CHAPTER 4

RESULTS AND DISCUSSION

The primary aim of the study was to determine the efficacy of both Switch™ and Cellfood® as ergogenic aids for endurance athletes. The term "ergogenic" relates to the application of a nutritional, physical, mechanical, psychological, or pharmacological procedure or aid to improve physical work capacity or athletic performance (McArdle et al., 1991). An ergogogenic aid, simply defined, is any substance, process, or procedure that may, or is perceived to, enhance performance through improved strength, speed, response time or the endurance of the athlete. Another area of interest in ergogenic aids is to hasten recovery. The nature of the action of any supposed ergogenic aid may be elicited through the following:

- Direct action on muscle fibre;
- Counteracting fatigue producing by-products;
- Providing fuel needed for muscular contraction;
- Affecting the heart and circulatory system;
- Affecting the respiratory system; and
- Counteracting the inhibitory affects of the central nervous system on muscular contraction and other functions (Fox and Bowers, 1993).

The primary aim of the study was to determine the efficacy of both Cellfood® and Switch™ as ergogenic aids for endurance athletes. In order to reach this goal a pre-test – post-test, double-blind cross-over, placebo controlled experimental design, with two levels of the independent variable, was adopted for the study. Accordingly subjects were randomly assigned to either a placebo, Cellfood® or Switch™ group. Each of the groups underwent a supplementation period comprising three four-week cycles of varying dosages, as recommended by the manufacturer. After each cycle the subjects stopped supplementation during a two-week washout period, prior to crossing-over to an alternative supplementation and dosage cycle.

Accordingly the groups were arranged as follows over the duration of the study:

Group	Cycle 1		Cycle 2		Cycle 3	
	Product	**Dosage**	**Product**	**Dosage**	**Product**	**Dosage**
A	Placebo	28ml	Cellfood®	39.2ml	Switch™	91.7ml
B	Cellfood®	28ml	Switch™	78.4ml	Placebo	44.8ml
C	Switch™	53.2ml	Placebo	39.2ml	Cellfood®	44.8ml

The results of the study are displayed in tabular and graphic form and are reported in the following categories of dependant variables:

1. Haematology
   - Ferretin values
   - Haemoglobin
   - Red blood cell count
   - Hematocrit
   - Fasting glucose
2. Pulse oximetry
3. Rate of perceived exertion
4. Heart rate
5. Capillary blood lactate concentrations
6. Oxygen utilization and related spirometry

Haematology

4.1 Ferretin

Absolute pre- and post-test values can be observed in Table I and the relative changes are presented graphically in Figure 4.1.

Cycle 1 (Low Dosage)

An increase in ferretin levels were observed in two of the groups while the remaining group showed a decrease from the pre-test. Switch™ showed an increase of 44.8%

while the placebo showed an increase of 58.8%. Cellfood® showed a decrease of 24.2%. There were, however, no statistically significant differences ($p>0.05$) in the changes between groups.

Cycle 2 (Intermediate Dosage)

Both Cellfood® and placebo showed increases in ferretin values of 72.9% and 4.7% respectively, while Switch™ showed a decrease of 14.1%. There were, however, no statistically significant differences ($p>0.05$) in the changes between groups.

Cycle 3 (High Dosage)

Both Switch™ and Cellfood® showed increases of 18.3% and 37.4%, respectively. The placebo showed a decrease of 6.6%. There were, however, no statistically significant differences ($p>0.05$) in the changes between groups.

Discussion

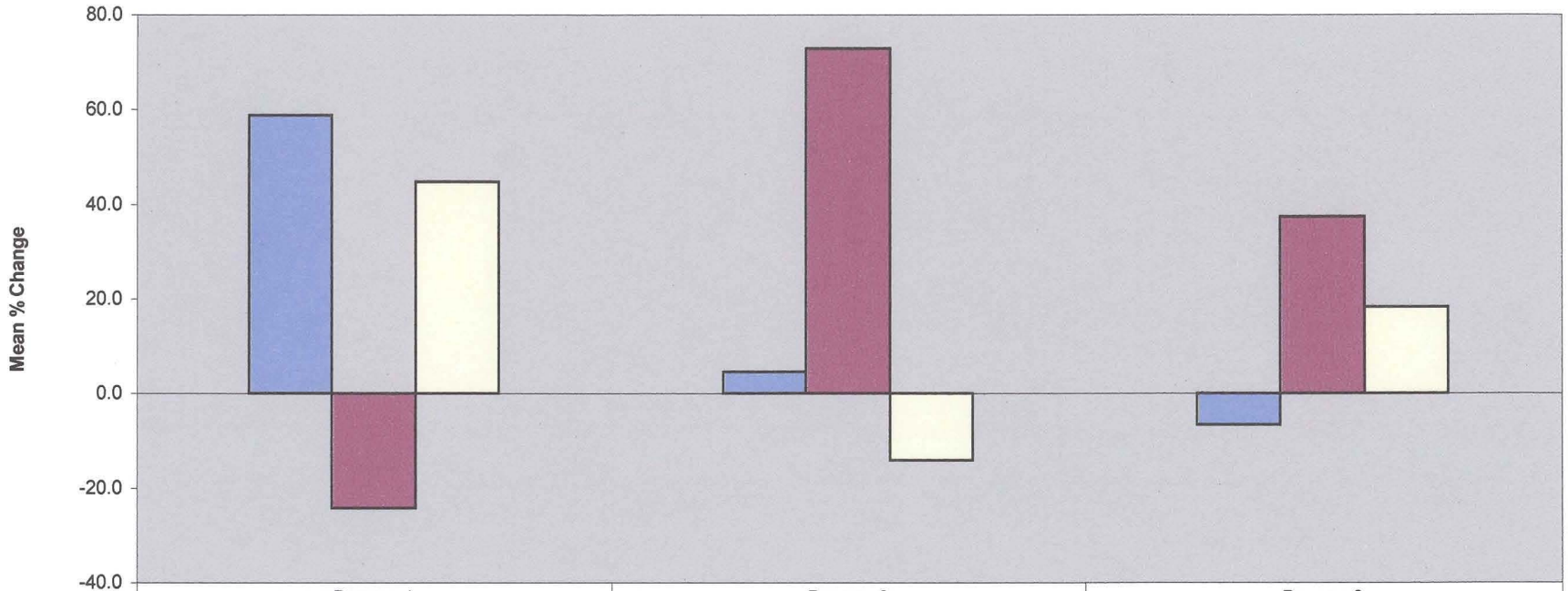
Iron has two very important exercise-related functions. Firstly, about 80% of the iron in the body is found in functionally active compounds combined with haemoglobin in red blood cells. This iron-protein compound increases the oxygen carrying capacity of the blood about 65 times. Secondly, iron (about 5%) is a structural component of myoglobin, which aids in the transport and storage of oxygen within muscle cells (McArdle et al., 1991). About 20% of the iron in the body is found in the liver, spleen and bone marrow in the forms of hemosiderin and ferretin. Since ferretin is present in the plasma it is an excellent indicator of the iron stores of the body (Meyer and Meij, 1996). Normal iron levels are crucial in preventing conditions such as iron deficiency anaemia (McArdle et al., 1991). Iron deficiency anaemia is characterized by sluggishness, loss of appetite and a reduced capacity for sustaining even mild exercise (McArdle et al., 1991). Keeping the above mentioned in mind one can see why it would be beneficial if either one of the products would be effective in increasing the iron stores in the body.

TABLE I: HAEMATOLOGICAL ANALYSIS

* = p< 0.05; % Δ = Relative Change; NS = Not Significant (p> 0.05)

