Analyzing Lactic Acid Communication to Develop Training Zones for Preventing Lactic Acidosis

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Research Question

Research Question: How can the analysis of lactic acid accumulation in swimmers be used to creating training zones to prevent lactic acidosis and improve sprint performance?

Abstract

Lactic acid buildup during sprint swimming impairs performance and leads to severe health risks. When swimmers exceed their lactic acid thresholds, they may experience blackouts which can lead to brain damage which is known as lactic acidosis. To address this issue, there have been novel approaches. One such approach involves developing training zones based on lactic acid levels. By identifying how long swimmers can safely remain in each zone before recovery, athletes can optimize their performance while minimizing health risks. This study aims to investigate the relationship between lactic acid accumulation and sprint outcomes through primary data collection and analysis. By measuring both lactic acid levels and performance times, our research seeks to determine if training zones improve sprint performance.

Background

Our research methods include a quantitative analysis that looks at how lactic acid levels relate to sprint performance and recovery in swimmers. By collecting baseline performance data and lactic acid values during sprint swims, we aim to identify optimal lactic acid thresholds for swimmers to effectively train. In our meta-analysis we found that when anaerobic metabolism takes place, hydrogen ion buildup contributes to muscle fatigue and can escalate into lactic acidosis, a condition linked to both physical and neurological harm (Kalimo et al., 1981; Chen et al., 2019). By creating individualized training zones based on these thresholds, our group of swimmers can better regulate their intensity, reduce health risks, and improve competitive outcomes. This study builds upon prior findings while addressing gaps of previously untested ideas to see whether specialized training zones are effective or not.

Method/Process

The meta-analysis study utilized peer-reviewed journal articles and case studies from universities and several educational institutions that documented their composting programs and practices. These sources were selected based on their credibility and relevance to the research topic. We explored existing peer-reviewed studies covering topics such as anaerobic metabolism, lactic acid thresholds, fatigue, recovery, and even the neurological consequences of sustained lactic acidosis. This phase was essential — it helped us identify key gaps in the current research, especially when it came to swimmer-specific training strategies.

In addition to the literature review and data analysis, we had the opportunity to interview Coach Melodii Peoples, a Level 3 certified coach, who graciously allowed us to test lactic acid levels on her swim team. Our first round of preliminary data collection took place at Lifetime Swim Club, where we observed swimmers completing repeated sprint sets. We recorded their times across 50-yard and 100-yard freestyle efforts, with particular attention to fatigue curves across rounds.

We later expanded our testing in partnership with Coach Lyana Goshko, a Level 3 certified swim coach. With her support, we tested lactic acid levels on her athletes immediately following sprint sets. We tracked both sprint times and corresponding lactate readings using fingertip blood tests, recorded within 60 seconds post-effort for accuracy.

After we finished our early research and testing, we wanted to find a way to help swimmers train hard without building up too much lactic acid. So, we created a simple system to guide workouts: a model with four training zones based on how much lactic acid is in the body. For different zones, we also assigned recommended durations for training for different swimmers. Lastly, we collected data of lactic levels and made sure to rotate swimmers through different zones to confirm their training zones**.**

Materials

- ·For the meta-analysis, peer-reviewed journal articles and case studies from academic databases were utilized as primary sources.
- ·The interviews were conducted on zoom and discussion occurred in-person at lifetime swim team center.
- We created charts, graphs, and tables using Excel.
- To collect Lactic Acid levels, we used a lactic acid analyzer.
- To collect sprint timings of each swimmer, we used a stop-watch.
- Swimmers used were from Highschool Lifetime Swim Team

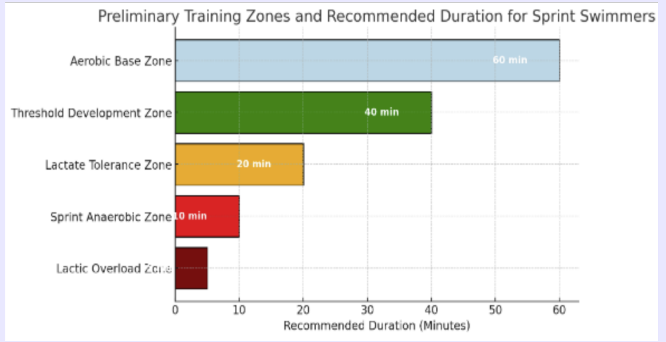
Criteria for Success/Hypothesis

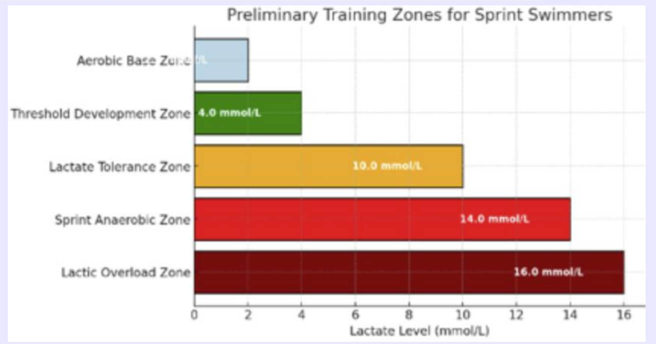
- **Hypothesis**: If swimmers train within specific lactic acid zones, their performance will improve while reducing the risk of lactic acidosis.
- The independent variable consists of the training zones themselves. The dependent variable will be defined by the **criteria for success**, such as improved sprint timings, fewer number of blackouts or other physiological responses, and fewer number of longer breaks, injuries, or cramps.

