Tracking Competitive Season Training Load via TRIMP in a Collegiate Distance Runner: A Case Study

by
Morgan Jane Anderson

A THESIS

submitted to

Oregon State University

University Honors College

in partial fulfillment of
the requirements for the
degree of

Honors Baccalaureate of Science in Kinesiology
(Honors Associate)

Presented May 23, 2016
Commencement June 2016

AN ABSTRACT OF THE THESIS OF

Morgan Jane Anderson for the degree of Honors Baccalaureate of Science in Kinesiology presented on May 23, 2016. Title: Tracking Competitive Season Training Load via TRIMP in a Collegiate Distance Runner: A Case Study .

Abstract approved:

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Jason Penry

Objectively quantifying workload is challenging due to a variety of factors. One way to measure workload is by training impulse (TRIMP). TRIMP uses time in physiologically significant heart rate zones to quantify a workload for a given bout of physical activity. Tracking average workload over time can then be used to assess individual fitness and fatigue levels. This method has been used in elite male cyclists and recreational male distance runners, but not female endurance athletes. This study assesses the acute and chronic exercise training load placed upon a female collegiate distance runner by quantifying time spent in physiologically significant heart rate zones. One individual was observed over a six-month period during the fall collegiate cross country training and competitive season. Heart rate was recorded with a wearable monitor, and TRIMP scores were calculated via the SportTracks 3.1 computer software. Heart rate zones were determined by a 3-minute, 30-second endurance capacity test. Chronic training load (CTL) increased as mileage and overall workout intensities increased. Acute training load (ATL) generally decreased preceding competitions. Race performance did not consistently reflect training stress balance (TSB) scores. Although the TSB scores prior to important races were positive, a successful race outcome did not always occur. However, the participant's most successful race did follow the most positive TSB score.

Key Words: TRIMP, training load, performance, tapering, endurance

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

Morgan Jane Anderson, Author

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Introduction

Training elite athletes is dependent on multiple factors to achieve optimal performance. Combining physical, psychological, and social elements in conjunction with peak timing has previously been an art that takes skill and expertise. The relationship between these factors and their combined effect on physical and psychological workload has no standard of measure. Traditional training plans for endurance athletes utilize base-mileage training followed by "tapering" before competitions to attempt to provide the ideal physical fitness for race success. There is an absence of a standard method to quantify workload and objectively measure an individual's fitness level over time.

One measure of workload is via heart rate. Heart rate is linearly related to workload above 40% of an individual's VO_{2max}. Training impulse (TRIMP) is the measure of workload by using time spent in physiologically significant heart rate zones (1). These zones are reflective of low, moderate, and high intensity physical activity and have corresponding numeric values (1, 2, and 3) to quantify workload for a given bout of physical activity (1). Research proposes that training bouts offer an immediate effect on fitness gains but slowly fade until the next training session (1). This effect is represented in the equation $dT/dt=k_1$ (W-T) (1). In this equation, the increase in fitness is the product of the constant k and the difference in the stimulation effect of TRIMP (represented as W) and the base effect (T) (1). Both W and T are in TRIMP units (1). The effect of fatigue can also be expressed in the equation $dF/dt=k_2$ (W-F) (1). In this equation, F is the fatigue effect also expressed in TRIMP units (1).

The exponential decay of fitness training effect is expressed as $1/k_1$ and the exponential decay of fatigue effect is expressed as $1/k_2$ (1).

This direct quantitative method has proven accurate in measuring individual responses to training load in elite male cyclists, male recreational runners, and male and female swimmers (4,6,8). Foster et al. evaluated exercise responses in elite cyclists utilizing the TRIMP method during several 3-week cycle tour races (4). Heart rate data and TRIMP scoring were only recorded for each race, but not for training sessions (4). The energy expenditure recorded via TRIMP were similar in magnitude to other studies on professional cyclists and comparable to data collected in elite runners, sub-elite runners, and elite junior skiers (2,5,7,12). Manzi et al. compared the TRIMP method to methods that use average-based group values in male recreational distance runners (8). TRIMP values were recorded for 8 weeks of typical marathon training for recreational runners and 2 performance assessments of 5,000- and 10,000-meter track tests were completed (8). Findings indicated that the TRIMP method adequately reflected adaptations to the training load and provided feedback on the progression of fitness and prediction of performance (8). The results of the study suggested that TRIMP could be used to individually tailor training plans and predict race performance in long distance runners (8). Hellard et al. aimed to evaluate this method in both male and female elite swimmers during a 52 week training period (6). Swimmers varied in different training groups depending on their distance specialty (6). TRIMP was recorded during training and competition performance results were noted (6). The study found an average number of days between the end of a training period and a following peak performance, but that the time to recovery