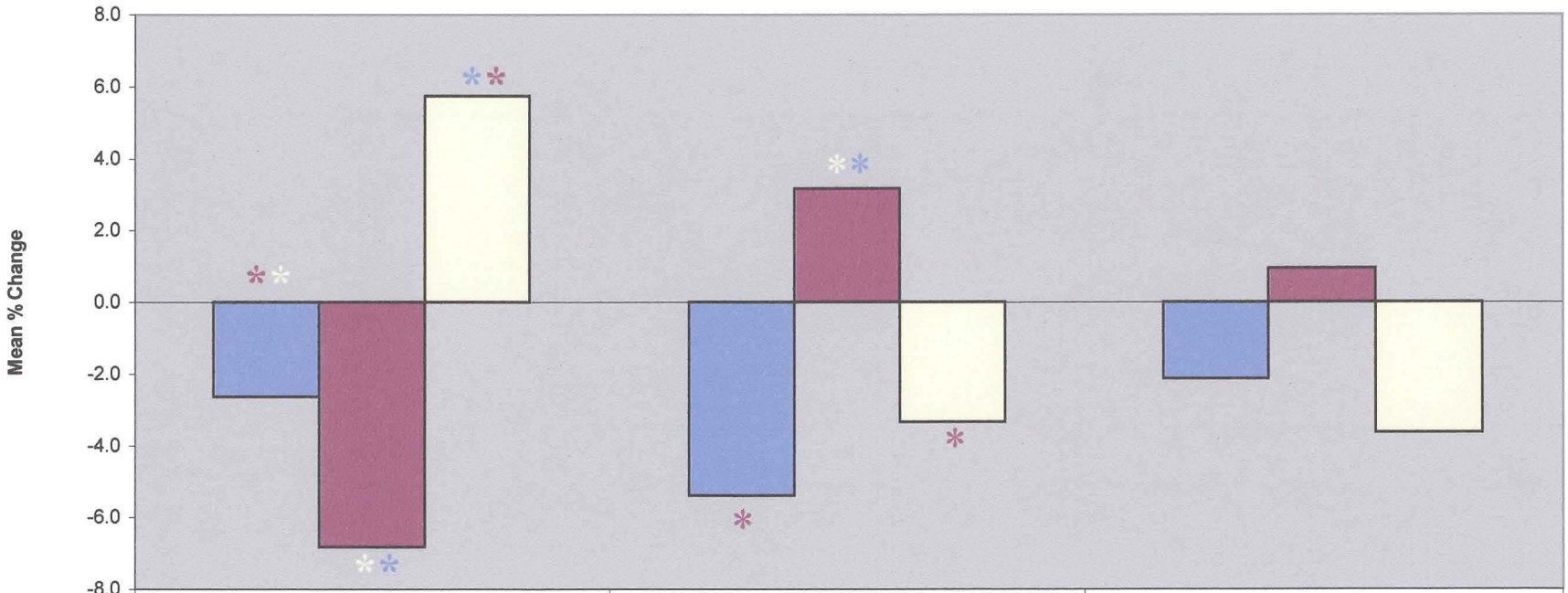
VARIABLES			PL: PLACEBO (N=10)					CF: CELLFOOD (N=10)					SW: SWITCH (N=10)					SIGNIFICANCE		
BLOOD VALUES	Cycle	UNITS	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PL vs CF	PL vs SW	CF vs SW
Ferretin	1	ng/mL	67.5	54.5	107.2	127.8	**58.8**	123.7	152.1	93.7	72.7	**-24.2**	97.2	65.9	140.6	113.3	**44.8**			
Ferretin	2	ng/mL	97.2	65.9	101.7	122.3	**4.7**	67.5	54.5	116.7	81.6	**72.9**	123.7	152.1	106.2	113.8	**-14.1**		**NS**	
Ferretin	3	ng/mL	123.7	152.1	115.6	120.4	**-6.6**	97.2	65.9	133.5	131.3	**37.4**	67.5	54.5	79.9	59.9	**18.3**			
Haemoglobin	1	g/dL	15.2	1.6	14.8	1.5	**-2.6**	15.0	1.4	13.9	1.2	**-6.8**	14.8	1.3	15.7	1.0	**5.7**	*	*	*
Haemoglobin	2	g/dL	14.8	1.3	14.0	1.2	**-5.4**	15.2	1.6	15.7	1.6	**3.2**	15.0	1.4	14.5	1.5	**-3.3**	*	**NS**	*
Haemoglobin	3	g/dL	15.0	1.4	14.6	1.2	**-2.1**	14.8	1.3	15.0	1.6	**0.9**	15.2	1.6	14.6	1.8	**-3.6**		**NS**	
Red Blood Cell	1	10^12/L	4.9	0.6	4.7	0.5	**-4.8**	4.6	1.1	4.6	0.5	**-1.2**	4.7	0.4	5.1	0.3	**7.8 ***	**NS**	*	*
Red Blood Cell	2	10^12/L	4.7	0.4	4.6	0.4	**-3.7 ***	4.9	0.6	5.0	0.6	**2.4**	4.6	1.1	4.8	0.5	**2.8**			
Red Blood Cell	3	10^12/L	4.6	1.1	4.8	0.5	**3.4**	4.7	0.4	4.8	0.5	**1.1**	4.9	0.6	4.7	0.5	**-4.3**		**NS**	
Hematocrit	1	%	45.0	4.3	43.1	4.3	**-4.3**	46.9	10.6	41.4	3.7	**-11.8**	44.0	4.1	46.7	3.1	**6.2 ***	*	*	*
Hematocrit	2	%	44.0	4.1	41.4	3.8	**-6.0 ***	45.0	4.3	46.4	4.5	**3.0**	46.9	10.6	43.3	3.8	**-7.7**	*	**NS**	*
Hematocrit	3	%	46.9	10.6	43.0	3.7	**-8.3**	44.0	4.1	44.1	4.8	**0.1**	45.0	4.3	43.1	5.4	**-4.4**		**NS**	
Glucose	1	mmol/L	4.7	0.6	4.6	0.4	**-1.1**	4.6	0.6	4.6	0.5	**2.0**	4.5	0.5	4.8	0.5	**6.0**			
Glucose	2	mmol/L	4.5	0.5	4.7	0.4	**5.3**	4.7	0.6	4.7	0.5	**0.4**	4.6	0.6	4.4	0.5	**-2.4**		**NS**	
Glucose	3	mmol/L	4.6	0.6	4.5	0.5	**-0.7**	4.5	0.5	4.7	0.6	**3.3**	4.7	0.6	4.8	0.6	**1.9**			

FIGURE 4.1: FERRETIN CONCENTRATION



	Dosage 1	Dosage 2	Dosage 3
Placebo	58.8	4.7	-6.6
Cellfood	-24.2	72.9	37.4
Switch	44.8	-14.1	18.3

FIGURE 4.2: HEAMOGLOBIN CONCENTRATION (* = p< 0.05)



	Dosage 1	Dosage 2	Dosage 3
Placebo	-2.6	-5.4	-2.1
Cellfood	-6.8	3.2	0.9
Switch	5.7	-3.3	-3.6

When evaluating the ferretin levels, it seems that Cellfood® was not effective at all during cycle 1, when Cellfood® was administered at the lowest dosage. Cellfood® was the most effective during cycle three when it was administered at the highest dosage. The inverse seems to be true for the Switch™ product. The most effective dosage was during the first cycle when the dosage was the lowest. It seems that the efficacy of the Switch™ product declined at the higher dosages during cycle 3. This pattern seems to repeat itself throughout all of the haematology results. Both Cellfood® and Switch™ had beneficial effects on the ferretin levels of the subjects. Although the products differed regarding their optimal dosage it seems that Cellfood® was the superior product regarding the increase of iron stores in the body.

4.2 Haemoglobin

Absolute pre- and post-test values can be observed in Table I and the relative changes are presented graphically in Figure 4.2.

Cycle 1 (Low Dosage)

Switch™ was the only group to show an increase (5.7%) in haemoglobin (Hb) concentration after the first cycle. Both placebo and Cellfood® showed a decrease of 2.6% and 6.8%, respectively. The improvement in Switch™ was significantly greater ($p<0.05$) than the decreases in both the placebo and Cellfood®. The decrease in placebo was significantly less ($p<0.05$) than in Cellfood®.

Cycle 2 (Intermediate Dosage)

Cellfood® showed an increase of 3.2%, while both Switch™ and placebo showed decreases in haemoglobin values of 3.3% and 5.4%, respectively.. The improvement in Cellfood® was significantly greater ($p<0.05$) than the decreases in both Switch™ and the placebo. The decreases in Switch™ and placebo did not differ significantly ($p>0.05$).

Cycle 3 (High Dosage)

Cellfood® showed an increase of 0.9 % in haemoglobin concentration. Both Switch™ with 3.6% and placebo with 2.1% showed decreases. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups.

Discussion

Haemoglobin is essential for the transport of both oxygen and carbon dioxide. Haemoglobin also serves the important function of acting as an acid base balance buffer (Meyer and Meij, 1996). Oxygen is not very soluble in fluid substances, only about 0.3ml gaseous oxygen dissolves in each 100ml of plasma. Although this is a very small amount it serves an important physiological purpose in establishing the $P0_2$ of the blood and the tissues. This pressure plays a role in the regulation of breathing and also determines the loading and release of oxygen from haemoglobin in the lungs and tissues respectively (McArdle et al., 1991). This means that the majority of oxygen is carried through the body in chemical combinations. This takes place with the help of haemoglobin. Haemoglobin contributes to about 34% of the volume of a red blood cell. Haemoglobin increases the blood's oxygen carrying capacity with about 65 to 70 times compared to that of the dissolved oxygen in the plasma. Thus for each litre of blood about 197ml of oxygen are carried through the body in chemical combination with haemoglobin (McArdle et al., 1991) Men have approximately 15-16 g of haemoglobin in each 100ml of blood. The blood's oxygen carrying capacity changes only slightly with normal variations in haemoglobin values, while a significant decrease in iron content of the red blood cells will lead to a decrease in the blood's oxygen carrying capacity and corresponding reduced capacity for sustaining even mild aerobic exercise (McArdle et al., 1991). Both Cellfood® and Switch™ had beneficial effects on the haemoglobin content of the subjects. Again the Cellfood® was more effective at the intermediate and higher dosages while Switch™ showed the best results when administered at the lowest dosage.

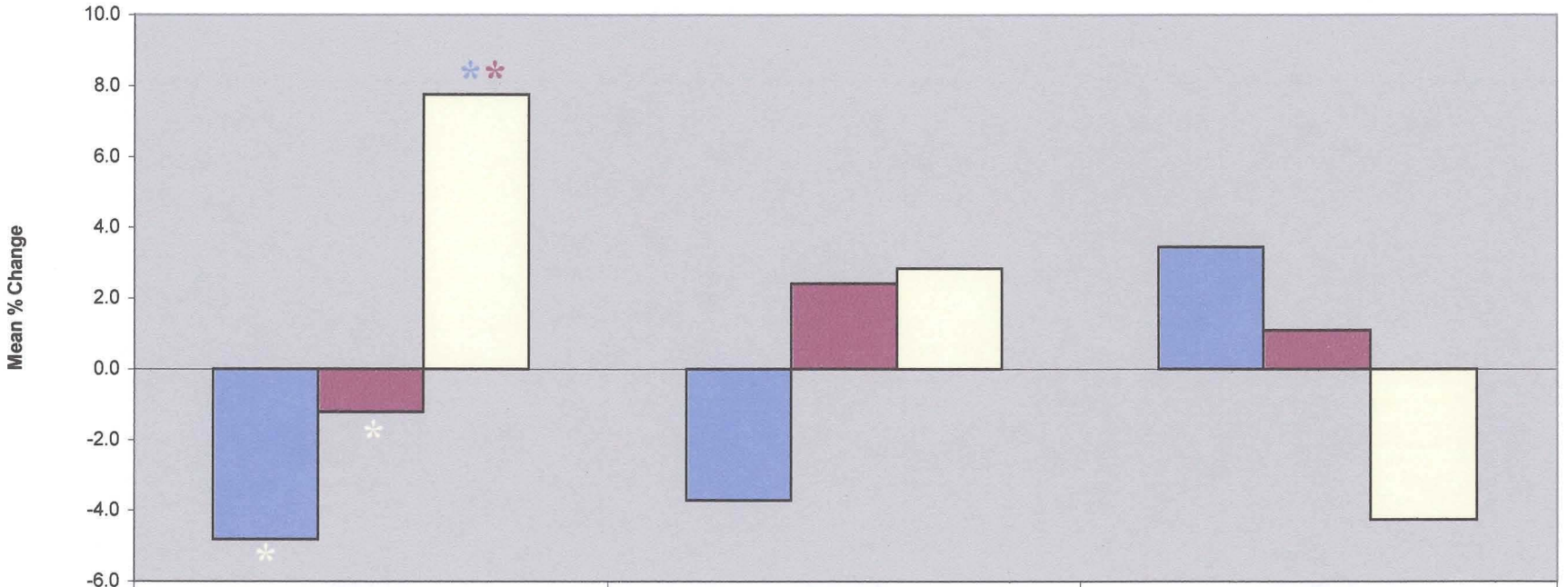
4.3 Red Blood Cell Count

Absolute pre- and post-test values can be observed in Table I and the relative changes are presented graphically in Figure 4.3.

Cycle 1 (Low Dosage)

Switch™ showed an increase in red blood cell count of 7.8%, while both placebo and Cellfood® showed decreases of 4.8% and 1.2%, respectively after the first cycle. The improvement in Switch™ was significantly greater ($p<0.05$) than the decreases in

FIGURE 4.3: RED BLOOD CELL COUNT (* = p< 0.05)



	Dosage 1	Dosage 2	Dosage 3
Placebo	-4.8	-3.7	3.4
Cellfood	-1.2	2.4	1.1
Switch	7.8	2.8	-4.3

both Cellfood® and the placebo. The decrease in Cellfood® was, however, not significantly less ($p>0.05$) than in the placebo. The within-group ergogenic improvement from base-line values of 7.8% in red blood cell count observed in Switch™ was statistically significant ($p<0.05$).

