbohydrate solution ingestion both influenced blood glucose levels.

2. The relationship between blood glucose and performance is unclear.

3. No significant difference between the treatments was found in heart rate, rating of perceived exertion, blood urea, blood lactate or speed for the group.

4. Individual differences were experienced in the above parameters.

CONCLUSION

Based on the results of this study, the following conclusions are applicable to the sample of male junior elite triathletes studied regarding the use of either glucose or glucose polymer carbohydrate treatment during a simulated triathlon:

1. Both treatments increased blood glucose levels. However, the relationship between blood glucose and performance is obscure. As noted by Wilber R and Moffat R. (11). "It would appear that elevations in blood glucose evident during the carbohydrate run contributed to the improvement in performance. However, the specific mechanism by which blood glucose affected running performance could not be identified."

2. There were no statistical differences between the glucose and the glucose polymer treatments. Heart Rate, R.P.E., Blood Urea, Blood Lactate, Blood glucose, and Speed were similar for the group. This is supported by Howley et al (10) who also found "Provided the CHO is ingested sufficiently frequently in appropriate volumes, it seems likely that there will not be any physiologically important differences in the rates of exogenous. CHO oxidation from ingested Glucose, maltose, Sucrose or Glucose polymer solutions. During prolonged exercise all the ingested CHO are ultimately oxidized at a rate of $\approx$ 1 g/min."

3. Minor individual differences occurred between the two treatments. This is due to individual metabolic physiological differences.

4. Palatability is of great importance, as a CHO beverage that is palatable is more likely to be consumed in sufficient quantity. Therefore, individual taste preferences are an important factor in choosing a CHO sports drink.

APPLICATIONS

As a result of the findings and conclusions of this study, the following practical applications are offered:

1. Use of a CHO supplement during training and racing may help improve performances and recovery, and delay fatigue.

2. The type of carbohydrate used in a supplement take during exercise is highly individual both in terms of physiological responses and palatability.

3. As a consequence of point 2, it is advisable to experiment with different types of carbohydrate source and mixtures of carbohydrate type to establish which is most effective for an individual.

4. The experimentation with carbohydrate types in sports drinks should occur at competition intensity.

RECOMMENDATIONS

Based up an the findings of this study, the following suggestions for future research are made:

1. Muscle biopsies in several muscle groups should be performed prior to and following the simulated triathlon to calculate the rate of muscle depletion, and to determine if the carbohydrate ingested during the triathlon was effective in sparing muscle glucose stores.

2. Maximal oxygen uptake throughout the simulated triathlon would give more complete data of the metabolic responses.

3. Hormonal measures including insulin could be measured in a attempt to clarify the pathways and mechanisms underlying any differences an substrate utilization.

4. Similar investigation should be performed during actual triathlon competitions of varying distances or duration. Responses may be different for events of 2,5 and 10 plus hours.

5. A study of adult triathletes would broaden our understanding by offering potential differences between junior and adult blood glucose responses.

6. One of the limitations of this study was the small subject pool, and heavy race commitment of the subjects. It is recommended for further study to use a larger subject pool with athletes under a less heavy race schedule.

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HONG KONG SPORTS INSTITUTE
HUMAN PERFORMANCE LABORATORY
SPORTS SCIENCE DEPARTMENT

MVO2 TEST OF TRIATHLETES

Date	Mode	Subject	Age (yrs)	Ht (cm)	Wt (kg)	FVC (1/min)	Max HR (b/min)	MVE (1/min)	MVO2 (1/min)	MVO2 (ml/kf/min)	Peak [Lactate (mM)	HR (b/min)	Anaerobic Threshold VO2 (ml/kg/min)	Max HR (%)	] Max Vo2 (%)
Jul-96	Run	D	19	176	65	-	200	136.9	4.657	71.64	-	189	62.41	94.5	87.1
Oct-96	Bike	D	19	176	67	-	190	143.1	4.385	65.64	-	167	49.42	87.9	75.3
Jan-96	Run	J	14	166	57	4.21	202	112.3	3.785	66.98	17.05	172	51.97	85.1	77.6
Feb-96	Bike	J	14	166	57	-	195	96.6	3.429	61.67	8.01	185	53.57	94.9	86.9
Jan-96	Run	K	16	162	63	4.56	205	137.9	4.693	74.14	12.75	186	57.56	90.1	77.6
Feb-96	Bike	K	16	162	63	-	192	143.9	4.188	66.47	8.34	173	54.6	90.1	82.1
Jan-96	Run	F	19	180	68	5.78	191	127	4.161	61.64	10.31	174	51.34	91.1	83.3
Feb-96	Bike	F	19	180	68	-	190	120.1	4.11	59.57	10.47	172	51.08	90.5	85.7
Feb-96	Run	A	18	170	65	5.7	195	153.2	3.892	59.51	10.84	173	48.24	88.7	81.1
Feb-96	Bike	A	18	170	65	-	194	154.4	3.934	61	8.49	185	54.41	95.4	89.2
Mar-96	Run	JE	16	180	74	-	187	147.8	4.911	66.36	9.2	168	57.78	89.8	87
Apr-96	Bike	JE	17	180	74	-	182	167.8	5.276	71.3	10.64	171	60.13	94	84.3