of performance and the time to peak performance after training was widely variable across participants (6). The researchers concluded the stability of Bannister's TRIMP model across all participants (6). However, thus far, the effectiveness and utility of the TRIMP method has not been assessed in female endurance athletes or trained distance runners.

This method can provide an additional objective measurement to aid in training volume and intensity prescriptions (4,6,8,9,10). TRIMP data has the potential in practical applications to be used to refine training plans and "tapering" strategies for both coaches and athletes (9).

The purpose of this study is to assess the acute and chronic exercise training load placed upon a female collegiate distance runner by utilizing the TRIMP method.

Methods

The participant was a healthy 21-year-old female (height 160 cm, weight 50.8 kg) who was an endurance-trained collegiate distance runner. The course of this study was during the 6-month cross country training and competitive season between June and November 2015. The participant's previous fastest 6,000-meter race performance was a time of 21:56 prior to the 2015 season.

The participant kept a detailed training log recording daily workout descriptions, and overall physical and psychological health. A heart rate monitor was worn for each workout bout and the entirety of competition days including pre-race runs, race competitions, and post-race runs. Heart rate was measured via a Wahoo Tickr X workout tracker worn around the participant's trunk. Data from the workout

tracker was synced after each exercise bout to a corresponding smartphone app that stored the data to be imported into the SportsTracks 3.1 software (Zone Five Software, Durham, NC). This software calculated TRIMP scores for each training session using the sum of time (min) spent in different pre-determined heart rate zones multiplied by zones weighting factors (1, 2, and 3). Physiologically significant heart rate zones were determined by a 3-minute, 30-second endurance capacity field test in which heart rate was recorded in relation to critical power (11). Zone 1 = 115-150 bpm, Zone 2 = 150-170 bpm, and Zone 3 = ≥170 bpm. These TRIMP scores were also used to create a 15-day acute training load (ATL) and a 45-day chronic training load (CTL) TRIMP score average for any given date. ATL scores reflected the individual's "fatigue" level and CTL scores reflected the individual's "fitness" level (3). Training stress balance (TSB) was calculated as the difference between CTL and ATL scores (TSB= CTL – ATL) on any given date.

Results

The participant's cross country training began mid-June 2015 after 2 weeks of rest. TRIMP scores were recorded for over 21 weeks (Figure 1). Overall increases in TRIMP scores reflected increases in training load. Training sessions that included interval or progression workouts, long runs, or competitions resulted in high TRIMP scores. As mileage and subsequent workload increased during pre-competition training months, ATL averages were consistently higher than CTL averages, and TSB scores were negative. Mileage during the summer months increased from 30 mi/wk to 60 mi/wk over the course of 10 weeks. The participant's first competition of the cross

country season was a 5,000-m race on 9/01. Competition results were recorded along with the TSB score from the day prior to competition (Table 1). A calf muscle injury occurred prior to the Sundodger Invitational (9/19) and was noted in the participant's training log. This injury prevented the participant from competing in this event. TSB score prior to injury was -8.0. Subsequent training following the injury was modified to include cross-training activities and anti-gravity treadmill running. Resulting TSB scores after training modifications were the most positive of the season (+8.2, +4.8, +2.8). Workload modifications and decreased mileage resulted in decreased ATL averages but little change in CTL averages (Figure 1). The participant performed a 6,000-meter personal best (PB) of 21:45 at the Washington Invitational (10/02) and had another successful race performance the following competition (Bradley Pink Invite, 10/16). Her 21:51 performance (10/16) was not a PB, but the participant described it as a "good race" due to being only 5 seconds slower than her PB on a hilly course.

