

# Physiological and Anthropometric Changes in a Recreational Cyclist Preparing for the Tour de France Route: A Case Study

Case Study

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## Abstract

**Introduction:** To examine longitudinal changes in aerobic fitness, anaerobic performance, neuromuscular function, flexibility, and body composition in a recreational cyclist preparing to complete the 2025 Tour de France course.

**Methods:** A male recreational cyclist (48 years of age) underwent physiological and musculoskeletal assessments in November 2024, January 2025, and June 2025 during an eight-month training period leading up to the completion of the 2025 Tour de France racecourse starting on June 28<sup>th</sup>, 2025. One month following the race, aerobic power was also reassessed. Measurements included maximal oxygen uptake ( $VO_{2max}$ ), anaerobic power, grip strength, vertical jump height, flexibility, body mass, and limb muscle thickness. Percent changes were calculated.

**Results:**  $VO_{2max}$  increased from 43.9 to 54.5  $mL \cdot kg^{-1} \cdot min^{-1}$ . From January to June, anaerobic peak power increased by 4.2% (839 to 874 Watts), while grip strength (95 to 115 kg; 21.1%) and vertical jump height (15.5 to 17 inches; 9.7%) revealed substantial neuromuscular adaptation. Body mass decreased slightly (-0.8%), while modest increases in muscle thickness were observed (0.2–3.1%). Flexibility remained largely unchanged.

**Conclusions:** This case study demonstrates marked aerobic and neuromuscular adaptations in a recreational cyclist preparing for an extreme endurance challenge. Training to complete a professional-level race route elicited significant improvements in physiological capacity, highlighting the adaptability of non-elite athletes to high-volume endurance training. The recreational cyclist successfully completed all 21 stages of the Tour de France racecourse, cycling 3409 km with an elevation gain of over 50,585 meters, and burned an estimated 86,478 kcals.

**Key Words:** Cycling, Endurance, Mitochondria

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## Introduction

Endurance cycling performance is determined by the interaction of cardiovascular fitness, muscular power, neuromuscular efficiency, and body composition<sup>1,2</sup>.

Among these factors, maximal oxygen uptake ( $VO_{2max}$ ), anaerobic threshold, and maximal power output are considered primary predictors of competitive cycling success<sup>3,4</sup>.

Professional cyclists competing in events such as the Tour de France display exceptionally high aerobic capacities and power-to-weight ratios, developed through years of high-volume and high-intensity training<sup>5,6</sup>. In contrast, recreational cyclists typically demonstrate lower baseline fitness but may experience large training-induced adaptations<sup>7</sup>. In 2025, the participant in this study undertook training with the goal of completing the same route as that used in the Tour de France race. Such an endeavor requires exceptional aerobic endurance, sustained power output, and fatigue resistance.



However, limited research has examined how recreational athletes adapt physiologically when preparing for professional-level race routes<sup>8,9</sup>.

Case studies provide valuable insight into individual responses to intensive training and complement larger cohort studies<sup>10,11</sup>. Therefore, the purpose of this investigation was to document longitudinal changes in aerobic power, neuromuscular performance, flexibility, and muscle morphology in a recreational cyclist preparing for a Tour de France course.

## Methods

### *Participants*

One male recreational cyclist (age: 48 years; height: 1.88 m) participated in this longitudinal case study. The participant had several years of recreational cycling experience but no professional or even competitive background. During the study period, he trained with the specific objective of completing the 2025 Tour de France route. All procedures conformed to institutional ethical standards and the Declaration of Helsinki. Written informed consent was obtained prior to participation. A Get Active Questionnaire (GAQ) was completed before testing to screen for medical conditions and ensure that the participant was apparently healthy and safe to engage in strenuous exercise.

### *Protocol*

Assessments were conducted four times:

- November 2024 (baseline, aerobic power)
- January 2025 (mid-training, complete physical assessment)
- June 2025 (late-training, complete physical assessment)
- August 2025 (post-race, aerobic power)

The training program emphasized high-volume endurance riding, interval training, and supplementary resistance exercise. A typical training week included: a rest day, two high intensity interval training days (typically 30 mins or low-cadence strength), two light/short rides (30-60 min zone 2 or zone 3 ride), a long/medium ride (typically 4+ hours at zone 2 [Z2] with spurts at higher intensity mid ride), and a long recovery ride (typically 2-4 hours at zone 1 [Z1] or Z2). He transitioned from indoor stationary cycling to outdoor cycling in April/May as the weather permitted. By May/June his weekend rides were 4-6+ hours per day.