Cycle 2 (Intermediate Dosage)

Both Switch™ and Cellfood® showed increases in red cell count of 2.8% and 2.4%, respectively. The placebo showed a decrease of 3.7%. The improvement in Switch™ did not differ significantly ($p>0.05$) from either the decreases in the placebo or the incease in Cellfood® ($p>0.05$).

Cycle 3 (High Dosage)

Cellfood® and placebo showed an increase of 1.1% and 3.4%, respectively. Switch™ showed a decrease of 4.3%. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups.

Discussion

It is possible to determine the amount of red blood cells per volume unit of blood. The average count for adult males vary from 4.6 to 6.2 x 10^{12} /l blood and adult woman from 4.2 to 5.4 x 10^{12} /l. The red cell count is higher in newborn babies as well as people who live at high elevations above sea level. The values could also be higher or lower during certain illnesses (Meyer and Meij, 1996). Three of the main functions of red blood cells include the following: firstly they are responsible for the transport of oxygen from the lungs to the tissue and transport of carbon dioxide from the tissue to the lungs. Secondly, red blood cells help to maintain pH homeostasis within the body. Thirdly, red blood cells contribute just as much to the viscosity of the blood as plasma proteins.

Both Cellfood® and Switch™ were effective in increasing the red blood cell counts of the subjects. Cellfood® was the most effective at the intermediate and high dosage while Switch™ showed the best results at the lowest dosage tested. Switch™ was the superior product for increasing the red blood cell counts.

4.4 Hematocrit

Absolute pre- and post-test values can be observed in Table I and the relative changes are presented graphically in Figure 4.4.

Cycle 1 (Low Dosage)

The only increase in hematocrit was found in Switch™ with 6.2%. Both Cellfood® and placebo showed lower hematocrit values with decreases of 11.8% and 4.3%, respectively. The improvement in Switch™ was significantly greater ($p<0.05$) than the decreases in both Cellfood® and the placebo. The decrease in placebo was significantly less ($p<0.05$) than in Cellfood®. The within-group ergogenic improvement from base-line values of 6.2% in hematocrit observed in Switch™ was statistically significant ($p<0.05$).

Cycle 2 (Intermediate Dosage)

Only Cellfood® showed an increase of 3.1%. Both Switch™ and placebo showed decreases in hematocrit values of 7.7% and 6.0%, respectively. The improvement in Cellfood® was significantly greater ($p<0.05$) than the decreases in both Switch™ and placebo. The decreases in Switch™ and placebo did not differ significantly ($p>0.05$).

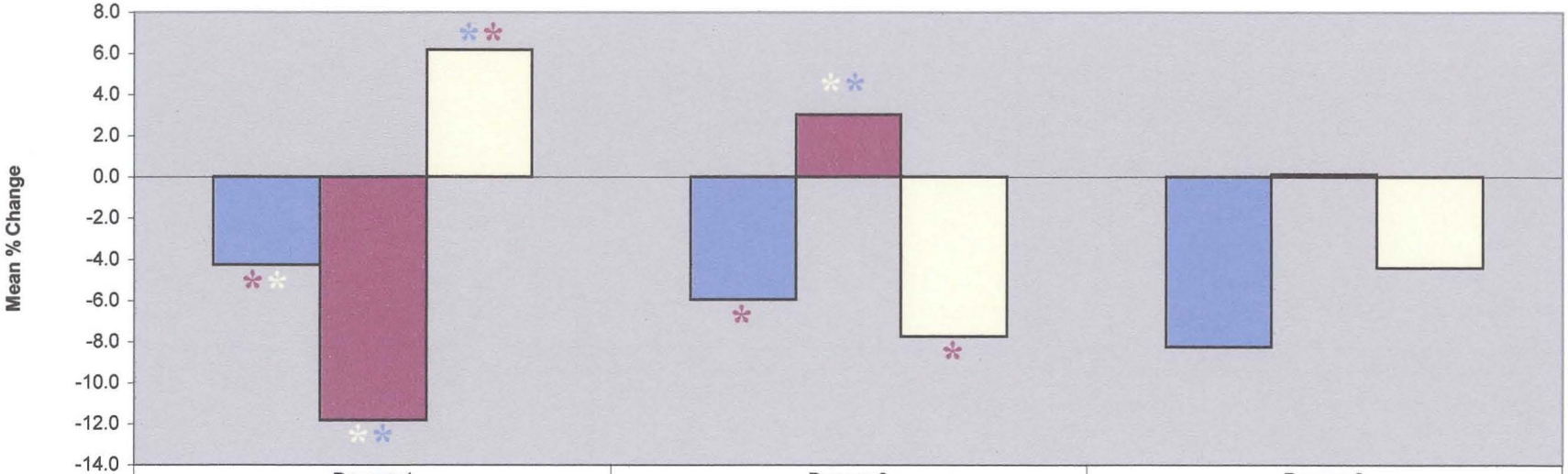
Cycle 3 (High Dosage)

Although a very slight increase of 0.1%, Cellfood® was the only group that showed an increase in hematocrit. Both Switch™ and placebo showed lower and reduced hematocrit values 4.4 % and 8.3%, respectively. There were no statistically significant differences ($p>0.05$) in these changes between groups.

Discussion

Hematocrit refers to the contribution of cells to a certain volume of blood. White blood cells contribute less than 0.08% to the hematocrit. The contribution of cells is higher in newly born infants and people who live at high elevations above sea level as well as people who are dehydrated and people with naturally high red cell counts. The values are lower in people who suffer from anaemia (Meyer and Meij, 1996). The haemoglobin, red blood cell count and hematocrit values showed significant results during the first two cycles.

FIGURE 4.4: HAEMATOCRIT VALUES (* = p< 0.05)



	Dosage 1	Dosage 2	Dosage 3
Placebo	-4.3	-6.0	-8.3
Cellfood	-11.8	3.0	0.1
Switch	6.2	-7.7	-4.4

During the first cycle it was clear that Switch™ was superior to both Cellfood® and the placebo regarding haemoglobin ($p<0.05$), red cells ($p<0.05$) and hematocrit ($p<0.05$). During cycle two, at a higher dosage, Cellfood® was more effective than Switch™ and placebo regarding all three of the above-mentioned variables of red blood cell count ($p<0.05$), heamatcorit ($p<0.05$) and haemoglobin ($p<0.05$). When considering the results of the haematology studies it is clear that Switch™ was more effective for the endurance runner at lower dosages while Cellfood® shows a higher degree of efficacy at a higher dosage, with the intermediate dosage being the most effective.

4.5 Fasting Glucose

Absolute pre- and post-test values can be observed in Table I and the relative changes are presented graphically in Figure 4.5.

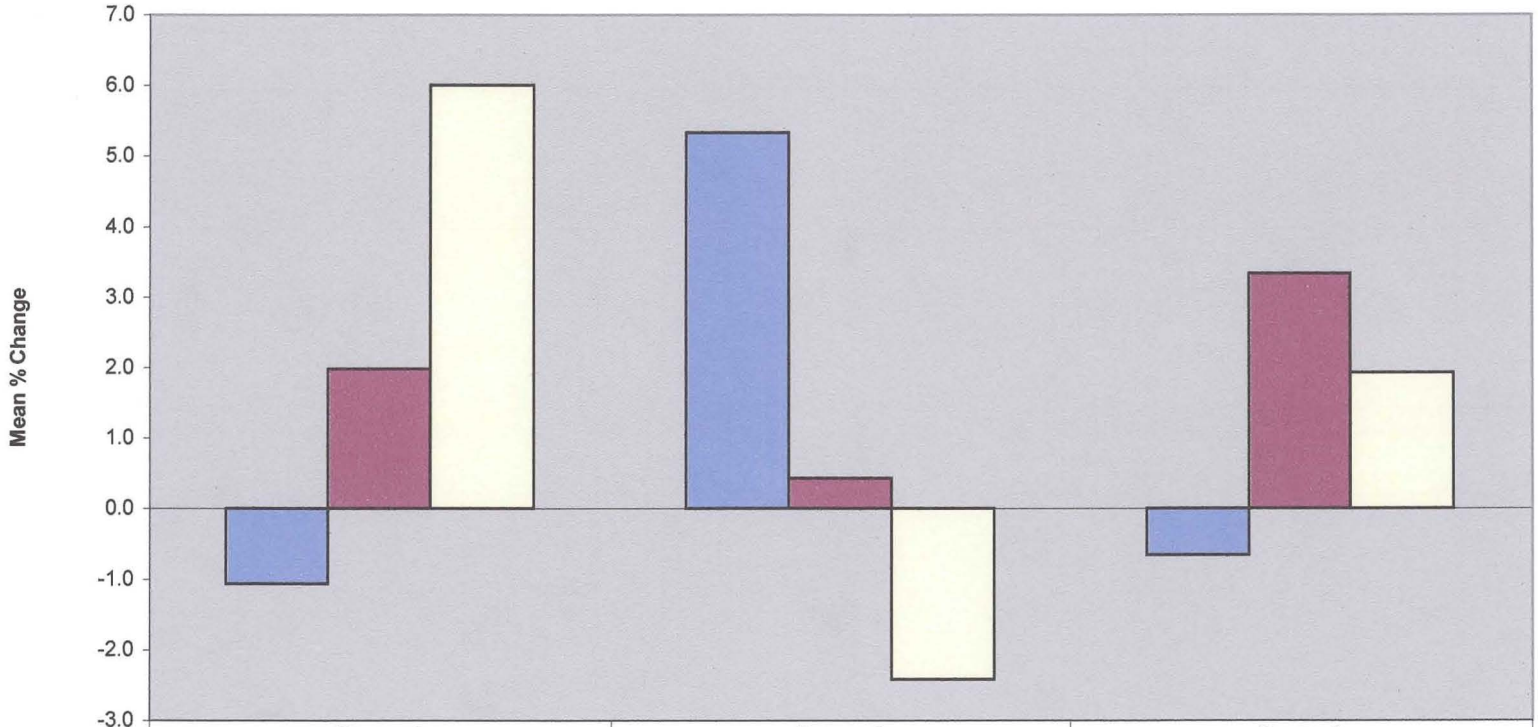
Cycle 1 (Low Dosage)
Both Cellfood® and Switch™ showed increases in fasting blood glucose with values of 2.0% and 6%, respectively. The placebo showed a decrease of 1.1%. There were no statistically significant differences ($p>0.05$) in these changes between groups.