Conclusions

It was expected that aggregate TRIMP scores would increase during the pre-competition training period. This was reflected in the data collected in Figure 1. A positive TSB score indicated that the participant's "fitness" level was higher than her "fatigue" level, and that a successful race performance should follow. This is the idea behind traditional "tapering" – that training load decreases before competition so that the athlete is fresh and not overly fatigued as to be able to perform at her peak fitness. The most positive TSB score (+8.2) preceded the participant's PB (10/02) and highest

team finish. Ideally, the greatest positive TSB scores should have occurred towards the end of the season before championship races (10/30 and 11/13). While TSB scores were positive before these 2 races (+4.8 and +2.8), they were not the most positive and the two races were subjectively unsuccessful. The most negative TSB scores preceded an early season calf injury and could indicate too high of training load the weeks before. Because this injury altered initial training plans, the participant's workload was lessened immediately post-injury and she was able to rest and have lower ATL averages, increasing her TSB score before the next race.

The trend of increasing ATL and CTL levels during the months of June – August follows the athlete's training plan of increased mileage and subsequent workload each week. The participant's pre-competition training followed a plan of incremental increases in workload but an absence of de-load weeks. A de-load week involves a slight decrease in training load to allow for further fitness adaptations without over-training. Instead of cycles of building and rest, the athlete gained fitness but potentially at the cost of overtraining leading to injury.

Unsuccessful performances despite prior positive TSB scores could have been linked to outside factors not measured by TRIMP. The NCAA West Regional meet was held in Seattle, WA in November in cold temperatures and rainy weather. The course conditions were unfavorable and other competitors had slow times on a usually "fast" course. Other internal factors such as psychological health, degree of self-efficacy, or physical health the day of the race could have also affected race performance. This highlights the flaw that TRIMP scoring does not take into account these factors in their effect on workload in training or in predicting race performance.

A limit of this study is the small sample size. Other studies have noted the same challenge (6,8). It would be advantageous to assess and compare this method on multiple athletes on the same training plans, competing in the same events. Another issue noted was that after the calf injury and training modification, TRIMP scoring might have reflected workload differently in cross training activities (stationary bike, elliptical, anti-gravity treadmill, and swimming) versus land running. In comparing race performances, cross country competitions provide a challenge in that courses have different terrains, elevation changes, and routes, with only measured distance as an assumed constant.

The TRIMP method can be valuable in tracking training and predicting performance as seen in marathon runners, recreational runners, and in this case study (8,9). By using aggregate values of time spent in different heart rate zones, a greater overall reflection for each workout bout is obtained. If heart rate zones are determined for each individual based off their VO_{2max} or comparable assessment, this method is a way to measure workload and track fitness accurately for endurance athletes (4,6,7,8,10). Moving averages of ATL, CTL, and TSB scores allow coaches and individuals to notice fitness and fatigue trends in a calculable way as opposed to relying on subjective measurements to determine the effects of training. Coaches and individuals who devise training plans work off of information from other experts to best prepare their athletes or themselves for the best possible race results. The TRIMP method is an easily accessible and low-cost tool that has the potential to aid in providing quality training information and adequate reflections of training adaptations and improvements.

In conclusion, the results of this study demonstrates that the TRIMP method is valid in measuring individuals' fitness and performance levels using significant heart rate zones. This method is a valuable way to individually track training load and prepare for potential positive performance outcomes.