No structured dietary guidance was provided; however, he noted that he prioritized carbohydrates and protein, especially protein recovery shakes after hard training days and used long rides to practice fueling strategies with a combination of real food (e.g., sandwiches and bananas) and commercially available products such as carbohydrate gels and sports drinks. The participant also noted that he ingested creatine (5 grams/day)<sup>12</sup> and used beta-alanine (a precursor for carnosine)<sup>13</sup>.

### *Aerobic Power and Wingate*

$\dot{V}O_{2max}$  was measured using a graded exercise test (GXT) performed on a cycle ergometer with continuous breath-by-breath gas analysis (iworx). The metabolic device was calibrated using a 3-liter syringe and a two-point gas calibration (atmosphere and calibration gas). Oxygen uptake was averaged over 20 seconds and expressed relative to body mass ( $\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ )<sup>4,14</sup>. Final power output was defined as the highest workload achieved during the GXT. The GXT began at 1.5 kiloponds at 85 to 90 RPM and increased by 0.5 kiloponds every two minutes until volitional exhaustion. Heart rate was monitored during the test with a polar H10 heart rate monitor. Anaerobic peak power and fatigue index were assessed using a standardized 30 second Wingate anaerobic test protocol<sup>15,16</sup> that used a resistance setting of 7.5% body mass. Peak power (5 second average) and average power (30 second average) were reported in absolute (W) and relative ( $\text{W}\cdot\text{kg}^{-1}$ ) terms. Fatigue index was determined based on peak power minus minimum power divided by peak power multiplied by 100.

### *Grip Strength and Neuromuscular Performance*

Grip strength was assessed using a calibrated handgrip dynamometer. The participant held the grip dynamometer to the side and was given two tries on each hand. The best score of each hand was recorded and summed to determine their grip strength score. Lower-body power was evaluated using countermovement vertical jump testing according to established procedures<sup>17</sup>. Briefly, the participant was given three tries to jump as high as possible using a Vertec device and measured to the nearest 0.5 inch.

### Flexibility

Hamstring and lower-back flexibility were measured using the sit-and-reach test <sup>14</sup>. Briefly, the participant performed a modified hurdler stretch on each side for 20 seconds followed by two attempts on the sit and reach device. The results were recorded to the nearest 0.5 cm.

### Body Mass and Muscle Thickness

Body mass was measured using a physician's scale (Health-o-meter) and measured to the nearest 0.1 kg. Muscle thickness of the elbow flexors and knee extensors was measured using B-mode ultrasound (LOGIQ e BTO8, GE Healthcare, Milwaukee, Wisconsin, USA). Detailed methodological procedures are described elsewhere <sup>18</sup>. Briefly, elbow flexor muscle thickness was taken on the midline of the biceps brachii muscle belly between the medial acromion and the fossa cubiti, approximately 1/3<sup>rd</sup> of the distance away from the cubital fossa. The participants positioned their arm in a relaxed extended position flat on a table. Knee extensor muscle thickness was taken at the midline between the middle of the patella and the anterior superior iliac spine. Measurement was made 1/3<sup>rd</sup> of the distance from the patella to the anterior hip crease. The participant was seated on a table with their knee flexed at 90°. Once these points were established, a detailed individualized land marking procedure (using overhead transparencies) was employed to ensure precise placement of the ultrasound probe pre- and post-training. Four measurements were taken and the averages of the two closest measurements were used to calculate the muscle thickness value. Muscle thickness was determined by the same researcher at each time point. The coefficient of variations from previous research were 2.1% for the elbow flexors and 0.9% for the knee extensors.

### Race Performance Data

Race performance data, including power output, speed, distance, elevation gain, and time, were obtained from the participant's Strava activity records. Data were recorded using a GPS-enabled cycling computer (Garmin Edge 1050), power meter (Garmin Rally RS200), and heart rate monitor (Polar H10) synchronized with the Strava platform. Stage-level and cumulative values were extracted and used to quantify external workload and overall race performance.

### Statistical Analysis

All data are presented descriptively. Percent changes were calculated to evaluate late-phase training adaptations. Due to the single-subject design, no inferential statistics were performed.

## Results

Physiological and anthropometric data are shown in Table 1.