Cycle 2 (Intermediate Dosage)
Both Cellfood® with 0.4% and placebo with 5.3% showed increases while Switch™ showed a decrease of 2.4%. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups.

Cycle 3 (High Dosage)
Cellfood® showed an increase of 3.3% while Switch™ showed an increase of 1.9%. A decrease of 0.7% was observed in the placebo group. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups.

Discussion
During prolonged exercise, glucose production may be reliant on gluconeogenesis because of hepatic glycogen depletion. This may cause the fall of glucose production below that required by the working muscle and other essential tissue such as the brain.

FIGURE 4.5: FASTING GLUCOSE VALUES



	Dosage 1	Dosage 2	Dosage 3
Placebo	-1.1	5.3	-0.7
Cellfood	2.0	0.4	3.3
Switch	6.0	-2.4	1.9

Also in prolonged exercise leading to dehydration and hyperthermia, shunting of blood flow away from the liver and kidneys occurs. Thus, levels of gluconeogenic precursors (lactate, pyruvate, alanine) rise, and hepatic glucose production decreases. In this case of falling blood glucose, the exercise becomes subjectively more difficult because of CNS starvation and difficulty in oxidizing fats in muscle due to the absence of anaplerotic substrates (Brooks et al., 1996). A higher resting blood glucose level (within normal physiological range) would be beneficial in delivering energy in the transition from rest to exercise as well as shortening the process of ATP production via anaerobic glycolysis.

Switch™ had the best effect on the fasting blood glucose values during cycle 1 (lowest dosage) while Cellfood® had the most beneficial influence on the glucose values during cycle 3 (highest dosage). The glucose values correlated with the pattern regarding the optimal dosages noted thus far.

4.6 Pulse Oximetry

Absolute pre- and post-test values can be observed in Table II and the relative changes are presented graphically in Figure 4.6.

Cycle 1 (Low Dosage)

Switch™ was the only group that generally showed improved haemoglobin saturation levels across all the running speeds on the treadmill. Cellfood® only showed notable increases during the last two running (higher) speeds while at the other speeds, except 12 km/h, it showed decreased saturation levels There were, however, no statistically significant differences ($p>0.05$) in these changes between groups. Placebo showed decreases during two running speeds while there were increases during three of the speeds with no change at one of the running speeds.

Cycle 2 (Intermediate Dosage)

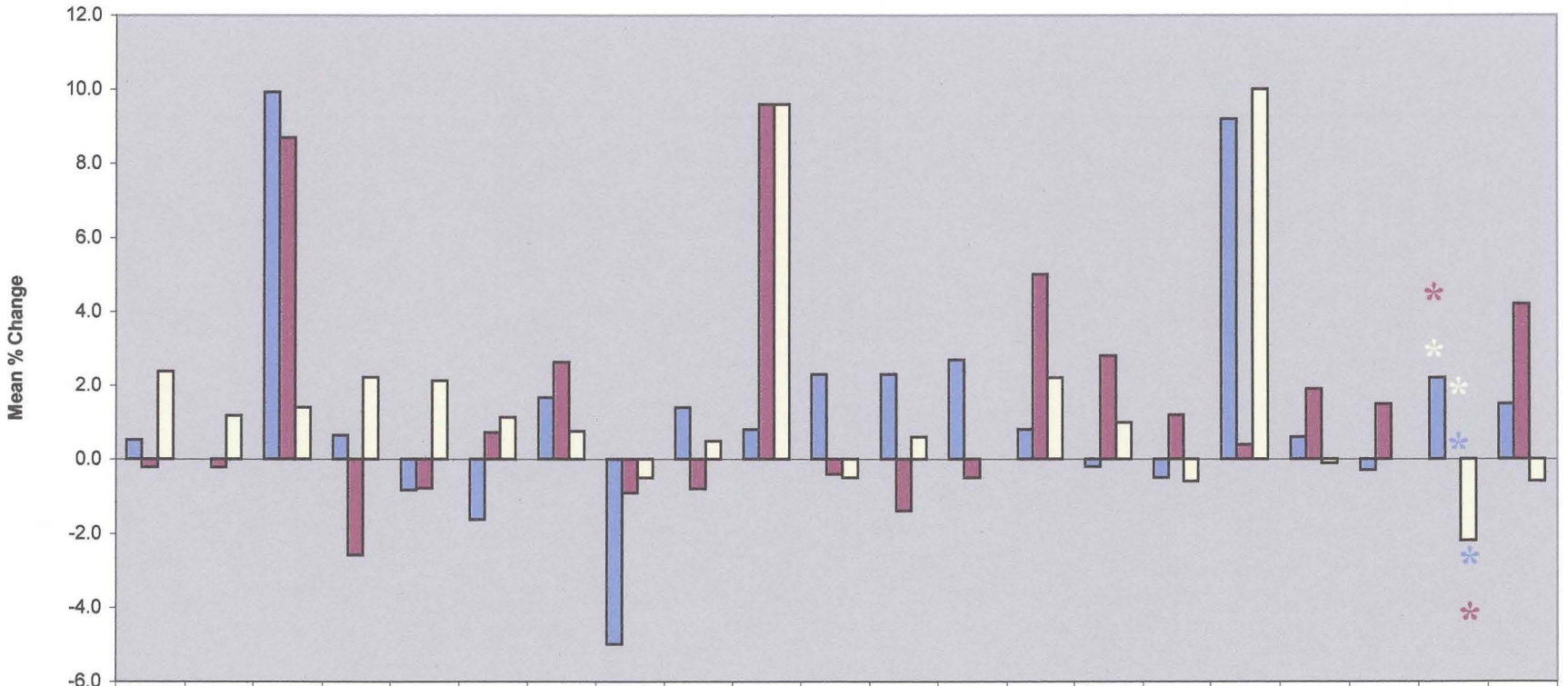
Switch™ showed increases in saturation levels on four of the seven running speeds, while Cellfood® only showed increases during two of the seven running speeds. There were no statistically significant differences ($p>0.05$) in these changes between groups

TABLE II: PULSE OXIMETRY

*** = p< 0.05; % Δ = Relative Change; NS = Not Significant (p> 0.05)**

VARIABLES			PL: PLACEBO (N=10)					CF: CELLFOOD (N=10)					SW: SWITCH (N=10)					SIGNIFICANCE		
RUNNING SPEED	Cycle	UNITS	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PL vs CF	PL vs SW	CF vs SW
8km/h	1	%Sp02	94.1	2.2	94.6	1.3	0.5	94.6	1.4	94.4	1.4	-0.2	92.5	5.2	94.7	1.6	2.4			
8km/h	2	%Sp02	92.5	5.2	87.9	21.1	-5.0	94.1	2.2	93.3	2.8	-0.9	94.6	1.4	94.1	1.5	-0.5	NS		
8km/h	3	%Sp02	94.6	1.4	94.4	1.3	-0.2	92.5	5.2	95.1	1.5	2.8	94.1	2.2	95.0	1.2	1.0			
10km/h	1	%Sp02	94.2	1.4	94.2	1.5	0.0	94.5	1.8	94.3	1.6	-0.2	92.6	3.9	93.7	1.8	1.2			
10km/h	2	%Sp02	92.6	3.9	93.9	2.6	1.4	94.2	1.4	93.4	2.2	-0.8	94.5	1.8	95.0	1.2	0.5	NS		
10km/h	3	%Sp02	94.5	1.8	94.0	1.7	-0.5	92.6	3.9	93.7	2.0	1.2	94.2	1.4	93.6	1.3	-0.6			
12km/h	1	%Sp02	84.6	28.7	93.0	3.5	9.9	85.1	26.8	92.5	2.2	8.7	92.2	3.0	93.5	2.7	1.4			
12km/h	2	%Sp02	92.2	3.0	92.9	3.3	0.8	84.6	28.7	92.7	1.8	9.6	85.1	26.8	93.3	1.4	9.6	NS		
12km/h	3	%Sp02	85.1	26.8	92.9	1.1	9.2	92.2	3.0	92.6	2.1	0.4	84.6	28.7	93.1	1.2	10.0			
14km/h	1	%Sp02	91.8	1.7	92.4	3.4	0.7	92.9	2.2	90.5	2.9	-2.6	90.3	5.1	92.3	2.5	2.2			
14km/h	2	%Sp02	90.3	5.1	92.4	2.1	2.3	91.8	1.7	91.4	2.7	-0.4	92.9	2.2	92.4	1.6	-0.5	NS		
14km/h	3	%Sp02	92.9	2.2	93.5	1.4	0.6	90.3	5.1	92.0	2.3	1.9	91.8	1.7	91.7	2.6	-0.1			
16km/h	1	%Sp02	91.0	2.6	90.3	4.0	-0.8	92.0	2.8	91.3	1.8	-0.8	89.9	2.8	91.8	2.6	2.1			
16km/h	2	%Sp02	89.9	2.8	92.0	2.3	2.3	91.0	2.6	89.7	2.9	-1.4	92.0	2.8	92.6	2.4	0.6	NS		
16km/h	3	%Sp02	92.0	2.8	91.7	1.3	-0.3	89.9	2.8	91.2	2.5	1.5	91.0	2.6	91.0	2.2	0.0			
17km/h	1	%Sp02	92.0	4.0	90.5	4.4	-1.6	91.0	2.8	91.7	2.3	0.7	88.0	2.7	89.0	2.4	1.1	NS		
17km/h	2	%Sp02	88.0	2.7	90.4	1.3	2.7	92.0	4.0	91.5	3.5	-0.5	91.0	2.8	91.0	1.9	0.0			
17km/h	3	%Sp02	91.0	2.8	93.0	1.0	2.2	88.0	2.7	88.0	1.0	0.0	92.0	4.0	91.0	0.0	-2.2	*	*	*
18km/h	1	%Sp02	89.5	3.5	91.0	0.0	1.7	88.7	4.2	91.0	1.4	2.6	87.3	2.1	88.0	3.2	0.8			
18km/h	2	%Sp02	87.3	2.1	88.0	2.8	0.8	89.5	3.5	94.0	0.0	5.0	88.7	4.2	90.6	1.9	2.2	NS		
18km/h	3	%Sp02	88.7	4.2	90.0	3.1	1.5	87.3	2.1	91.0	0.0	4.2	89.5	3.5	89.0	0.0	-0.6			

FIGURE 4.6: PULSE OXIMETRY (* = p < 0.05)



	Dose 1: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h	Dose 2: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h	Dose 3: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h
Placebo	0.5	0.0	9.9	0.7	-0.8	-1.6	1.7	-5.0	1.4	0.8	2.3	2.3	2.7	0.8	-0.2	-0.5	9.2	0.6	-0.3	2.2	1.5
Cellfood	-0.2	-0.2	8.7	-2.6	-0.8	0.7	2.6	-0.9	-0.8	9.6	-0.4	-1.4	-0.5	5.0	2.8	1.2	0.4	1.9	1.5	0.0	4.2
Switch	2.4	1.2	1.4	2.2	2.1	1.1	0.8	-0.5	0.5	9.6	-0.5	0.6	0.0	2.2	1.0	-0.6	10.0	-0.1	0.0	-2.2	-0.6

Cycle 3 (High Dosage)

Cellfood® showed higher saturation levels during six of the seven running speeds while Switch™ only showed higher saturation levels during two of the seven running speeds. The only significant ($p>0.05$) changes were at 17 km/h were both Switch™ and placebo showed significantly greater changes than Cellfood®. The decrease with Switch™ also was significantly greater than the increase of placebo or Cellfood, which showed an anomalous trend of no change.