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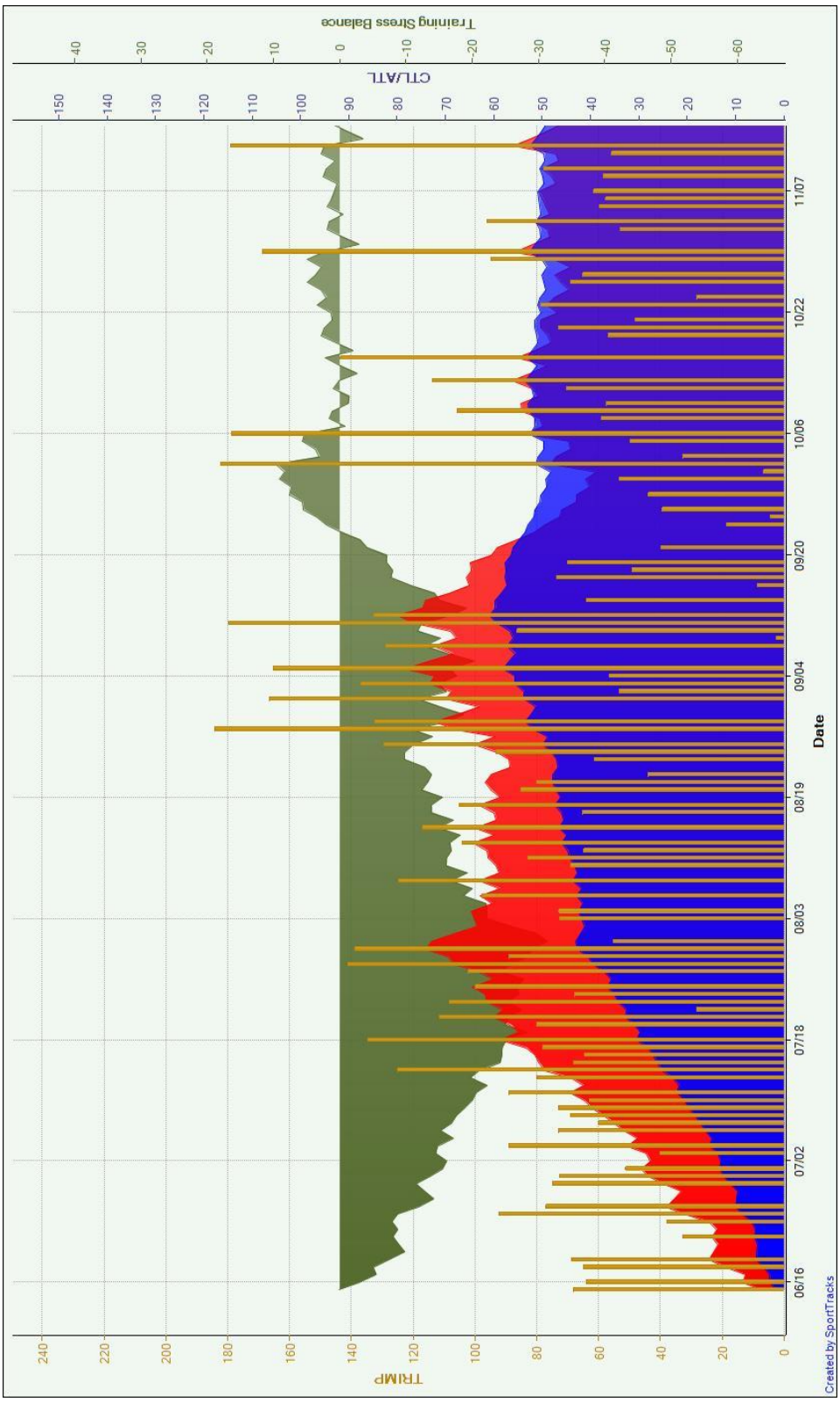

Figure 1 – Daily TRIMP scores with CTL, ATL, and TSB averages. **Yellow** bars are exercise bouts. **Green** line is TSB averages. **Red** line is ATL averages. **Blue** line is CTL averages.

Date	Race Name	Course Distance	Result (min:sec)	TSB prior
09/01/15	Westmoreland Quintet	5,000m	18:35	-15.1
09/19/15	Sundodger Invitational	6,000m	DNS	-8.0
10/02/15	Washington Invitational	6,000m	21:45	+8.2
10/16/15	Bradley Pink Invite	6,000m	21:51	-0.1
10/30/15	Pac-12 Championships	6,000m	22:21	+4.8
11/13/15	NCAA West Regional	6,000m	23:40	+2.8

Table 1 – Race performances and prior TSB scores.

