THE INTEGRATED NEUROMUSCULAR MODEL OF EXERCISE PHYSIOLOGY AND ATHLETIC PERFORMANCE. (CENTRAL GOVERNOR MODEL)*

1. Preamble

Over the past years, exercise scientists have made great strides in understanding exactly how the human body responds and adapts to physical exercise. New science and methods Have enabled them to reveal the shortcomings of many of the accepted theories and dogma of past decades

Professor Tim Noakes OMS, MBChB, MD, DSc, FACSM, Hon FFSEM(UK), Head of the Bioenergetics of Exercise Research Unit of the Medical Research Council and the University of Cape Town has kindly given me permission to quote from his latest book ***"LORE of RUNNING"*** **(fourth edition**).

Don't believe that the book is all about running as it has a tremendous amount of information on every aspect of physical exercise. I shall be quoting a variety of subjects from the book which I found extremely informative about most things that were new to me:

It is my intention in following articles to try to share this information with coaches who have not studied the book and who are interested in hearing more about it, possibly before purchasing it.

2. The Cardiovascular / Anaerobic Model of Exercise Physiology

(What we have believed so far, considerably shortened)

- This model, holds that high-intensity exercise is ultimately limited by the development of anaerobic condition in the active muscles. This absence of oxygen results from the heart's inability to increase its output above some limiting maximum value. As a result, oxygen delivery to the active muscles 'plateaus', forcing the muscles to rely on anaerobic metabolism for their energy supply. The by-products of this anaerobic metabolism eventually accumulate in the muscle, causing exhaustion.
- The model was proposed by H.V.Hill more than 75 years ago. But scientists have been less than enthusiastic to acknowledge that Hill understood the fatal flaw of any model which predicts that the heart must fatigue before the exercising muscles.

Although Hill thought his theory was valid, he also believed that there was some sort of 'governor' involved during stressful exercise but could not clearly identify what was happening in the body. Thus Prof Noakes recognizes his contribution.

3. (The Hill, Noakes) Central Governor Model (Integrated Neuromuscular Recruitment Model Of Exercise Physiology And Athletic Performance) *Considerably shortened*

- This new model of maximum exercise performance holds that the heart is the organ at greatest risk of developing an oxygen deficiency during stressful conditions – especially vigorous exercise at extreme altitude. Thus a mechanism must exist to restrain the over-vigorous use of the exercising muscles that would imperil the heart.

- The model proposes the existence of a 'governor' which monitors the state of oxygenation of the heart and perhaps the (brain, diaphragm) and others as well.

When the oxygenation approaches the limits of what is safe, the brain motor cortex, which recruits the exercising muscles, is informed and it stops recruiting muscles.
As a result:

- Fatigue is experienced (Note: That, like pain, fatigue is always sensed exclusively by the brain, even though it appears to be coming from elsewhere, for example in the muscles (exhaustion and discomfort) or on the skin (pain).
- The work output of the muscles and the heart falls.

This leads to a reduction in the oxygen demand of the heart, thereby protecting the more delicate heart from damage caused by oxygen starvation.

Thus, this model predicts that maximum exercise capacity is a process, co-ordinated subconsciously by the brain, limited by the maximum capacity of the coronary blood flow to supply oxygen to he heart, and regulated to prevent heart damage during maximal exercise.

- (The following is from correspondence with Prof Noaks)
- "The muscle's function is regulated by both the brain and its own function to insure that anaerobiosis does not develop. If you reduce the blood supply to the muscle it reduces its mechanical performance in proportion to the drop in oxygen supply so that the work done is covered by the available oxygen – hence anaerobiosis does not develop. In addition, for the muscle to become anaerobic requires that the heart first become anaerobic. We know that this does not happen so *ipse facto*, the other cannot happen either. **Prevention of the heart becoming anaerobic comes from a reflex arriving from the brain."**

…"The old idea that muscles stop working because of acidosis and so on is not supported by any firm evidence – it is just accepted dogma. We are also finding that the brain reduces its muscle recruitment progressively during exercise as well – reasons unknown – and this also causes the fatigue of prolonged exercise".

- "As another issue- I am beginning to think that fatigue is perceived in the brain and is a 'learned response'- That is we programme ourselves to fatigue at a certain time during exercise. That is another reason why high-speed training is so important – trains the brain as much as anything else.

- Throughout the book, proof of the validity of The Central Governor Model is clearly demonstrated in all physical exercise under many differing circumstances and cannot be faulted. Probably the best single proof is in the physiology of high altitude climbers.

<u>Exercise at Altitude</u>

With an increase in altitude, the barometric pressure decreases and with it the oxygen content of the air. The fall in the oxygen content of the air causes a predictable fall in the VO2 max equivalent to about 10 per cent for every 1000m above 1200m.
But the reason why climbers complain of weakness in their muscles and an inability to climb rapidly at extreme altitude are not, as discussed subsequently, those that might seem the most obvious.

In fact the key to successful climbing at altitude is an ability to sustain higher than expected oxygen tension in the arterial blood supplying both the heart and brain (and has nothing to do with the capacity of the exercising muscles to use oxygen)
Exercise at altitude provides the single best test of the Central Governor Model. Crucial findings are:-

1) Blood lactate concentrations *fall* progressively at peak exercise with increasing altitude.
2) Heart rate and heart output – the amount of blood pumped by the heart, most of which goes to the muscles being exercised – decreases at increasing altitude. Most crucial of all, recruitment of skeletal muscle also falls during exercise at altitude. Hence, neither the heart nor the skeletal muscles become anaerobic at extreme altitude when the oxygen content of inspired air is so low that it is barely able to sustain human life.

But according to the Cardiovascular/Anaerobic Model, the skeletal muscle and the heart must surely become anaerobic under these conditions.

If the muscles were able to work normally, as at sea level, the oxygen content of the blood supplying the (heart and brain) would drop so low that the normal functioning of the heart and brain would be impossible, inducing unconsciousness.

Without the Central Governor, mountaineers would risk death from heart and brain hypoxia whenever they ascended above 5000m.

Indeed, we can safely predict that if the human had been designed by exercise physiologists according to the Cardiovascular/Anaerobic model, no human would have survived a climb above base camp at Mount Everest, much less have reached the summit.

H.G. Lynn. e.mail: gorlynn@vodamail.co.za