**Table 1.** Physiological and anthropometric changes over time.

	November 2024	January 2025	June 2025	% change from January	% change from November
VO <sub>2</sub> max (mL·kg <sup>-1</sup> ·min <sup>-1</sup> )	43.9	49.4	54.5	10.3	24.1
GXT Peak Power Output (Watts)	320	320	376	17.5	17.5
Anaerobic Peak Power (Watts)		839	874	4.2	
Anaerobic Peak Power (Watts/kg)		9.53	10.04	5.4	
Fatigue Index (%)		37.9	38.1	0.5	
Grip Strength (kg)		95	115	21.1	
Vertical Jump (inch)		15.5	17	9.7	
Sit and Reach (cm)		-5	-5.5	10.0	
Body Mass (kg)	88.9	88.2	87.5	-0.8	-1.6
Right Leg Muscle Thickness (cm)		6.03	6.04	0.2	
Left Leg Muscle Thickness (cm)		6.39	6.45	0.9	
Right Arm Muscle Thickness (cm)		3.87	3.96	2.3	
Left Arm Muscle Thickness (cm)		3.93	4.05	3.1	

GXT = graded exercise test

### Aerobic Capacity and Cycling Performance

VO<sub>2</sub>max increased from 43.9 mL·kg<sup>-1</sup>·min<sup>-1</sup> in November to 49.4 mL·kg<sup>-1</sup>·min<sup>-1</sup> in January and 54.5 mL·kg<sup>-1</sup>·min<sup>-1</sup> in June, representing a 24.1% increase over the study period. Final power output increased from 320 W in January to 376 W in June (+17.5%). Anaerobic peak power improved from 839 W to 874 W (+4.2%), while relative peak power increased by 5.4%. Fatigue index remained stable (37.9% to 38.1%).

### Neuromuscular Performance

Grip strength increased by 21.1%, and vertical jump height improved by 9.7%, indicating enhanced neuromuscular function and lower-body muscular power.

### Flexibility

Sit-and-reach scores showed minimal change, suggesting limited adaptation in flexibility.

### Body Mass and Muscle Thickness

Body mass declined slightly from 88.9 kg to 87.5 kg. Muscle thickness increased modestly in both upper and lower limbs (0.2–3.1%).

### Race Data

The participant completed the Tour de France course (3409.28 km with 50585 m in elevation gain) in 151 hours, 28 minutes, and 21 seconds. The participant averaged 22.8 km/h and 126.3 W. The participant finished the race on July 20<sup>th</sup>. Table 2 shows all the performance data collected during each stage.

**Table 2.** Performance data during the 21 stages of the Tour de France racecourse.

Stage	Distance (km)	Total Work (KJ)	Elevation Gain (m)	Time (hh:mm:ss)	Calories (kcal)	Average Power (Watts)	Max Power (Watts)	Average HR (bpm)	Average Speed (km/h)	Max Speed (km/h)
1	194.44	3014	1194	7:08:55	3711	117	716	133	27.2	61.7
2	222.02	3883	2426	8:17:55	4682	130	825	131	26.8	69.3
3	177.78	2341	790	6:06:23	2941	107	689	122	29.1	68.1
4	176.91	3081	1950	7:04:38	3767	121	805	133	25	63.1
5	36.9	544	164	1:32:09	691	98	600	103	24	43.2
6	205.52	4507	3384	8:27:37	5324	148	687	132	24.3	69.8
7	191.82	3592	2385	7:37:43	4430	131	767	121	25.1	64
8	173.86	2392	1547	6:09:31	3008	108	705	114	28.2	61.6
9	178.23	2964	890	6:29:37	3582	127	723	117	27.4	53.9
10	167.28	4746	4301	9:04:39	5599	145	743	135	18.4	60.4
11	167.33	1721	1720	6:43:39	3205	71	774	120	24.9	70.2
12	189.16	4836	3868	9:02:59	5693	148	672	133	20.9	77.2
13	23.09	779	735	1:32:10	924	141	668	123	15	66.5
14	189.48	5734	4925	10:32:28	6723	151	756	130	18	67.6
15	173.64	3327	2403	7:19:16	4020	126	708	117	23.7	66.5
16	186.24	4175	3022	8:08:50	4963	142	674	127	22.9	61.1
17	166.08	2921	1691	7:24:24	3635	110	814	109	22.4	55.2
18	185.55	6282	5585	11:32:46	7376	151	702	131	16.1	66.5
19	137.4	5090	4573	9:36:27	5987	147	616	122	14.3	66.6
20	182.95	3737	2296	7:51:56	4493	132	612	115	23.3	66.5
21	83.6	66	736	3:44:19	1724	101	672	97	22.4	29.2
<b>Average</b>	<b>162.3</b>	<b>3320.6</b>	<b>2408.8</b>	<b>7:12:00</b>	<b>4118.0</b>	<b>126.3</b>	<b>710.9</b>	<b>122.1</b>	<b>22.8</b>	<b>62.3</b>
<b>St.Dev.</b>	<b>51.6</b>	<b>1648.3</b>	<b>1535.2</b>		<b>1735.5</b>	<b>21.3</b>	<b>63.8</b>	<b>10.5</b>	<b>4.3</b>	<b>10.3</b>
<b>Total</b>	<b>3409.28</b>	<b>69732</b>	<b>50585</b>	<b>151:28:21</b>	<b>86478</b>					

Table 3 shows the percentage of time the participant spent in the five heart rate zones. The majority of time was spent in zone 2 followed by zone 1. We assessed their  $VO_{2max}$  on August 14, 2025, following a period of very low volume training. Their  $VO_{2max}$  was maintained at  $54.3 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$  and he achieved a max power output of 360 W during the GXT. Their body mass began to increase slightly up to 88.1 kg.