Discussion

One molecule of Hb is capable of maximally combining with four molecules of oxygen as follows:

$$\mathbf{Hb_4 + 4\ O_2 \leftrightarrow Hb_4\ (O_2)_4}$$

One gram of Hb becomes saturated with oxygen when it combines with 1.34ml of oxygen. Once the Hb saturation point and the Hb concentration in the blood is known one can calculate what is referred to as the oxygen capacity of Hb:

O_2 capacity of Hb (ml O_2 / 100ml blood) = Hb concentration (grams Hb / 100ml blood) x (1.34 ml O_2/ gram Hb)

At rest and at sea level, about 15 grams of Hb are present in every 100ml blood (for males, 16 grams per 100ml and for females, 14 grams per 100ml). Therefore under these conditions, the oxygen capacity of Hb is 15 x 1.34 =20.1ml O_2/ 100ml blood, or 20.1 volumes percent (volumes percent in this case refers to millilitres of O_2 per 100ml blood). With exercise the Hb concentration of blood increases by 5 – 10%. This is due, in part, to fluid shifts from the blood into the active muscle cells, and hemoconcentration results. A 10% hemoconcentration during exercise implies that there will be about 16.5 grams of Hb per 100ml of blood instead of 15 grams. The oxygen capacity of Hb would in this case increase from 20.1 to 22.1 volumes percent, a definite advantageous change. The last important concept regarding Hb is the percent saturation of Hb with oxygen. The percentage saturation of haemoglobin with oxygen ($\%SO_2$) was measured incrementally throughout the treadmill tests. These

values relate the amount of oxygen actually combined with haemoglobin (content) to the maximum amount of oxygen that could be combined with haemoglobin (capacity):

$\%SO_2$ = (O_2 content of Hb/ O_2 capacity of Hb) x 100

A saturation of 100% indicates that the oxygen actually combined with the Hb is equal to the oxygen capacity of Hb. The use of $\%SO_2$ takes into account individual variations in Hb concentrations (Fox et al., 1993).
When looking at the haemoglobin saturation values throughout the three cycles it is clear that Switch™ performed optimally during cycle 1 (lower dosage) and Cellfood® at its best during cycle 3 (higher dosages).

4.7 Rate of Perceived Exertion

Absolute pre- and post-test values can be observed in Table III and the relative changes are presented graphically in Figure 4.7.

Cycle 1 (Low Dosage)
Switch™ showed reduced rates of perceived exertion (RPE) values for all the running speeds during the treadmill test while Cellfood® only showed reduced values on the last three (faster) of the seven running speeds. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups. Placebo showed increases in RPE during four running speeds with two decreases and one speed that showed no change.

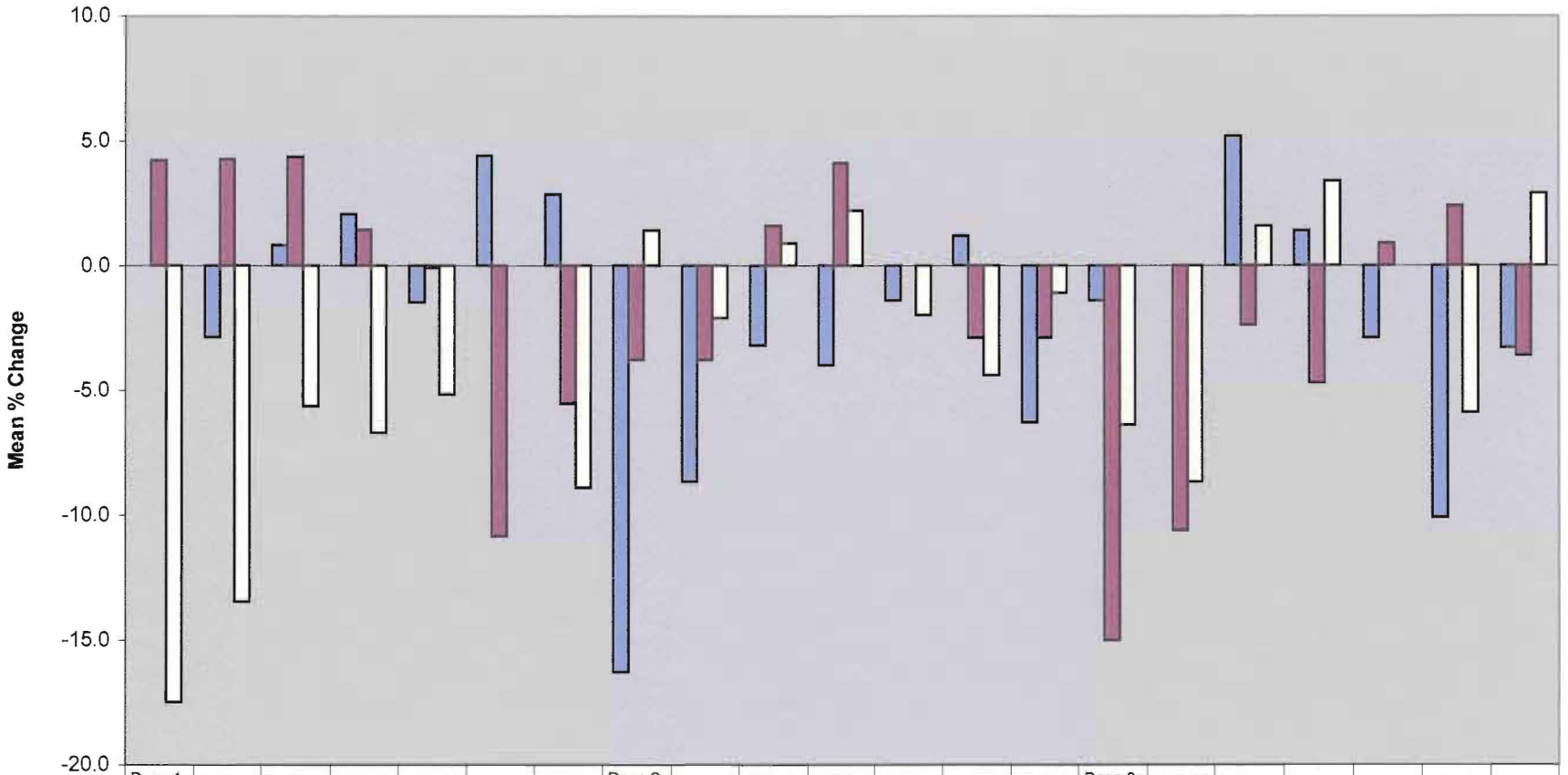
Cycle 2 (Intermediate Dosage)
Both Cellfood® and Switch™ showed reduced values on four of the seven running speeds. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups. Placebo showed lower values on six of the seven running speeds, with only one increase.

TABLE III: RATE OF PERCEIVED EXERTION

* = p< 0.05; % Δ = Relative Change; NS = Not Significant (p> 0.05)

VARIABLES			PL: PLACEBO (N=10)				CF: CELLFOOD (N=10)				SW: SWITCH (N=10)				SIGNIFICANCE		
RUNNING SPEED	Cycle	UNITS	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PL vs CF	PL vs SW	CF vs SW
8km/h	1		7.8	1.3	7.8	1.4	0.0	7.1	1.1	7.4	1.3	4.2	8.0	1.6	6.6	1.7	-17.5	NS		
8km/h	2		8.0	1.6	6.7	0.5	-16.3	7.8	1.3	7.5	2.0	-3.8	7.1	1.1	7.2	1.3	1.4			
8km/h	3		7.1	1.1	7.0	1.9	-1.4	8.0	1.6	6.8	1.3	-15.0	7.8	1.3	7.3	1.2	-6.4			
10km/h	1		10.4	1.7	10.1	1.3	-2.9	9.4	1.5	9.8	1.5	4.3	10.4	1.4	9.0	1.9	-13.5	NS		
10km/h	2		10.4	1.4	9.5	0.8	-8.7	10.4	1.7	10.0	2.6	-3.8	9.4	1.5	9.2	1.6	-2.1			
10km/h	3		9.4	1.5	9.4	1.3	0.0	10.4	1.4	9.3	1.4	-10.6	10.4	1.7	9.5	1.3	-8.7			
12km/h	1		12.3	2.2	12.4	1.2	0.8	11.5	1.1	12.0	1.4	4.3	12.4	1.3	11.7	2.2	-5.6	NS		
12km/h	2		12.4	1.3	12.0	1.2	-3.2	12.3	2.2	12.5	2.6	1.6	11.5	1.1	11.6	1.4	0.9			
12km/h	3		11.5	1.1	12.1	2.0	5.2	12.4	1.3	12.1	0.9	-2.4	12.3	2.2	12.5	1.4	1.6			
14km/h	1		14.5	2.6	14.8	1.2	2.1	13.9	1.4	14.1	2.1	1.4	14.9	2.1	13.9	2.2	-6.7	NS		
14km/h	2		14.9	2.1	14.3	1.6	-4.0	14.5	2.6	15.1	3.0	4.1	13.9	1.4	14.2	1.5	2.2			
14km/h	3		13.9	1.4	14.1	2.3	1.4	14.9	2.1	14.2	0.9	-4.7	14.5	2.6	15.0	1.6	3.4			
16km/h	1		17.0	2.8	16.8	0.9	-1.5	15.9	0.8	15.9	2.5	-0.1	16.6	1.7	15.7	2.3	-5.2	NS		
16km/h	2		16.6	1.7	16.3	1.7	-1.4	17.0	2.8	17.0	2.4	0.0	15.9	0.8	15.6	0.8	-2.0			
16km/h	3		15.9	0.8	15.4	2.4	-2.9	16.6	1.7	16.7	1.5	0.9	17.0	2.8	17.0	1.7	0.0			
17km/h	1		17.0	2.0	17.8	0.5	4.4	17.6	1.1	15.7	1.5	-10.8	17.0	1.4	17.0	2.0	0.0	NS		
17km/h	2		17.0	1.4	17.2	1.5	1.2	17.0	2.0	16.5	3.5	-2.9	17.6	1.1	16.8	0.8	-4.4			
17km/h	3		17.6	1.1	15.8	1.3	-10.1	17.0	1.4	17.4	0.5	2.4	17.0	2.0	16.0	0.0	-5.9			
18km/h	1		17.5	0.7	18.0	0.0	2.9	18.0	1.0	17.0	1.4	-5.6	18.7	1.5	17.0	0.8	-8.9	NS		
18km/h	2		18.7	1.5	17.5	0.7	-6.3	17.5	0.7	17.0	0.0	-2.9	18.0	1.0	17.8	1.3	-1.1			
18km/h	3		18.0	1.0	17.4	1.5	-3.3	18.7	1.5	18.0	0.0	-3.6	17.5	0.7	18.0	0.0	2.9			

