

A Review of the Physiological Demands Placed on An Adult Male Body During the Tour De France Road Bicycle Race

Physiologically speaking, not all sports were created equal; whilst some sports such as gymnastics will place a high demand on muscles' ability to be flexible or strong, some sports such as cycling will demand more of the cardiovascular system and endurance (Lucia, 2000). To cope with this, it is imperative that coaches, athletes, and amateur alike possess some understanding as to what is required of them and their bodies during participation in their sports, in order to optimise training and nutrition efficiency, reduce risk of injury, and achieve their athletic goals (Faria, 2005).

Whilst it is important universally across sports to have an understanding of the demands they place on the body, arguably the more competitive and higher-stakes the sport is the more fine-tuned that knowledge is required to be; better understanding and more specified training should produce better results in a competitive setting - where the difference between 1st and 2nd place could be milli-seconds - resulting in more recognition and reward for their prowess.

The Tour de France has long been held in high-esteem as one of the most physically and mentally demanding road-cycling races in the world (Santalla, 2012). Since its inception in 1903 as a publicity stunt that any male member of the public could enter, the race has gradually evolved into the longer and more physiologically demanding endurance test that we see today (Peinado, 2011). In the earlier years since inception athletes would be very much flying solo; they would be in charged with maintaining their own hydration and nutritional needs over the race's 21-stage 3-week race duration, and whilst this has now changed to the point where athletes have a strategical team in place to help them achieve their goals, the competition itself has remained largely the same.

Presently, as defined by Santalla (2012) the Tour de France is an annual road race, competed in by roughly 200 male cyclists covering around 3600km over the course of 3 weeks in July, held usually on-or near-Bastille Day. The Tour consists of 21 'stages' through this time period, with each stage sitting within one of three defined stage types; Flat (FT), Semi-Mountainous (SM), Mountainous (MT) or Time Trial (TT) stages which are completed in as a group peloton (van Erp, 2021), and although equipment has become more advanced and specified to assist in performance during the race, due to how starkly different each stages can be the physiological demands of the race can still vary over the course of the whole Tour de France (Lucia, 2000). Arguably, it is the tempestuousness of the race that makes the Tour so prestigious; an athlete who can conquer each stage and win the Tour has indeed achieved something great.

The principle aim of the Tour de France is to finish the race first, however each stage of the race requires different physiological qualities to the stage before it (Billat, 2013). The Flat and Time Trial stages of the Tour require quick acceleration, speed, aerodynamic awareness, and a lightness of body weight, whilst the Semi-Mountainous and Mountainous stages put more demand on power, strength and lactate endurance that come with more

muscle, and subsequently a higher body weight which may make the faster-paced stages more difficult (van Erp, 2021).

Whilst the Tour is heavily reliant on an athlete's aerobic capabilities, depending on which stage they reach and which muscles are needed at the time, they are also required to switch to anaerobic metabolism in order to make advancement. Generally, across the Tour athletes are more reliant on their slow-twitch muscle fibres to sustain them, however on entering the faster-paced FT and TT stages more fast-twitch muscle fibres are employed to accelerate and gain speed, whilst on the SM and MT stages fast-twitch fibres are used to again exert power and enable the athlete to advance along the stage (Santalla, 2012. Bishop, 2014).

Due to the fluctuation in utilisation of fast-twitch glycolytic, fast-twitch oxidative glycolytic, and slow-twitch oxidative fibres, there is a consequential fluctuation in energy metabolism. Additionally to this, there is no black-and-white switch between energy metabolism, instead the nature of the Tour demands a continuum shade of grey in how the body metabolises energy to achieve the desired end goal (Smith et al, 2022). In cases of an immediate increase in energy requirement such as acceleration or exertion of power, Adenosine Triphosphate (ATP) needs increase with urgency, and so with it does the need for replenishment of phosphocreatine (PC) (Bishop, 2014). Within muscle fibres – proportionally more is stored in fast-twitch glycolytic fibres versus slow-twitch oxidative fibres - the body stores enough ATP to exert maximal effort for around 2-3 seconds, during which time one of the three phosphate molecules is cleaved off the end of the ATP molecules, the reaction of which generates energy, heat, water, and Adenosine Diphosphate (ADP) (Bishop, 2014. Smith 2022). Following this the body calls on its muscle PC stores to replenish the ADP back to ATP (Smith et al, 2022). Whilst this is a quick anaerobic process, the body has limited stores of PC too; nearly four times the amount of stored ATP, but it does have a limit so this process is not something that the body can rely on for long (Sturgeon, 2018).

After the body has anaerobically used its supply of immediately available ATP, it then turns to the breakdown of muscle glycogen using the Lactic Aerobic system, which releases energy much like the ATP-PC system, however during this process there is also the release of pyruvate (Smith, 2022). This pyruvate becomes pyruvic acid and then reduces into lactic acid that can cause cramp if not managed, due to lactates ability to speed up the depletion of ATP stores and thereby depleting stores further, which poses a huge risk to endurance sport (Bishop, 2014). To combat this, knowledge of Lactate Shuttling and Buffering is important in determining how best to train on the run-up to and endure the event (Brooks, 2021).

