The Effects of Carbohydrate Supplement on Hong Kong Cycling Athletes

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ABSTRACT

Three Hong Kong male cyclists are involved in two experiments with a total of five trials. Commercially available glucose polymer powder was used to mix carbohydrate (CHO) supplement in solution form. In Experiment 1, two subjects took part in three trials: Trial 1, C-C-C (C- Carbohydrate containing supplement) were given before, during and after cycling on ergometer for 2 hours; Trial 2 C-P-C (P- Placebo); Trial 3 P-P-P. Blood glucose, haemoglobin, ammonia, lactate, heart rate, and body weight were monitored. Blood glucose response was about the same whether a carbohydrate supplement or placebo was used before or during exercise. However, an increase in blood glucose was observed when carbohydrate (2.0 g / kg BW) was given immediately after exercise, which was not seen with placebo. Relationship between body weight and haemoglobin was not seen. Blood ammonia at rest was generally lower than during exercise but not always followed by recovery after exercise. Blood lactate seemed to associate with exercise intensity and not to the amount of carbohydrate supplemented. Three subjects took part in Experiment 2 which involved two trials of 220 km road training. Carbohydrate supplements used were a glucose polymer solution, energy bar and banana. Blood glucose, lactate and body weight were monitored. All subjects lost more than 2% body weight after exercise when 5 - 10 ml / kg BW per hour of fluid was taken, suggesting that subjects need a higher volume of fluid replenishment. Blood glucose profile was more stable throughout exercise when carbohydrate supplements were given regularly. Moreover, after blood glucose has dropped below 90 mg/dl, giving a concentrated carbohydrate solution (20%) can increase blood glucose quickly. It is believed that CHO solutions with 6 - 8 % CHO have the highest gastric emptying rate. Study on gastric emptying rate of 15 - 20 % solution is needed in order to fully evaluate the benefit of using a more concentrated CHO solution although subjects did not report any intolerance or discomfort.

Report on the Effects of Carbohydrate Supplement on Hong Kong Cycling Athletes

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PURPOSE

Many studies showed that sports performance in endurance events is closely related to glycogen storage in the body. Among many factors to the time of exhaustion, one of them is muscle glycogen storage. The concentration of muscle glycogen can be raised by increasing dietary carbohydrate (CHO) intake. Many CHO supplementation regimes have been suggested for before, during and after exercise (1,2,3,4). The purpose of this study was to investigate the effects of CHO supplement on Hong Kong cycling athletes.

SUBJECTS AND METHOD

Three elite Hong Kong male cyclists, Wong Kam Po, Man Wai Chung and Tong Wai Bun agreed to participate in a total of five trials in two experiments. Age and weight (BW) were 23, 21, 22 yr. and 65, 50, 60 kg, respectively. Their usual dietary habits and training schedules were not changed during the period of experiments, except on trial days.

Experiment 1

Only Man and Tong were involved in three trials with one day in between each trial.

Feeding Protocol

Trial	Before exercise	During exercise	After exercise
1	CHO	CHO	CHO
2	CHO	placebo	CHO
3	placebo	placebo	placebo

Where CHO is indicated, the subjects were given:
Before exercise: 2.5g CHO per kg BW, 25% CHO solution (including TANG crystals) 3 hours before exercise

During exercise: 1.2g CHO per kg BW, 11% CHO solution (including TANG crystals), ingested periodically

After exercise: 2.0g CHO per kg BW, 18% CHO solution (including TANG crystals), immediately after exercise

CHO used in these trials was a commercially available maltodextrin powder (Maxim) made in UK. Placebo was water, flavoured with TANG crystal. Subjects consumed the CHO solutions and placebo at the same time intervals in each trial. Subjects recorded their food intakes on each trial day.

Exercise Protocol
Subjects exercised for 2 hours on cycle ergometer at approximately 80% maximum heart rate (HR max.).

Parameters Monitored
Body weight, blood glucose, haemoglobin, lactate, ammonia, heart rate

Experiment 2

Man, Wong and Tong participated in two trials of road training in Experiment 2.