FIGURE 4.7: RATE OF PERCEIVED EXERTION



	Dose 1: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h	Dose 2: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h	Dose 3: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h
Placebo	0.0	-2.9	0.8	2.1	-1.5	4.4	2.9	-16.3	-8.7	-3.2	-4.0	-1.4	1.2	-6.3	-1.4	0.0	5.2	1.4	-2.9	-10.1	-3.3
Cellfood	4.2	4.3	4.3	1.4	-0.1	-10.8	-5.6	-3.8	-3.8	1.6	4.1	0.0	-2.9	-2.9	-15.0	-10.6	-2.4	-4.7	0.9	2.4	-3.6
Switch	-17.5	-13.5	-5.6	-6.7	-5.2	0.0	-8.9	1.4	-2.1	0.9	2.2	-2.0	-4.4	-1.1	-6.4	-8.7	1.6	3.4	0.0	-5.9	2.9

Cycle 3 (High Dosage)

Cellfood® showed reduced perceived exertion values on five of the seven running speeds. Switch™ only showed reduced values on three of the seven running speeds. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups. Placebo showed increases on two of the running speeds, four speeds showed lower values, with one speeds showing no change.

Discussion

Rating of perceived exertion (RPE) has been found to be a valuable and reliable indicator in monitoring an individual's exercise tolerance. Borg's RPE scale was developed to allow the exerciser to subjectively rate their feelings during exercise, taking into account personal fitness level, environmental factors and general fatigue levels (Borg, 1973). The greatest value of the scale is it that provides exercisers of all fitness levels with easily understood guidelines regarding exercise intensity. It has been found that a cardio-respiratory training effect and the threshold for blood lactate accumulation are achieved at a rating of "somewhat hard" or "hard" which corresponds to a rating of 13 to 16 on the scale used during the study.

Switch™ showed the best results regarding the RPE scale during cycle 1 (low dosage) while Cellfood® was superior to both the Switch™ product and the placebo during cycle 3 (high dosage).

4.8 Heart Rate Values

Absolute pre- and post-test values can be observed in Table IV and the relative changes are presented graphically in Figure 4.8.

Cycle 1 (Low Dosage)

Both Cellfood® and Switch™ showed reduced heart rates on all the running speeds. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups. Placebo showed lower heart rates at all the speeds except the last two running speeds.

Cycle 2 (Intermediate Dosage)

Both Cellfood® and Switch™ showed reduced heart rates on all the running speeds. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups. Placebo showed lower heart rates at all the running speeds except the last (18km/h).

Cycle 3 (High Dosage)

Cellfood® showed reduced heart rate values on all of the running speeds while Switch™ only showed reduced heart rate values on the first two (8 and 10 km/h) running speeds. The reduction in heart rate at a running speed of 10 km/h in Switch™ was, however, significantly less ($p<0.05$) than in Cellfood® and placebo. Placebo showed lower heart rate values during all the running speeds of the treadmill test.

Discussion

Heart rate is one of the two important factors influencing cardiac output, the other being stroke volume.

Q (litres per minute) = SV (stroke volume, litres per beat) x HR (beats per minute)

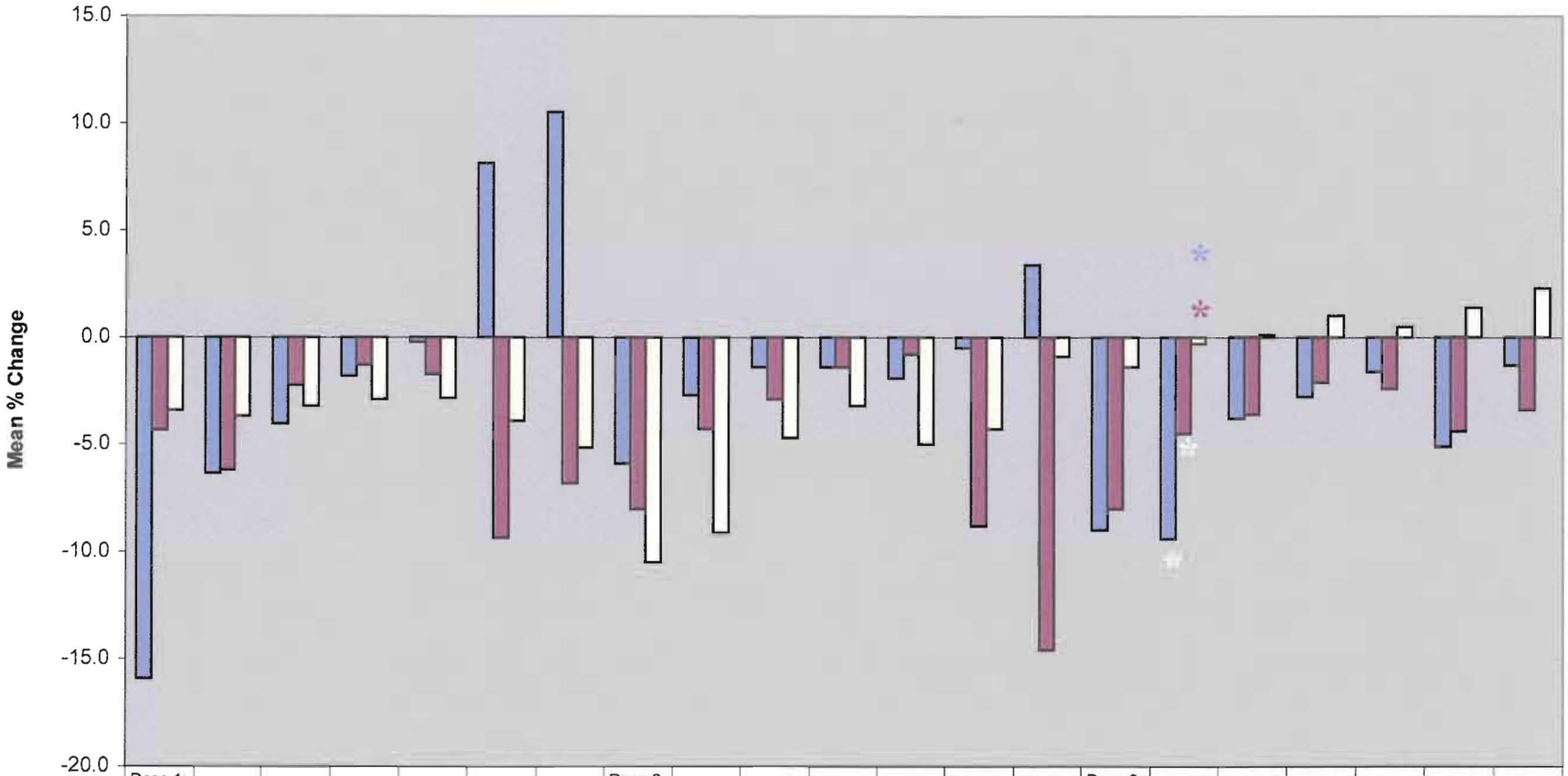
Cardiac output is defined as the amount of blood ejected per minute by the heart, specifically the left ventricle. At rest there is little difference in cardiac output between trained and untrained subjects, with average values ranging between 5 and 6 litres per minute. Maximal cardiac output in trained male subjects can reach values in excess of 30 litre per minute. Women tend to have a slightly higher cardiac output when performing at the same level of oxygen consumption. This difference amounts to between 1.5 and 1.75 litres per minute. This means that, the cardiac output will be 1.5 to 1.75 litres per minute higher on the average in woman than in men for a given oxygen consumption. The reason for this is probably compensatory due to the woman's lower oxygen-carrying capacity of blood, resulting from lower levels of haemoglobin. Also, the maximal cardiac output of both trained and untrained woman is generally lower than that of their male counterparts (Fox and Bowers, 1993). The increase in cardiac output and redistribution of blood flow that occur during exercise

TABLE IV: HEART RATE VALUES

* = p< 0.05; % Δ = Relative Change; NS = Not Significant (p> 0.05)