Findings

- By synthesizing findings from the literature, we gained clarity on how lactic acid affects sprint swimmers both physically and neurologically. This background knowledge helped us refine our research question and shape the direction of our practical work. With a stronger understanding of the science, we then moved into preliminary testing with Lifetime Swim Club, where we began comparing sprint times with real-world training data.
- The interview collaboration with coach Melodii provided valuable insight into how lactic acid buildup specifically affects swimmers during high-intensity sprints. Through the testing, we gained a deeper understanding of lactic acidosis and its impact on swimmer performance, recovery, and overall health.
- As seen in prelim. data testing*, swimmers experienced an average drop of 1.5–2.0 seconds between their first and third sprints — despite maintaining consistent effort. Lactate readings ranged from 10.8 to 12.6 mmol/L, placing them well above the commonly accepted anaerobic threshold of ~4.0 mmol/L. These elevated levels are characteristic of lactic acidosis, which directly impacts muscle contraction, neuromuscular response, and sprint sustainability. This early-stage testing confirmed what we found in our literature review: that repeated anaerobic effort leads to rapid lactate accumulation and corresponding performance decline.
- The second round of data helped confirm that our zones were not only based in science, but they worked in practice. Swimmers trained harder, recovered faster, and stayed healthier

Graphs





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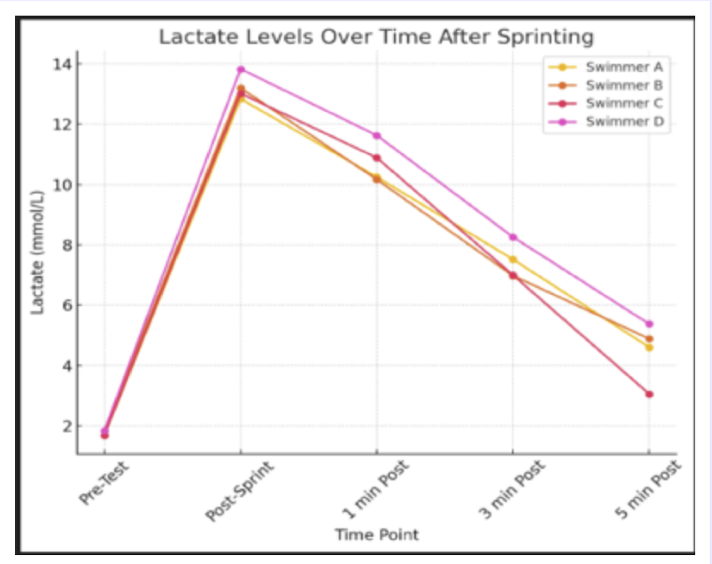

To identify when swimmers began entering unsustainable lactic acid zones — areas where performance starts to decline and health risks increase. We tracked both sprint times and corresponding lactate readings using fingertip blood tests, recorded within 60 seconds post-effort for accuracy.
Here is a sample of the data collected during one of our 50-yard sprint test sets:

Swimmer ID	Sprint #1 Time (50y)	Sprint #2 Time (50y)	Sprint #3 Time (50y)	Average Time (50y)	Post-Set Lactate (mmol/L)
A01	24.32	25.1	26.04	25.15	11.3
B02	23.85	24.67	25.9	24.81	10.8
C03	25.41	26.33	27.85	26.53	12.6
D04	24.77	25.6	26.48	25.62	11.9

The swimmers training in the Threshold Development Zone and Lactate Tolerance Zone showed better control over fatigue and didn't slow down as much over repeated sprints. Their lactate levels also stayed under the dangerous 14–16 mmol/L range, confirming that the training zones were helping avoid lactic overload. As observed as well, there were no blackouts and injuries. There were also fewer number of longer breaks as reported by the coach.

Swimmer ID	Training Zone	50y Sprint Time (Avg)	Post-Training Lactate (mmol/L)	Notes
A01	Threshold Development Zone	24.98 sec	6.5	Maintained speed; recovered well
B02	Lactate Tolerance Zone	24.12 sec	9.2	Mild fatigue, good form
C03	Sprint Anaerobic Zone	25.20 sec	13.8	Noticeable fatigue, slower 3rd sprint
D04	Threshold Development Zone	24.87 sec	5.9	Smooth, consistent pacing

Next Steps

- Creating a digital tool or app, where swimmers and coaches can track their times, lactate levels, and get feedback on which zone they're training in.
- We'd also love to look deeper into recovery strategies, and how they affect lactic acid removal and performance over time.

Conclusion

Swimmers can now use our zones to figure out where they need to be during practice — not just going fast but going fast *smart*. Instead of crashing in the middle of a set, they'll know how to stay efficient, recover faster, and avoid that nasty muscle fatigue that lingers for days.

For coaches, this project is like a new tool in the toolbox. They can plan sets based on science, not just instinct — tailoring workouts to fit each swimmer's needs. It's less about guessing, more about growing.

And finally, for teams and clubs, this means stronger athletes, better meet results, and fewer injuries. It could also be a step toward changing how we think about training in sports — making it more personal, more data-driven, and a whole lot more effective.

Citations & Acknowledgements

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