Feeding Protocol
Subjects had breakfast at 6:30 a.m. on trial days. CHO intake from breakfast was pre-determined to be 30% of 8.5g CHO per kg BW per day and breakfast provided 30% of daily total energy.

CHO used to mix the supplement was a maltodextrin powder from Holland (Polycal) flavoured with lemonade, other sources of CHO were banana and energy bar (Power Bar) in the amount of 1g CHO per kg BW per hour. Additional diluted Pocari (3.6% CHO-electrolyte drink) was allowed to be consumed.

Note:
Maxim and Polycal are both pure maltodextrin preparation. Polycal was used in the second experiment because it is substantially cheaper than Maxim but is virtually identical to Maxim.

Exercise Protocol
Road training at a distance of 220 km which took place 2.5 weeks apart.
Subjects cycled 20 km at 60-65% HR max. from HKSI to training base, and in

Trial 1

cycled 12 rounds (180 km total) at 71-79% HR max.,

Trial 2*

cycled 10 rounds (150 km total) at 73-80% HR max.

and then returned to HKSI at 60-65% HR max.

*Training time in Trial 2 was shortened due to hot weather.

Parameters Monitored
Body Weight, blood glucose, lactate

RESULTS

1. Body weight and fluid loses

In Experiment 1, results (see table 1) showed that BW decreased after exercise at 80% HR max. for 2 hours which indicated loss of body fluid. Man's body weight decreased by 2.4% and Tong's decreased by 1.0%. Man's fluid repletion was 10.9 ml/kg BW *hr whereas Tong's repletion was 11.2 ml/kg BW*hr.

In Experiment 2, Wong, Man and Tong repleted with 11.4, 5.2, 8.5 ml/kg BW*hr respectively. Temperature in experiment 2 (26-30 C) was higher than in experiment 1 (20-21 C). All subjects experienced weight loss of greater than 2% body weight in experiment 2.

2. Blood glucose and CHO supplement

In Experiment 1, the results (table 3 and 5) showed that blood glucose levels decreased from the time of 3 hr prior to exercise to the end of exercise in all trials. Blood glucose levels were about the same across all trials before and during exercise. From the result of Experiment 2, although two of the athletes, Man and Tong, had exercised for almost 4 hours (including the time from HKSI to training field), their blood glucose levels were still above 75mg/ dl (figure 6). At that time, however, they had consumed only a total of 36g and 63g CHO respectively from Pocari during exercise. The results also showed that CHO supplement could significantly increase blood glucose concentration either immediately after exercise (repletion of 2.0 per kg BW) in Experiment 1 (table 3) or after blood glucose has decreased to approximately 75mg/dl (repletion of 2.3g CHO for Man and 1.6g for Tong per kg BW) in Experiment 2 (figure1). In Experiment 2, Wong's blood glucose responses to random (30-50g, one time per round) and regular CHO supplement were slightly different. His blood glucose was maintained at about 110mg/dl throughout trial 2 where regular supplementation was given, but more fluctuation took place during trial 1 when repletion was random (figure 2).

3. Haemoglobin

A strong relationship between body weight and haemoglobin did not exist (table 2).

4. Heart rate and blood lactate , and ammonia

In experiment 2, the average heart rate during exercise was 71-82% of max. HR, Wong's highest, Man's lowest.

Blood lactate (table 5,6) was likely to be associated with exercise intensity, but not to the amount of CHO supplement.

Blood ammonia (table 7) at rest was generally lower than during exercise and not always followed by recovery after exercise.

5. Consumed CHO forms during exercise

The percentage of solid and fluid CHO consumed was each about 50% (table 8). Athletes favoured CHO solution and banana over the energy bar. Solutions with 8-20% CHO were used in intensive exercise with no intolerance and/or discomfort reported by the subjects. When beverages and solid CHO were ingested , Wong ingested more CHO than Man and Tong which might indicate a high performance and disciplined athlete would pay more attention to CHO supplement.

CONCLUSIONS

1. We did not find a significant difference in blood glucose pattern before and during exercise in all trials of Experiment 1.

2. It was shown in Experiment 1 that consuming a 2.0g/ kg BW CHO solution immediately after exercise significantly increase blood glucose level. It is widely recognised that CHO repletion within 2 hours after exercise can reload muscle glycogen most effectively and that rate of restoration slows progressively overtime (5).