Appendix ii

Consent To Simulated Triathlon Testing

Athlete Name ____

Date ______________________ Time ________________________

I authorize researcher ______________________ and such assistants of designees may be selected by them to perform a Simulated Triathlon Testing to determine the effect on performance or 3 different carbohydrate feeds. The test will facilitate evaluation of performance, and assist, the exercise physiologist or coach in prescribing or evaluating carbohydrate feeding strategies. It is my understanding that I will be questioned and have 'Base-Line' tests prior to taking the final tests trials.

Exercise testing will be performed in a swimming pool cycle simulator, and treadmill allowing workload to be controlled at a set % of the subjects Max. Heart Rate, Perceived Effort, Speed and / or Work output, Lactate, Blood Glucose and urea will be monitored.

There exists the possibility that this test will be stressful on the athlete and will result in fatigue. Professional care in selection and supervision of individuals provides appropriate precaution against such problems.

The benefits of such testing are the scientific assessment of working capacity in relation to carbohydrate feeding and the clinical appraisal of performance.

I have read the foregoing information and understand it. Questions concerning this procedure have been answered to my satisfaction. I am in agreement that information from this can be used for research purposes.

Participant Signature ______________________________________

Witness Signature / Parent For Under 18 Years ____________________

Test Supervisor ____

APPENDIX iii

PERCEIVED EXERTION SCALE

6

7 VERY, VERY LIGHT

8

9 VERY LIGHT

10

11 FAIRLY LIGHT

12

13 SOMEWHAT HARD

14

15 HARD

16

17 VERY HARD

18

19 VERY, VERY HARD

20

Feeding Time Table And Monitoring

Feeding cup no.	Warm up	Speed	H.R.	Distance	Time for swim
	Bike 8 mins				
	Run 5 mins				
-20mins 1	Swim 150 Mt				

	Swim Running Time +Splits			RT + S		RT + S		RT + S		RT + S
-1 mins 2	100m		200m		300m		400m		500m	
	600m		700m		800m		900m		1000m	
		Distance	Time	H.R.	Perceived Effort	Speed	Watts	Feeds	Remarks	
3		* Swim-Bike Transition * Test * Feed								
	Bike Start	Bike 0km							No Feed	
4		0.5km								
5		4km								
6		8km								
7		12km								
		15km + Test							No Feed	
8		16km								
9		20km								
10		24km								
		Cycle Stop 27km							No Feed	
		Test							No Feed	
11		Transition * Feed								
	Run Start	Run 0mile							No Feed	
12		0.95m								
13		1.90m								
14		2.85m								
15		3.80m								
weight	Test 1	4.50m Finish	0 mins						No Feed	
	Test 2		5 mins							
	Test 3		10 mins							

Drink (Recovery Solution)

APPENDIX iv b

Blood Profile Testing Time Table

Subject :
Date :
Time :
Test :

Test #
Tester#

Test	Distance	/Time	m/mol Lactate	Mg/dl Glucose	Mg/dl Urea	Remarks
Pre-Exercise						
Post Swim						
Start Bike	1km	0mins				
Test	15km					
Finish Bike and Test	27km					
Start Run	0km	0mins				
Finish Run and Test	4.50 Miles	0mins				
Post Exercise Test II		5mins				
Post Exercise Test III		10mins				

	Weight	Temp	Humidity
Pre - Exercise			
Post Swim			
Post Bike			
Post Run			

Appendix iv c

FEEDING TIMES

CYCLE	RUN
4k	0.95mile
8k	1.90mile
12k	2.85mile
16k	3.80mile
20k	
24k	
(27k)	

Appendix V

Questions for Consideration on Palatability and Acceptability of CHO Drinks

(a. strongly agree b. agree c. neither agree or disagree
d. disagree e. strongly disagree)

1. This drink is palatable when taken before exercise.
   a _____ b_____ c_____ d_____ e _____

2. I would like to take this drink during practice and competition.
   a ____ b _____ c _____ d _____ e _____

3. This drink is more palatable than Hydra Fuel.
   a ____ b ____ c _____ d _____ e _____

4. This drink forms a coating in the mouth when taken during exercise.
   a _____ b_____ c _____ d _____ e _____

5. I would rather take this drink than water.
   a _____ b _____ c _____ d _____ e _____

6. I feel this drink has helped my performance.
   a _____ b _____ c _____ d _____ e _____

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