### Discussion

This case study demonstrates substantial aerobic and performance adaptations in a recreational cyclist preparing to complete a Tour de France race route. The observed increase in  $VO_{2max}$  (+24.1%) is comparable to improvements reported in longitudinal endurance training studies<sup>5,7</sup> and reflects enhanced cardiac output (stroke volume), mitochondrial density, and peripheral oxygen utilization<sup>4</sup>. The improvement in final power output (+17.5%) achieved during the GXT indicates improved aerobic power and the lower hearts achieved at the submaximal workloads demonstrated improved cycling economy, both of which are critical for prolonged mountain stages characteristic of

Tour de France routes <sup>3,6</sup>. In contrast, anaerobic peak power showed smaller gains, consistent with the participant's emphasis on endurance rather than sprint training. Significant increases in grip strength and vertical jump performance suggest meaningful neuromuscular adaptation.

**Table 3.** Percentage of time spent in each zone during each stage of the race.

Stage	% Zone 1 (0-109 bpm)	% Zone 2 (110-144 bpm)	% Zone 3 (145-162 bpm)	% Zone 4 (163-179 bpm)	% Zone 5 (>180 bpm)
1	3	79	11	7	0
2	12	63	18	6	1
3	15	79	5	1	0
4	8	67	19	6	0
5	67	33	0	0	0
6	9	64	25	2	0
7	20	76	3	1	0
8	34	66	0	0	0
9	23	76	1	0	0
10	9	60	30	1	0
11	27	65	7	1	0
12	14	51	33	2	0
13	25	65	10	0	0
14	16	68	16	0	0
15	31	67	2	0	0
16	22	53	24	1	0
17	51	49	0	0	0
18	16	60	24	0	0
19	17	83	0	0	0
20	29	71	0	0	0
21	54	46	0	0	0
<b>Average</b>	23.9	63.9	10.9	1.3	0.0
<b>St.Dev.</b>	16.3	12.3	11.3	2.2	0.2

Upper-body strength is important for prolonged climbing and bike handling, while lower-body power contributes to accelerations and fatigue resistance <sup>19</sup>. The participant performed consistent strength training with a personal trainer and the improvements in grip strength are likely due to the specific nature of those training sessions or possibly due to gripping the handlebars. Despite large performance gains, body mass remained relatively stable. The modest increases in muscle thickness suggest limited hypertrophy, which is consistent with endurance-dominant training and favorable for maintaining power-to-weight ratio <sup>2</sup>.

Flexibility did not improve, highlighting a common limitation in endurance-focused training programs and suggesting the need for targeted mobility interventions. The participant's flexibility was a concern; however, this did not appear to hinder his biking performance. Overall, the results indicate that preparing for a professional-level race route can induce substantial physiological adaptations in recreational athletes when training is systematic and progressive.

Lastly, the recreational participant was able to successfully complete the Tour de France. Over twenty-one stages he cycled over 3400 km with over 50,000 meters in elevation and burned an estimated 86,478 kcals. This energy expenditure was similar to another recreational athlete who completed the tour <sup>8,9</sup>. The adaptability of the physiological system and the ability to endure extreme physical feats by a recreational middle-aged cyclist was truly remarkable in this case study. This investigation is limited by its single-subject design and lack of detailed training load, dietary intake, and recovery monitoring. Additionally, body composition was inferred from body mass and ultrasound rather than direct imaging techniques such as DXA.

### Conclusions

This longitudinal case study demonstrates that a recreational cyclist preparing to complete the 2025 Tour de France route exhibited substantial improvements in aerobic fitness, cycling performance, and neuromuscular function over eight months of training. These adaptations occurred alongside stable body mass and modest muscular hypertrophy, highlighting the high trainability of motivated non-elite athletes undertaking elite-level endurance challenges. A recreational cyclist training for extreme endurance events, such as Tour de France routes, can achieve large

improvements in aerobic power and peak power outputs. Training programs should emphasize progressive endurance volume, structured intensity, resistance training, and flexibility work to optimize adaptation and reduce injury risk.

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### Conflict of Interest

The author declares no conflicts of interest.

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