3. Regular CHO supplementation during road training produced a more stable blood glucose profile than random supplementation. Wong was able to maintain blood glucose at a normal level of 110mg/dl with 1.5g CHO/kg BW*hr. Half of this came from the 15% CHO solution and the rest from solid food (banana and energy bar).

4. In experiment 2, it was found that fluid repletion of 5-10ml/kg BW*hr during road training was insufficient under warm temperature. Increasing fluid intake to 12-15 ml/kg BW*hr is recommended during exercise. Although the CHO solution used by the subjects in Experiment 2 contained more CHO (greater than or equal to 15%) than commercially available sports drinks (6-8%), none of the athletes reported intolerance or discomfort. It has been shown that many athletes have used more concentrated CHO solution in races successfully especially as an adjunct to sports drinks(5).

SUGGESTION FOR FURTHER STUDIES

1. Further investigation on the rate of gastric emptying of 15% CHO solution is recommended since it is known that more concentrated CHO solution empties the stomach slower than water or CHO solution at lower concentrations. However, total CHO absorbed is greater in more concentrated solutions. Therefore, it will be worthwhile to find out if the gastric emptying rate of more concentrated solutions is acceptable for adequate fluid replacement. However, the major drawback is that the gastric emptying test is rather invasive and is not recommended to be used on our athletes.
2. The CHO solutions used in these experiments did not contain electrolytes except for the diluted commercial product, Pocari, used in experiment 2. Prolonged exercise needs repletion of electrolytes. Further studies on the optimal amount of electrolytes in sports drinks are recommended.

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Table 1 Cyclists' Body Weight and Fluid Ingestion

Body Weight(B.W.) and Fluid Ingestion	Experiment 1*		Experiment 2 (Trial 2) **		
	Man	Tong	Wong	Man	Tong
Body Weight					
before exercise(kg)	49.1	62.7	64.8	50.2	60.2
immediately after exercise(kg)	47.9	62.1	63.2	48	58
total reduction(kg)	1.2	0.6	1.6	2.2	2.2
1 hr after exercise(kg)	48.3	62.5			
Fluid Ingestion(ml)					
during exercise					
total	1070	1400	4450	1575	3075
ml/hr	535	700	742	263	513
ml/kg BW hr	10.9	11.2	11.4	5.2	8.5
immediately after exercise	570	740			
ml/kg BW	11.4	12.3			

* mean from three trials

** values fromTrial 2

Table 2 Haemoglobin Concentration (g/dl)

Period	Man			Tong		
	C-C-C	C-P-C	P-P-P	C-C-C	C-P-C	P-P-P
3 hr before exercise	13.4	13.9	13.2	15	14.6	14
immediately before exercise	N/A	13.6	13.3	N/A	14.9	14.1
immediately after exercise	13.1	13.3	14.4	13.1	15.8	15.3
2 hr after exercise	11.2	12.9	12.5	15.8	15.2	12.5

Table 3 Average Blood Glucose in Experiment 1 *

Blood glucose and Supplement	C-C-C **	C-P-C ***	P-P-P ****
blood glucose			
before exercise (mg/dl)			
3 hr (resting)	118	106	118
0.5 hr	108	98	96
time 0	93	106	96
during exercise (range, mg/dl)	77-106	83-101	84-98
after exercise (mg/dl)			
immediately	95	89	82
0.5 hr	130	148	90
1 hr	111	131	85

* mean from three tests, and exercise time is 2 hrs

** C-C-C: carbohydrate supplement 3 hr before, during and immediately after exercise

*** C-P-C: carbohydrate supplement 3 hr before and after exercise, placebo during exercise

**** P-P-P: placebo 3 hr before, immediately after exercise

Table 4 Blood Glucose and Carbohydrate Supplement in Experiment 2

Blood Glucose and CHO Supplement	Trial 1			Trial 2		
	Wong	Man	Tong	Wong	Man	Tong
blood glucose (mg/dl)						
before exercise						
fasting blood sugar	84	83	N/A	88	93	77
time 0	68	89	94	87	127	91
during exercise (range)						
1-12 rounds (Trial 1) or 1-10 rounds (Trial 2)	86-123	83-110	84-96	110-119	76-100	83-117
after exercise						
after 12 th round (Trial 1) or10 th round (Trial 2)	88	76	66	103	109	109
after returning to HKSI	87	89	-	113	126	121
carbohydrate intake (g)						
breakfast	100	75	90	111	94	119
during exercise						
1-12 rounds (Trial 1) or 1-10 rounds (Trial 2)	383	231	245	430	140	139
g/kg BW hr	1.08	0.84	0.81	1.47	0.62	0.51