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APPENDIX A

Participant Training Log

Date	Workout Description	Miles	Notes
06/15	30 min run	3.60	
06/16	30 min run + 3x100m strides	3.71	At Bald Hill
06/17	Rest day		
06/18	30 min run	3.60	
06/19	30 min run + 3x100m strides	3.55	At Bald Hill
06/20	Active rest - hike		
06/21	Rest day		
06/22	40 min run	5.07	
06/23	Active rest – bike ride to pick berries		
06/24	35 min run + 3x100m strides	4.16	At Bald Hill
06/25	40 min run	5.36	At Willamette Park
06/26	35 min run + 3x100m strides	4.11	At Peavy Arboretum
06/27	Rest day		
06/28	Rest day		
06/29	45 min run + 3x100m strides	5.60	
06/30	20 min run	2.50	Ran in afternoon, too hot so cut run short and walked back
	45 min run	5.80	Night run when it was cooler
07/01	35 min run	4.40	In Avery Park
07/02	35 min run	4.40	
07/03	40 min run	5.10	On treadmill on vacation in Washington, DC
07/04	60 min run	7.50	On treadmill on vacation in Washington, DC

07/05	Rest day		
07/06	45 min run + 4x100m strides	6.00	
07/07	41 min run	5.48	
07/08	30 min run	4.00	
07/09	45 min run + 4x100m strides	5.60	
07/10	40 min run + 4x100m strides	5.00	At home in Silverton
07/11	60 min run	7.50	At Bald Hill
07/12	Rest day		
07/13	50 min run + 4x100m strides + weights	6.25	
07/14	40 min hilly run workout (accelerate on the uphill)	5.30	At Peavy Arboretum
	10 min shakeout run	1.48	
07/15	45 min run + weights	5.67	
07/16	50 min run	6.25	
07/17	45 min run	5.63	At Peavy Arboretum
	15 min shakeout run	1.90	
07/18	70 min run	8.53	At McDonald Forest (Saddle Loop)
07/19	Rest day		
07/20	50 min run + 4x100m strides + weights	6.18	
07/21	50 min + 4x200m strides	6.42	
07/22	50 min run + weights	6.39	
07/23	50 min run	6.39	
07/24	45 min run + 4x100m strides	6.18	
07/25	70 min run	9.00	
07/26	Rest day		
07/27	45 min run + 4x100m strides + weights	6.00	

	15 min shakeout run	1.94	
07/28	45 min hilly run workout	5.80	At Peavy Arboretum
	15 min shakeout run	2.00	
07/29	60 min run + weights	7.16	
07/30	60 min run + 4x100m strides	7.63	
07/31	50 min run	6.20	
08/01	Rest Day		Travel to Chiloquin + grandpa's Celebration of Life
08/02	75 min run	9.00	In Silverton
08/03	45 min run + weights	5.47	
08/04	20 min shakeout run	2.50	At Silverton High School, attempted to run with dog, proved to be a challenge
	45 min run + 4x300m strides	5.27	At Bald Hill
08/05	60 min run + weights	7.50	
08/06	60 min run	6.70	At Peavy Arboretum
08/07	Rest Day		
08/08	80 min run	8.85	At Nike HQ and surrounding trails, got lost
08/09	Rest Day		
08/10	45 min run + weights	5.23	
08/11	54 min run	5.20	At Peavy Arboretum
08/12	50 min run + weights	6.25	
08/13	60 min run	7.12	
08/14	15 min warm up + dynamics & strides 2x1 mile, 2x800m, 4x400m with 3 min jog recovery between repetitions 15 min cool down	9.00	
08/15	85 min run	10.60	At Fitton Greene park, very hilly

08/16	Rest day		
08/17	45 min run + weights	5.70	
08/18	45 min hilly run workout	5.80	At Peavy Arboretum
08/19	60 min stationary bike + weights		
08/20	50 min run	5.80	At Bald Hill
08/21	15 min warm up + dynamics & strides 5(3),4(2),3(2),2(1) minutes workout 75%(65%) effort 5 min cool down	5.60	Short recovery, rolled ankle in a hole on the trail and returned to training room to have evaluated. Just a strained muscle with soreness. Ankle taped for support for next week.
08/22	60 min elliptical		
08/23	Rest day		
08/24	45 min run + weights	5.60	Feeling a little run down and tired, made appointment with nutritionist. Increasing workload but not increasing calories. Going to work on eating more food.
08/25	45 min run	5.95	
08/26	60 min run + weights	8.01	
08/27	60 min run	6.62	At Fitton Greene park, hilly, warm, not feeling best
08/28	17 min warm up 25 min progression run 5 min rest 1x1600m cruise effort 15 min cool down	9.00	Felt like I was going to throw up by the end of the progression run (6:39-5:52 difference in pace) 6:08 final mile
08/29	90 min run	10.00	At Peavy Arboretum
08/30	Rest day		
08/31	30 min run	3.75	Short day to prep for race day
09/01 – Race Day Westmoreland Quintet	15 min warm up + dynamics & strides 5,000m race 15 min cool down	6.60	18:35 finish. First mile awesome, halfway through completely dead in a fog. No finishing kick. Afternoon race and didn't eat