VARIABLES			PL: PLACEBO (N=10)					CF: CELLFOOD (N=10)					SW: SWITCH (N=10)					SIGNIFICANCE		
RUNNING SPEED	Cycle	UNITS	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PRE-TEST. X ± SD		POST-TEST X ± SD		%Δ	PL vs CF	PL vs SW	CF vs SW
8km/h	1	Beats/min	125.6	8.4	105.6	31.8	-15.9	124.5	9.2	119.1	12.6	-4.3	123.1	17.8	118.9	7.4	-3.4	NS		
8km/h	2	Beats/min	123.1	17.8	115.8	15.0	-5.9	125.6	8.4	115.5	17.9	-8.0	124.5	9.2	111.4	13.2	-10.5			
8km/h	3	Beats/min	124.5	9.2	113.3	12.0	-9.0	123.1	17.8	113.2	12.2	-8.0	125.6	8.4	123.9	10.8	-1.4			
10km/h	1	Beats/min	141.6	12.6	132.6	12.1	-6.4	142.1	11.6	133.3	14.3	-6.2	138.7	15.1	133.6	9.1	-3.7	NS		
10km/h	2	Beats/min	38.7	15.1	134.9	9.3	-2.7	141.6	12.6	135.5	14.4	-4.3	142.1	11.6	129.2	13.4	-9.1			
10km/h	3	Beats/min	142.1	11.6	128.8	11.1	-9.4	138.7	15.1	132.4	9.6	-4.5	141.6	12.6	141.2	9.8	-0.3	NS	*	*
12km/h	1	Beats/min	155.8	14.5	149.5	9.8	-4.0	151.6	7.4	148.2	14.7	-2.2	152.0	15.6	147.1	12.4	-3.2			
12km/h	2	Beats/min	152.0	15.6	149.9	10.2	-1.4	155.8	14.5	151.7	15.9	-2.9	151.6	7.4	144.4	15.3	-4.7	NS		
12km/h	3	Beats/min	151.6	7.4	145.9	13.4	-3.8	152.0	15.6	146.6	11.1	-3.6	155.8	14.5	156.0	12.0	0.1			
14km/h	1	Beats/min	165.7	16.0	162.7	10.5	-1.8	162.9	7.4	160.8	13.8	-1.3	163.0	11.1	158.3	13.0	-2.9			
14km/h	2	Beats/min	163.0	11.1	160.7	9.9	-1.4	165.7	16.0	163.4	17.0	-1.4	162.9	7.4	157.7	15.0	-3.2	NS		
14km/h	3	Beats/min	162.9	7.4	158.3	15.2	-2.8	163.0	11.1	159.6	10.0	-2.1	165.7	16.0	167.3	12.0	1.0			
16km/h	1	Beats/min	171.9	14.9	171.5	7.1	-0.2	173.1	9.3	170.1	14.9	-1.7	173.2	11.5	168.3	15.4	-2.8			
16km/h	2	Beats/min	173.2	11.5	169.9	11.5	-1.9	171.9	14.9	170.6	19.9	-0.8	173.1	9.3	164.4	13.2	-5.0	NS		
16km/h	3	Beats/min	173.1	9.3	170.3	12.4	-1.6	173.2	11.5	169.1	11.4	-2.4	171.9	14.9	172.8	8.2	0.5			
17km/h	1	Beats/min	166.7	12.6	180.3	12.3	8.1	179.4	11.2	162.7	7.1	-9.3	176.2	13.8	169.3	11.4	-3.9			
17km/h	2	Beats/min	176.2	13.8	175.4	15.0	-0.5	166.7	12.6	152.0	21.2	-8.8	179.4	11.2	171.8	10.6	-4.3	NS		
17km/h	3	Beats/min	179.4	11.2	170.2	11.4	-5.1	176.2	13.8	168.4	11.3	-4.4	166.7	12.6	169.0	0.0	1.4			
18km/h	1	Beats/min	171.0	0.0	189.0	5.2	10.5	180.3	10.6	168.0	11.3	-6.8	179.0	14.0	169.8	7.0	-5.2			
18km/h	2	Beats/min	179.0	14.0	185.0	12.7	3.4	171.0	0.0	146.0	0.0	-14.6	180.3	10.6	178.8	10.5	-0.9	NS		
18km/h	3	Beats/min	180.3	10.6	178.0	12.0	-1.3	179.0	14.0	173.0	0.0	-3.4	171.0	0.0	175.0	0.0	2.3			

FIGURE 4.8: HEART RATE VALUES (* = p< 0.05)



	Dose 1: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h	Dose 2: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h	Dose 3: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h
Placebo	-15.9	-6.4	-4.0	-1.8	-0.2	8.1	10.5	-5.9	-2.7	-1.4	-1.4	-1.9	-0.5	3.4	-9.0	-9.4	-3.8	-2.8	-1.6	-5.1	-1.3
Cellfood	-4.3	-6.2	-2.2	-1.3	-1.7	-9.3	-6.8	-8.0	-4.3	-2.9	-1.4	-0.8	-8.8	-14.6	-8.0	-4.5	-3.6	-2.1	-2.4	-4.4	-3.4
Switch	-3.4	-3.7	-3.2	-2.9	-2.8	-3.9	-5.2	-10.5	-9.1	-4.7	-3.2	-5.0	-4.3	-0.9	-1.4	-0.3	0.1	1.0	0.5	1.4	2.3

can best be summarized by developing the concept of the oxygen transport system. The components of the system and their interrelationship are as follows:

$V0_2$ (oxygen transported) = SV x HR x a-$v0_2$ diff (arteriovenous oxygen difference)

From the above equation we can derive that to maintain a certain $V0_2$ during exercise with lower comparative heart rates the subjects must either experience an increase in stroke volume or a increase in arterial oxygen content ($Ca0_2$).

Keeping in mind the higher cellular oxygen content supposedly delivered by both Switch™ and Cellfood® it explains why the subjects showed decreased comparative heart rates during the treadmill tests.

4.9 Blood Lactate Concentrations

Absolute pre- and post-test values can be observed in Table V and the relative changes are presented graphically in Figure 4.9.

Cycle 1 (Low Dosage)
Switch™ showed reduced lactate concentration values on all the running speeds while Cellfood® only showed reductions on the last two running speeds. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups. Placebo showed higher values on the first two running speeds.

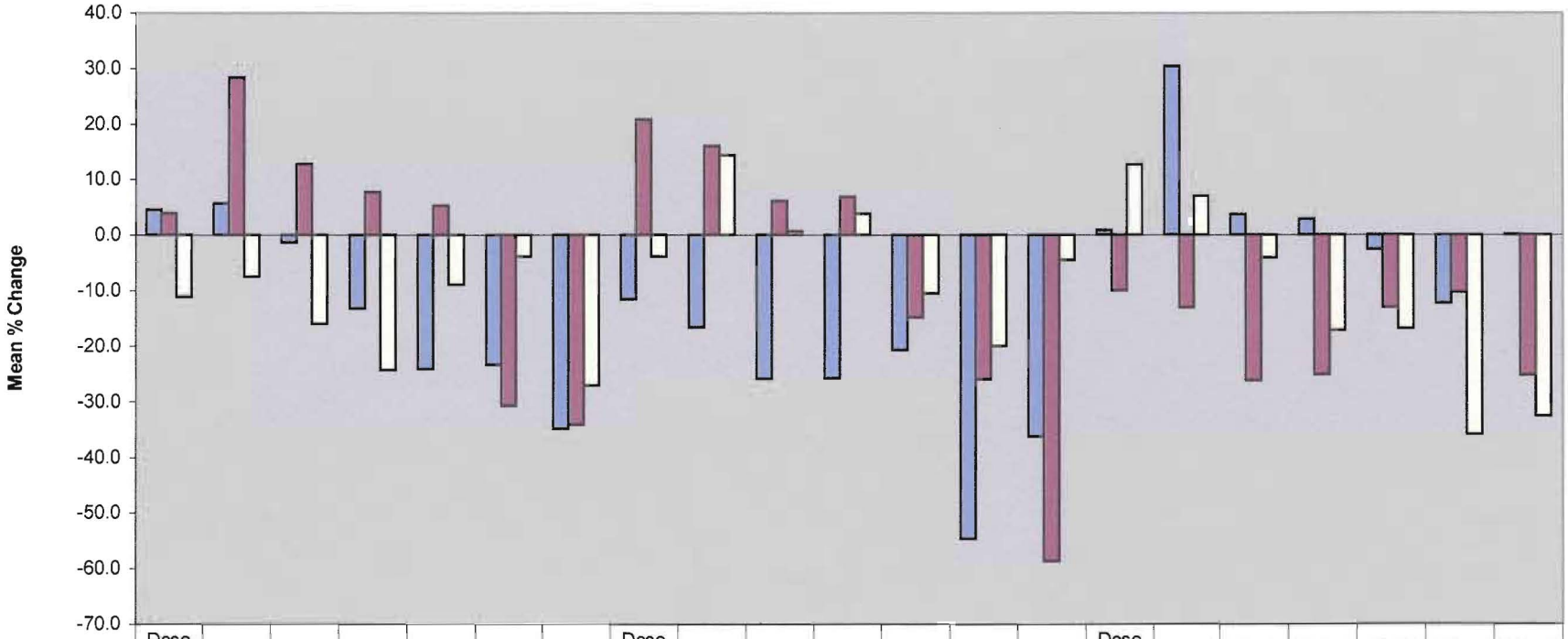
Cycle 2 (Intermediate Dosage)
Cellfood® showed reduced lactate values on the last three (higher) running speeds. Switch™ showed reduced lactate values on the initial and the last three (higher) running speeds. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups. Placebo showed lower values on all the running speeds. The within-group ergolytic improvement from base-line values of 6.9% in lactate concentration at 14km/h observed in Cellfood® was statistically significant ($p<0.05$).

TABLE V: BLOOD LACTATE VALUES

* = p< 0.05; % Δ = Relative Change; NS = Not Significant (p> 0.05)

VARIABLES			PL: PLACEBO (N=10)			CF: CELLFOOD (N=10)			SW: SWITCH (N=10)			SIGNIFICANCE		
RUNNING SPEED	Cycle	UNITS	PRE TEST. X ± SD	POST-TEST X ± SD	%Δ	PRE-TEST. X ± SD	POST-TEST X ± SD	%Δ	PRE-TEST. X ± SD	POST-TEST X ± SD	%Δ	PL vs CF	PL vs SW	CF vs SW
8km/h	1	mmol/L	2.2 0.8	2.3 0.4	4.5	2.3 0.5	2.4 0.7	3.9	2.5 1.1	2.2 0.7	-11.2	NS		
8km/h	2	mmol/L	2.5 1.1	2.2 0.6	-11.6	2.2 0.8	2.7 0.3	20.8	2.3 0.5	2.2 0.6	-3.9			
8km/h	3	mmol/L	2.3 0.5	2.3 0.5	0.9	2.5 1.1	2.3 0.5	-10.0	2.2 0.8	2.5 0.4	12.7			
10km/h	1	mmol/L	2.1 0.8	2.2 0.5	5.7	1.9 0.7	2.5 1.1	28.4	2.7 1.0	2.5 0.6	-7.4	NS		
10km/h	2	mmol/L	2.7 1.0	2.3 0.7	-16.6	2.1 0.8	2.5 0.4	16.1	1.9 0.7	2.2 0.6	14.4			
10km/h	3	mmol/L	1.9 0.7	2.5 0.4	30.4	2.7 1.0	2.3 0.6	-13.0	2.1 0.8	2.3 0.5	7.1			
12km/h	1	mmol/L	3.0 0.7	2.9 0.6	-1.4	2.7 0.9	3.1 1.6	12.8	3.4 1.2	2.9 0.9	-16.0	NS		
12km/h	2	mmol/L	3.4 1.2	2.5 0.6	-25.9	3.0 0.7	3.1 0.8	6.1	2.7 0.9	2.8 0.6	0.7			
12km/h	3	mmol/L	2.7 0.9	2.8 0.6	3.7	3.4 1.2	2.5 0.5	-26.2	3.0 0.7	2.8 0.4	-4.1			
14km/h	1	mmol/L	4.4 0.9	3.8 0.6	-13.3 *	3.7 1.1	4.0 1.5	7.8	4.6 1.4	3.5 1.1	-24.3	NS		
14km/h	2	mmol/L	4.6 1.4	3.4 1.2	-25.8	4.4 0.9	4.7 1.1	6.9 *	3.7 1.1	3.9 1.6	3.8			
14km/h	3	mmol/L	3.7 1.1	3.8 1.2	2.9	4.6 1.4	3.5 0.9	-25.2	4.4 0.9	3.6 0.6	-17.2 *			
16km/h	1	mmol/L	6.4 1.7	4.9 1.0	-24.1	5.0 1.4	5.3 1.5	5.3	5.5 1.4	5.0 1.3	-8.9	NS		
16km/h	2	mmol/L	5.5 1.4	4.4 1.0	-20.8	6.4 1.7	5.5 1.8	-14.8	5.0 1.4	4.5 1.0	-10.5			
16km/h	3	mmol/L	5.0 1.4	4.9 1.6	-2.6	5.5 1.4	4.8 1.1	-13.1	6.4 1.7	5.3 1.3	-16.8			
17km/h	1	mmol/L	7.6 2.4	5.9 0.9	-23.4	7.1 1.1	4.9 2.0	-30.7	6.8 2.9	6.5 2.3	-3.9	NS		
17km/h	2	mmol/L	6.8 2.9	3.1 1.9	-54.7	7.6 2.4	5.7 2.6	-26.0	7.1 1.1	5.7 1.9	-20.0			
17km/h	3	mmol/L	7.1 1.1	6.2 1.8	-12.3	6.8 2.9	6.1 1.1	-10.3	7.6 2.4	4.9 0.0	-35.8			
18km/h	1	mmol/L	9.2 2.8	6.0	-34.8	7.4 1.5	4.9 0.4	-34.1	9.5 4.6	6.9 3.0	-27.1	NS		
18km/h	2	mmol/L	9.5 4.6	6.1 2.8	-36.3	9.2 2.8	3.8 0.0	-58.7	7.4 1.5	7.1 3.0	-4.5			
18km/h	3	mmol/L	7.4 1.5	7.4 1.9	0.1	9.5 4.6	7.1 0.0	-25.3	9.2 2.8	6.2 0.0	-32.6			