Table 5 Blood Glucose and Lactate in Test 1 and 2 of the Experiment 2

Period	Blood Glucose						Blood Lactate					
	Wong		Man		Tong		Wong		Man		Tong	
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
fasting	84.2	87.8	83	92.7		77						
before exercise start	68.1	86.5	89.2	127	94.3	91.4	2.17	1.63	1.81	1.54	1.72	2.02
1	86.5	113	93.4	95.4	93.2	92.2	2.23	2.94	1.64	1.24	2.47	4.24
2												
3	112	117	110	88.8	90.6	98.5	3.05	2.98	1.52	0.98	4.88	3.26
4												
5	123	118	83.2	83.2	93.5	88.7	N/A	1.91	0.67	1.37	3.08	1.51
6				91.1		87.1				1.17		2.23
7	106	110	91.7	99.8	95.9	83.2	2.15	3.72	1.5	1.1	3.37	1.72
8				85.3		78				1.42		5.3
9	101	119	95.7	76.5	84.2	117	2.2	5.18	1.06	4.44	3.37	2.82
10		103		109	65.6	109		8.05		2.25		4.69
11	111		98.7									
12	88.3		75.8									
after exercise	87	113	89	126		121	1.49		0.74			

Table 6 Blood Lactate and Average Heart Rate in Experiment 1

Period	Time (min)	Man Wai Chung			Tong Wai Bun		
		C-C-C	C-P-C	P-P-P	C-C-C	C-P-C	P-P-P
before exercise	0	1.09	1.41	0.92	2.7	1.64	1.15
during exercise	10	2.51	2.57	2.48	6.89	5.23	4.19
	20	2.57	2.24	1.7	4.89	3.66	3.68
	40	1.45	2.08	3.19	3.5	3.13	3.74
	60	2.36	1.97	2.31	3.41	3.56	3.65
	80	2.44	3.34	2.55	1.96	3.6	3.02
	100	2.61	1.52	1.93	2.57	3.45	1.63
	120	1.54	1.7	4.17	1.26	3.12	1.85
after exercise	123	1.09	1.25	1.3	1.6	N/A	2.76
	125	N/A	1.07	1.78	N/A	2.54	1.93
	127	0.8	4.77	1.34	1.49	6.11	1.49
	135	2.65	1.1	1.11	2.74	3.01	
average	10-120	2.21	2.2	2.62	3.5	3.68	3.11
average HR	10-120	160	163	159		150	140
% in max HR		80.4	81.9	79.9		75.8	70.7

Table 7 Blood Ammonia in Experiment 1

Period	Time (min)	Man			Tong		
		C-C-C	C-P-C	P-P-P	C-C-C	C-P-C	P-P-P
before exercise	0	60	103	100	74	80	67
during exercise	20	170	116	116	116	124	232
	40	180	107	155	129	162	247
	80	181	76	183	262	249	251
	100	226	150	190	236	237	191
	120	309	147	160	279	175	143
after exercise	140	116	153	227	129	111	161

Table 8 Carbohydrate Consumption From Solid and Liquid Sources in Experiment 2

Carbohydrate Sources	Wong		Man		Tong	
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
Solution (g)	253	331	95	98	120	123
CHO concentration	8%	15%	8%	20%,8%	8%	20%,8%
percentage of total CHO	57	73	30	57	49	62
banana (g)	150	75	175	75	125	75
percentage of total CHO	33	17	56	43	51	38
power bar (g)	45	45	45	-	-	-
percentage of CHO	10	10	14	-	-	-
Total CHO	448	451	315	173	245	198