			enough.
09/02	40 min run + weights	5.00	Popliteal muscle tight and sore, ice afterwards
09/03	Hill Workout 15 min warm up = dynamics + strides 6x800m hill repeats Jog back recovery 15 min cool down	8.36	At Peavy Arboretum Pace descending from 3:05-2:50
09/04	45 min run	5.41	At Bald Hill
09/05	20 min warm up 5(5),4(4),3(3),2(2),1(1) minutes workout 75%(65%) effort 4 min recovery 5x200m with 30 sec recovery between 20 min cool down	10.61	
09/06	Rest day		
09/07	60 min run + weights	7.50	
09/08	Hill workout 15 min warm up + dynamics & strides 5x800m hill repeats Jog recovery 20 min cool down	8.41	At Peavy Arboretum. Struggling after 5th repeat, cut short workout but added to cool down
09/09	60 min run	7.34	
09/10	60 min run	7.51	
09/11	15 min warm up + dynamics & strides 1x1600 3 min recovery 5x 3(2) minutes workout 75%(65%) effort 3 min recovery 4x400m with descending rest 20 min cool down	10.34	
09/12	70 min run	8.75	
09/13	Rest day		

09/14	50 min run + weights	6.45	Calf/shin area begins feeling sore
09/15	15 min warm up + dynamics & strides 3x600m (1 min jog recovery between) 3 min jog recovery 3x1000m (2 min jog recovery between) 4x200m (30 sec recovery between) 15 min cool down	8.76	Treatment on calf, saw Dr. G, put in walking cast
09/16	45 min stationary bike		
09/17	45 min run	5.63	Shin still feeling pain, x-ray clean of obvious fracture
	45 min stationary bike		
09/18	15 min warm up over course Dynamics + strides 15 minute cool down	3.97	Pre-race prep. Shin area only sore on some steps.
09/19 – Race Day Sundodger Invitational	15 min warm up Dynamics + strides 30 min cool down	5.58	Did the full warm up for the race, literally pulled from starting line because coach didn't want to risk shin injury. Did run afterwards instead. MRI ordered.
09/20	Rest day		
09/21	40 min run + weights	5.00	MRI
09/22	50 min stationary bike		MRI results clear of stress response or inflammation. Put on anti-inflammatory medication. Injury looks to be muscular in the deep compartment of the calf.
09/23	45 min swim + weights		
09/24	35 min stationary bike		
09/25	57 min elliptical		Progression to running as long as pain doesn't get worse
09/26	37 min run	4.63	Pain doesn't worsen during run, relieved not a bone injury but worried on how to manage
09/27	Rest day		

09/28	45 min run + weights	5.64	
09/29	15 min warm up + dynamics & strides 1x1200m, 1x800m, 1x400m, 2x300m 15 min cool down	5.88	
09/30	45 min elliptical		
10/01	15 min warm up + dynamics & strides 15 min cool down	3.96	Race day prep. Nervous after having missed time running.
10/02 – Race Day Washington Invitational	15 min warm up + dynamics & strides 6,000m race 30 min cool down	9.50	21:45 finish. 6k PB. 3rd on team. Good Mile 1, Mile 2, Mile 3 drifted, last 1000m mentally recovered to finish. Fast course.
10/03	20 min run	2.40	
10/04	Rest day		
10/05	45 min run on AlterG + weights	6.43	At 75% body weight. Still managing calf pain.
10/06	15 min warm up 2x1600m 3 min recovery 1x1000m progression 3 min recovery 2x400m cut downs 15 min cool down	7.62	
10/07	50 min swim		
10/08	50 min run	6.25	
10/09	15 min warm up 3x1000m cut downs 3 min recovery b/w 15 min cool down	5.88	
10/10	50 min run	6.20	
10/11	Rest day		
10/12	50 min run	6.27	
10/13	15 min warm up + dynamics & strides 4x800m (80% effort), 2	8.00	