Lactate shuttling was originally thought to be an influential strategy for endurance exercise, using cardiac output to dissipate lactate build-up, this was even the absolute conclusion for more than 20 years, however research since has shown that lactic acid may not just be a hindrance that needs to be dissipated, it can also be a helpful tool in energy regulation, wound healing, muscle recovery, and neural function (Sun, 2017. Brooks, 2021), which are all arguably positive attributes needed during endurance cycling. Therefore, in either case, nutritional strategies involving the replenishment of muscle glycogen, knowledge of Lactate shuttle and buffering and how an individual athlete interacts with theirs, and other methods of energy metabolism such as beta-oxidation remain important to sustain the athlete and enable them to complete the Tour.

Beta-Oxidation is an energy metabolism process slower than the ATP-PC system due to the longer process of metabolising fat for ATP that then enters the Krebs Cycle to further release ATP, but due to the body storing more fat versus muscle glycogen it is certainly an energy source worth harnessing in an endurance sport where longevity is key (Bishop, 2014). This catabolism of fatty-acids that occurs in the mitochondria of the cell results in Acetyl-Co-enzyme-A (acyl-CoA) which then enters the Krebs Cycle to facilitate oxidative phosphorylation and electron transport to release more ATP, and whilst this is certainly a longer process than the ATP-PC system it is a system of energy metabolism with considerably more longevity than the ATP-PC system (Santalla, 2012).

Due to the very nature of the Tour and its changing demands on muscle endurance, and therefore changing demands on energy supply, there is also a heavy demand placed on the oxygen and cardiac efficiencies of the athletes (Brooks, 2021). The movement of molecules around the body places high demand on the efficiency of the cardiac muscle to pump the blood (and nutrients) where they need to be, and it is the body's aerobic capacity that further facilitates this. A study by Santalla (2012) which measured the VO_2 max of Tour de France athletes reported an average VO_2 max of $86 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ amongst winners, and so it is certainly imperative that training strategies prioritise highly the pulmonary and cardiac outputs of the athletes, without which energy metabolism and muscle function training would be based – and benefit greatly – from.

References

- Billat, V., Petot, H., Karp, J. R., Sarre, G., Morton, R. H., & Mille-Hamard, L. (2013). 'The sustainability of VO 2max: effect of decreasing the workload.' *European journal of applied physiology*, 113(2), 385-394
- Bishop, D. J., Granata, C., & Eynon, N. (2014). 'Can we optimise the exercise training prescription to maximise improvements in mitochondria function and content?' *Biochimica et Biophysica Acta (BBA)-General Subjects*, 1840(4), 1266-1275.
- Brooks, GA (2021) 'Role of the Heart in Lactate Shuttling' *Front. Nutr.* 8:663560. doi: 10.3389/fnut.2021.663560
- Faria, E. W., Parker, D. L., & Faria, I. E. (2005). 'The science of cycling: physiology and training - part 1'. *Sports medicine* (Auckland, N.Z.), 35(4), 285–312.
<https://doi.org/10.2165/00007256-200535040-00002>
- Lucia, A., Joyos, H., & Chicharro, J. L. (2000). 'Physiological response to professional road cycling: climbers vs. time trialists.' *International journal of sports medicine*, 21(07), 505-512
- Peinado, A. B., Benito, P. J., Díaz, V., González, C., Zapico, A. G., Álvarez, M., & Calderón, F. J. (2011). 'Discriminant analysis of the speciality of elite cyclists.' *Journal of Human Sport and Exercise*, 6(3), 480-489.
- Santalla, A. et al. (2012) 'The Tour de France: an updated physiological review', *International journal of sports physiology and performance*, 7(3), pp. 200–209. Available at: <https://doi.org/10.1123/ijsp.7.3.200>.
- Smith, D. Plowman, S. Ormsbee, M (2022) *Exercise physiology for health, fitness, and performance*, Mexico: Wolters Kluwer
- Sturgeon, D. (2018) *Introduction to anatomy and physiology for healthcare students*. London, [England] ;: Routledge.
- Sun, S., Li, H., Chen, J., & Qian, Q. (2017). 'Lactic Acid: No Longer an Inert and End-Product of Glycolysis.' *Physiology* (Bethesda, Md.), 32(6), 453–463.
<https://doi.org/10.1152/physiol.00016.2017>
- van Erp, T., Kittel, M. and Lamberts, R.P. (2021) 'Demands of the Tour de France: A Case Study of a World-Class Sprinter (Part I)', *International journal of sports physiology and performance*, 16(9), pp. 1363–1370. Available at: <https://doi.org/10.1123/ijsp.2020-0700>.