FIGURE 4.9: BLOOD LACTATE VALUES



	Dose 1: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h	Dose 2: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h	Dose 3: 8km/h	10km/h	12km/h	14km/h	16km/h	17km/h	18km/h
Placebo	4.5	5.7	-1.4	-13.3	-24.1	-23.4	-34.8	-11.6	-16.6	-25.9	-25.8	-20.8	-54.7	-36.3	0.9	30.4	3.7	2.9	-2.6	-12.3	0.1
Cellfood	3.9	28.4	12.8	7.8	5.3	-30.7	-34.1	20.8	16.1	6.1	6.9	-14.8	-26.0	-58.7	-10.0	-13.0	-26.2	-25.2	-13.1	-10.3	-25.3
Switch	-11.2	-7.4	-16.0	-24.3	-8.9	-3.9	-27.1	-3.9	14.4	0.7	3.8	-10.5	-20.0	-4.5	12.7	7.1	-4.1	-17.2	-16.8	-35.8	-32.6

Cycle 3 (High Dosage)

Cellfood® showed reduced lactate values on all of the running speeds during the test. Switch™ showed lower values on five of the seven running speeds. There were, however, no statistically significant differences ($p>0.05$) in these changes between groups. Placebo showed higher values on five of the seven running speeds, with two speeds showing lower values. The within-group ergogenic improvement from base-line values of 17.2% in lactate concentration at 14km/h observed in Switch™ was statistically significant ($p<0.05$)..

Discussion

Lactate is one of the by-products of glycolysis. It is both produced and used by the muscles. It's rate of production increases as the exercise rate increases and as more carbohydrate is used to fuel exercise (Noakes, 1992). Glycolysis refers to the process where carbohydrates are broken down to pyruvic acid or lactic acid (Meyer and Meij, 1996). Lactic acid does not necessarily accumulate at all levels of exercise. During light and moderate exercise the energy demands are adequately met by reactions that use oxygen. In biochemical terms, the ATP for muscular contraction is made available predominantly through energy generated by the oxidation of hydrogen. Any lactic acid formed during light exercise is rapidly oxidized. As such, the blood lactic acid levels remains fairly stable even though oxygen consumption increases. Lactic acid begins to accumulate and rise in an exponential fashion at about 55% of the healthy, untrained subject's maximal capacity for aerobic metabolism. The usual explanation for the increase in lactic acid is based on the assumption of a relative tissue hypoxia in heavy exercise (McArdle et al., 1991). For this reason it would be beneficial to the athlete if either one of the products could help the oxygen supply to the muscle and surrounding tissue, preventing or rather delaying the onset of hypoxia due to increased exercise intensity. Although the energy released during glycolysis is rapid and does not require oxygen, relatively little ATP is resynthezised in this manner. Consequently, aerobic (absence of hypoxia) reactions provide the important final stage for energy transfer, especially if vigorous exercise proceeds beyond several minutes. An untrained individual who fasted overnight and who has a sample of blood collected in the morning from an arm vein before any exercise, has a lactate level ranging from 0.44 to 1.7 mmol/L. Martin and Coe (1997) also found the equivalent of 0.3 to 0.6 mmol/L to be true for trained individuals, providing that they are not over-

trained. Within an hour after an intensive training session during which blood lactate levels reach the highest achievable values (15mmol/L), muscle lactate levels will return to normal (Noakes, 1992). Most of the lactic acid produced during vigorous exercise is removed by direct oxidation (55-70%) while the balance amount is converted to glycogen (<20%), protein constituents (5-10%) and other compounds (<10%) (Gupta et al., 1996). Lactic acid produced in working muscles is almost completely dissociated into H^+ and lactate within the range of physiological pH, which contributes to the metabolic acidosis (Hirokoba, 1992). Blood doping is one known method to try and lower lactate levels in endurance athletes. It is now clear that blood doping reduces blood lactate levels during exercise and alters the lactate turn point to higher running speeds. These effects are likely to be the more important explanations for the increased running performance after blood doping (Noakes, 1992).

L- Carnitine is a well-known supplement often used to try and lower lactate concentrations, it plays a role in regulating the balance between key chemicals in metabolic processes and is known to act as a buffer for pyruvate, thus reducing muscle lactate accumulation associated with fatigue (Armsey and Green, 1997).

It is clear when looking at the graphic presentation of the results that Switch™ was more effective during cycle 1, (lowest dosage) and Cellfood® was the most effective during cycle 3 (highest dosage) in keeping lactate production as low as possible.

4.10 Gas Analyses

Absolute pre- and post-test values can be observed in Table VI (A and B) and the relative changes are presented graphically in Figure 4.10-4.20

4.10.1 Respiratory Exchange Rate (Figure 4.10) and $VC0_2$ (Figure 4.11) (Table VI A)

Since the respiratory exchange ratio (RER) reflects the rate of carbon dioxide production to oxygen consumption it is an indication of the metabolic exchange of gases in the body tissues. Any change in either the $V0_2$ or $VC0_2$ would have a direct

influence on the RER. Essentially RER is a non-steady-state measurement that can vary from breath to breath as well as from time to time depending on physiological circumstances (Cooper and Storer, 2001).

Resting RER is typically 0.7-0.95, indicating that overall body metabolism utilizes a mixture of carbohydrate and fat. Resting RER is influenced by the nutritional state of the subject. When first measured breathing through a mouthpiece, RER tends to increase due to hyperventilation, which increases $VC0_2$ whilst having relatively little effect on $V0_2$.

With the onset of exercise, RER decreases. This transition phase occurs because of the important differences in the dynamic changes of $V0_2$ and $VC0_2$. Measured at the mouth, V02 increases more rapidly than $VC0_2$. This phenomenon is thought to be due to the greater solubility of $C0_2$, causing some of the $C0_2$ from increased muscle metabolism to load into body stores rather than to appear immediately in the exhaled breath. A reverse phenomenon is observed when exercise ends. In this situation the body continues to eliminate excess carbon dioxide until body stores have normalized. Consequently there is a transient increase in RER after exercise cessation. During incremental exercise, particularly after adjustment of body carbon dioxide stores, RER increases steadily. Above the metabolic threshold, when additional carbon dioxide is derived from bicarbonate buffering of lactic acid, RER increases more rapidly. End exercise RER has been advocated as a measure of maximal effort. Although there is some logic to this approach, it is not to be recommended. End-exercise RER can vary considerably between individuals and hyperventilation for various reasons can elevate RER independently of effort (Cooper and Storer, 2001).

Like oxygen consumption, carbon dioxide production increases during exercise because of increasing metabolic activity in the exercising muscles. The amount of carbon dioxide generated by the process is related to the oxygen consumption by the RER. Additional carbon dioxide is derived from bi-carbonate buffering of lactic acid at high work rates. In contrast to tissue oxygen supply, the actual cardiac output needed for $C0_2$ elimination is not critical. Rather, the quantity of ventilation relative to the $VC0_2$ determines arterial $PC0_2$. The tissue $PC0_2$ is defined by the arterial PC02, blood flow, and metabolic activity (Wasserman et al., 1986).

One must remain cognisant of the distinction between the terms carbon dioxide production and carbon dioxide output. Tissues might produce a certain amount of carbon dioxide but not all of this carbon dioxide is necessarily expelled through the lung or measured as carbon dioxide output. Carbon dioxide output should approximate tissue carbon dioxide production when the body is in steady state (Cooper and Storer, 2001).

Cycle 1 (Low Dosage)

At the end of this cycle Cellfood® showed a decrease of 0.4% in the RER at $V0_2max$, while Switch™ showed a increase of 5.8%. Corresponding with the changes in RER, Cellfood® showed a decrease of 7.4% in $VC0_2$ while Switch™ had an increase of 6.6%. Placebo showed an increase of 6.1% in RER and an increase of 8.1% in $VC0_2$. As explained above this relates to aerobic metabolism contributing to a larger portion of energy expenditure while using Cellfood®. It seems that the Switch™ product increased the contribution of anaerobic metabolism to the energy expenditure when used at this dosage. There were, however, no statistically significant differences ($p>0.05$) in the changes between groups.

Cycle 2 (Intermediate Dosage)

The Switch™ group showed decreases in both RER (2.7%) and $VC0_2$ (4.8%) indicating a bigger contribution by aerobic metabolism. The Cellfood® showed a decrease of 2.2% in the RER, which had to be related to the large increase in $V0_2$, during the cycle since the $VC0_2$ also increased (2.1%) for this group during this cycle. The bigger increase in the $V0_2$ compensated for the increase in carbon dioxide production leading to a decrease in the RER. The placebo showed a decrease of 1.8% in the RER while the $VC0_2$ showed no change from the previous cycle. It seems that both Cellfood® and Switch™ were effective at increasing the aerobic metabolism and its contribution to energy expenditure when used at this dosage. There were, however, no statistically significant differences ($p>0.05$) in the changes between groups.