Fig. 1 Blood Glucose Level in Test 2 of the Second Experiment

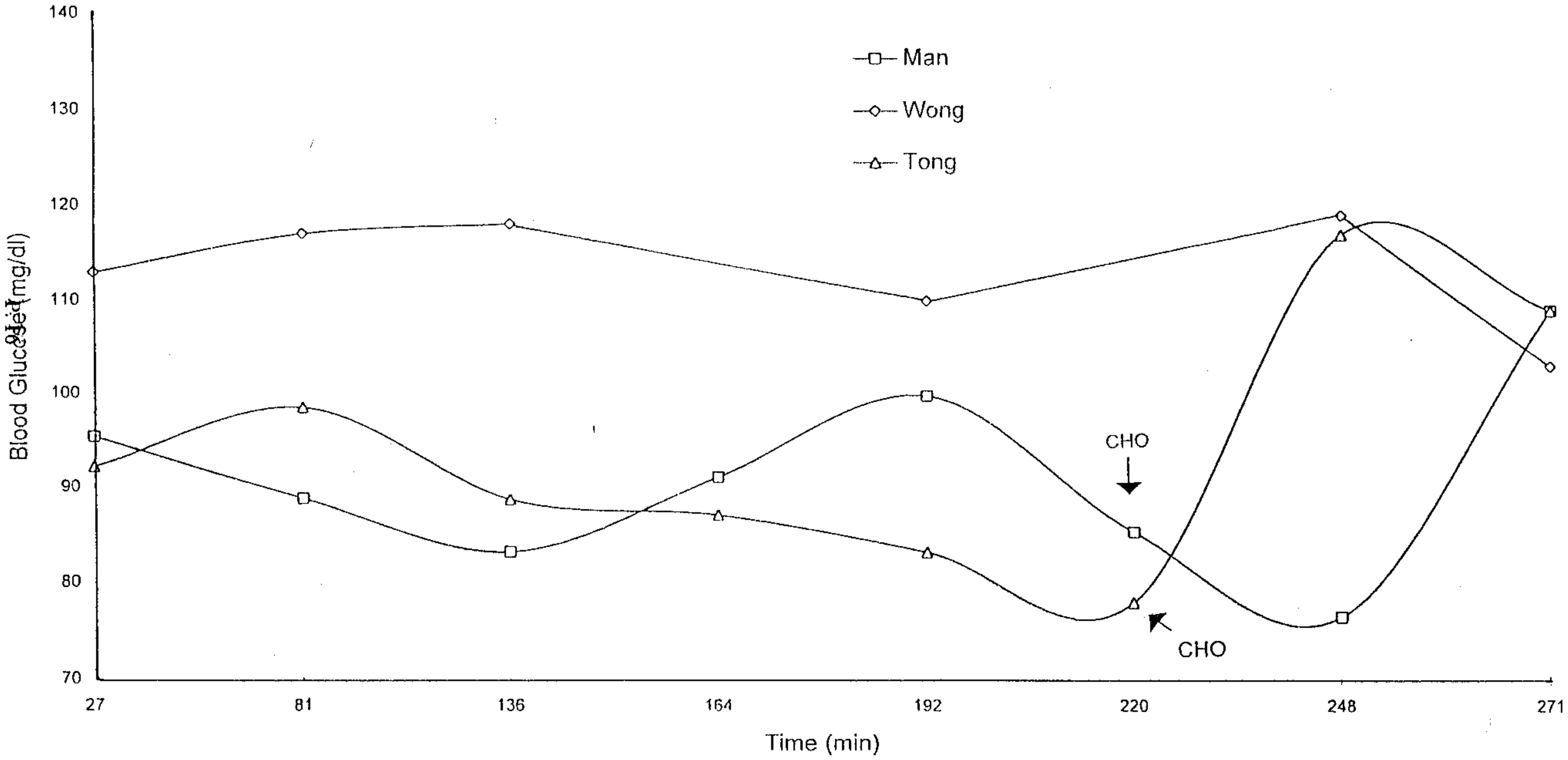

Fig. 2 Wong's Blood Glucose Level in the Second Experiment