	min rest between 3 min recovery after set 4x400m cut down, 400m jog recovery 15 min cool down		
10/14	50 min swim		
10/15	15 min warm up + dynamics & strides 15 min cool down	3.97	Race day prep
10/16 – Race Day Bradley Pink Invite	15 min warm up + dynamics & strides 6,000m race 15 min cool down	7.55	21:51 finish. Close to PB, overall good race. Course very hilly, a lot of bodies. Was mentally engaged during the race and calf didn't hurt. Finish was uphill. Rumors that course distance was 200m too long.
10/17	60 min swim		
10/18	Rest day		
10/19	45 min run + weights	5.65	
10/20	Workout on AlterG 15 min warm up 4x2min (600 effort), 1min between 4 min recovery between sets 2x4min (1000 effort), 2 min rest between 5 min recovery between sets 4x30sec (200 effort), 30 sec rest between 15 min cool down	8.56	80% body weight. Calf hurts less the faster I run. Don't like being separated from team doing workouts
10/21	45 min run + weights	5.64	
10/22	60 min swim		
10/23	Workout on AlterG 15 min warm up 4(4),3(3),2(2),1(1) minutes workout 80%(65%) effort 2x4.5min 2x3min	9.97	80% body weight. Longest workout in a while. Tired, but feel confident running pretty fast paces, even with less body weight.

	2x2:30min 2x1:30min 15 min cool down		
10/24	30 min run 60 min swim	3.75	
10/25	Rest day		
10/26	50 min run	6.25	
10/27	Workout on AlterG 15 min warm up 4min (1000 effort) 3min (800 effort) 2 min (600 effort) 1 min (400 effort) 2x30 sec (200 effort) 15 min cool down	6.51	
10/28	50 min swim		
10/29	15 min warm up + dynamics & strides 15 min cool down	3.91	Race day prep
10/30 – Race Day Pac12 Conference Championship	15 min warm up 6,000m race 15 min cool down	7.52	22:21 finish. Wasn't aggressive on the start. Far back in team standing. Felt out of it the entire race with no one to run with. Felt like I couldn't change gears to pass people or hang on to groups. Calf hurt last mile. Last 800m harder than normal. Last 400m dry heaving, threw up running to the finish line. Difficult to breathe, sprint, and throw up all at the same time. Felt angry, like a disappointment, and humiliated. Team scoring suffered.
10/31	Rest day		
11/01	Rest day		
11/02	50 min run	6.25	
11/03	15 min warm up + dynamics & strides 4x1000 with decreasing rest	7.2	

	4x200m cut downs 15 min cool down		
11/04	60 min swim		Getting tired of swimming. But my flip turns are getting almost as good as they were in high school.
11/05	50 min run	6.17	
11/06	Workout on AlterG 15 min warm up 5(5),3(3),2(2),1(1) minutes workout 80%(65%) effort 15 min cool down	7.54	Last AlterG workout. Wondering if this is helpful.
11/07	40 min run	5.11	
11/08	Rest day		
11/09	45 min run + weights	5.64	
11/10	15 min warm up + dynamics & strides 1x1200m 400m jog recovery 3x400m cutdowns 15 min cool down	5.45	Last workout before Regionals. Physically feel good, mentally a little checked out.
11/11	45 min swim		
11/12	15 min warm up + dynamics & strides 15 min cool down	3.84	Race day prep. Family stress.
11/13 – Race Day **NCAA West Regional**	15 min elliptical		Morning shakeout alternative.
	15 min warm up + dynamics & strides 6,000m race 15 min cool down	7.40	23:40 finish. Worst finish on team all season. Same course as PB, and this was my worst result all season. Cold, rained entire day, course muddy, slippery, people falling. Honestly gave up.