Applied Mathematical Science of Physical Training Part 2: The Body Across Terrain Loading

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1. Executive Summary

This paper will detail the protocol for calculating loading for the movement of the athlete's body across a terrain, starting with standard perfectly horizontal track running. I will build upon the system developed in my initial paper on loading: "Applied Mathematical Science of Physical Training Part 1: Loading." The logic and equations from that work are the point of the departure for this paper, and I will reference them extensively.

The Load placed on the organism through the training-competition process is the foundational quotient from which we derive all other athletic preparation variables; fatigue and fitness accumulated (both amount and time to recovery), calorie and macronutrient requirements, and so forth.

In the first paper, I identified the two fundamental training variables which combine to form the internal training Load: Intensity and Amount (reps). We process these values with an equation based on A.S. Prilepin's groundbreaking table for Weightlifting training organization/regulation, with the final value being the Abstract Internal Training Load.

To actualize this value into a completely relevant value for training programming, I introduced a revolutionary concept: the Spatial Form Stress Factor. I delineated the system for identifying the Stress Factor of all the major exercises of competitive lifting using the physics quantities (Newton Meters, Watts, Newton Seconds) of the world-record performances of each. The Abstract Internal Training Load and the Spatial Form Stress Factor product is the Actual Internal Training Load of a training "action" (rep or set). We sum these quantities to determine the Actual Load of training Activity, Session, Day, Microcycle, week, Mesocycle, month, Period, Macrocycle, year, and even Olympic Cycle (4 years).

In this paper, I will define what a training rep is regarding moving the body across terrain and how to determine the intensity. I will also delineate the logic for quantifying the Spatial Form Stress Factor for running.

Finally, I will provide the Actual Internal Training Load values for all the standard competitive running distances and compare them to the lifting competition and training load values established in the first paper. These comparisons will show how to use the Actual Internal Training Loading system to integrate running into a broader cross-training program.

2. Introduction

Running is used to improve conditioning across the biological adaptation spectrum, from raw speed (short distance sprinting) to anaerobic endurance (extended sprints) to aerobic (unloaded) endurance (distance running). Effective running is crucial for success during competition in many sports, including Track & Field and most bat & ball sports. Combat sports and racket sports utilize running extensively in the training process.

A fully developed supersystem that controls and regulates the entire training process must have a protocol to integrate running into broader cross-training programming. Combining lifting and running training into an integral training program has been the foundation of organized preparation since the dawn of serious athletics.

3. A Running Rep

Running Training amounts are not conventionally described in reps like lifting; this is due to the movement's cyclic rather than acyclic nature. Running amounts have been and always will be finally prescribed as distances (meters-kilometers or yards-miles). However, to fully integrate running training into an integral cross-training program, it is necessary to determine the actual training Load. For this, we must define a running "rep." We must divide the prescribed training distance by a certain"rep" distance to provide a number of "reps" in the running Action or Activity (or session, day, or training cycle).

To begin the process of defining intensity and amount for running, we will turn to the most outstanding maximum-intensity running performance of all time: Usain Bolt's world record 100 Meter dash.

To determine the maximal intensities of different running distances, we will compare the world-record results of various distances; I used a similar process in the first paper to determine the Spatial Form Stress Factors of the different lifts. A world record for any exercise provides the *Absolute* values for that exercise, and comparing absolute to absolute is the most useful way to compare performances in different spatial forms.

Since Usain Bolt is the most outstanding athlete of all time in terms of speed, we will use his maximum stride length as the distance of one universal running rep. Bolt's maximum stride length in his 100-meter world record performance was 2.7 meters. We will use the 2.7 meters as a universal running “rep.” Any amount of distance prescribed in training is then divided by 2.7 meters, providing the rep quotient for the action/activity. Later, when we look at the final loads of various distances and compare them to standard-practice running workouts, we will see the logic in this protocol. The total reps for different standard race distances are in table 1.

Race	Meters	Reps
100 Meters	100	37.0
200 Meters	200	74.1
400 Meters	400	148.1
800 Meters	800	296.3
1000 Meters	1000	370.4
1500 Meters	1500	555.6
Mile	1609.344	596.1
2000 Meters	2000	740.7
3000 Meters	3000	1111.1
2 Miles	3218.688	1192.1
5000 Meters	5000	1851.9
10,000 Meters	10000	3703.7
15 Kilometers	15000	5555.6
10 Miles	16093.44	5960.5
20 Kilometers	20000	7407.4
Half Marathon	21097.5	7813.9
30 Kilometers	30000	11111.1
Marathon	42195	15627.8
50 Kilometers	50000	18518.5
50 Miles	80467.2	29802.7
100 Kilometers	100000	37037.0
100 Miles	160934.4	59605.3

Table 1: Running Reps for Various Distances.

4. Running Intensity

The most relevant variable for determining running intensity is speed, measured in Meters Per Second (MPS). In lifting exercises such as Snatch, Clean, Powerlifting Squat, or Bench Press, we define our maximum as the Mass (KG) we can overcome in one repetition of movement through the specific spatial form; this is our one-rep maximum (1RM). For running, our "max" is the maximum MPS with which we can move for a running "rep."

To determine average intensities across standard distances, we will compare the average speeds of available world records. We will use Usain Bolt's 100 Meter world record to determine the World Record running 1RM. Bolt covered 100 meters in 9.85 seconds in the performance, producing an average speed of 10.44 MPS. 10.44 MPS is the all-time human best 1RM for running. We will use this to determine the intensities of other all-time human bests for various distances.

By dividing the average speed displayed in the world record performances of other distances by 10.44 MPS, we reach the average intensity of that distance. Table 2 shows the average intensity and the record holder's name and result for the standard race distances. Any distance less than 200 meters has an average intensity of 98%; using 99% for these distances returned loads that were not consistent with real-world running training prescription. 98% (which is still considered part of the "maximal" resistance intensity zone by Naglak) returns loads that are in sync with training praxis in the running world.

Race	Record Holder	Date	Meters	Record	Seconds	MPS	Intensity
100 Meters	Usain Bolt	Aug 16, 2009	100	9.58	9.58	10.44	99%*
200 Meters	Usain Bolt	Aug 20, 2009	200	19.19	19.19	10.42	99%*
400 Meters	Wayde van Niekerk	Aug 14, 2016	400	43.03	43.03	9.30	89%
800 Meters	David Rudisha	Aug 9, 2012	800	1:40.91	100.91	7.93	76%
1000 Meters	Noah Ngeny	Sep 5, 1999	1000	2:11.96	131.96	7.58	73%
1500 Meters	Hicham El Guerrouj	Jul 14, 1998	1500	3:26.00	206	7.28	70%
Mile	Hicham El Guerrouj	Jul 7, 1999	1609.344	3:43.13	223.13	7.21	69%
2000 Meters	Hicham El Guerrouj	Sep 7, 1999	2000	4:44.79	284.79	7.02	67%
3000 Meters	Daniel Komen	Sep 1, 1996	3000	7:20.67	440.67	6.81	65%
2 Miles	Daniel Komen	Jul 19, 1997	3218.688	7:58.61	478.61	6.73	64%
5000 Meters	Joshua Cheptegei	Aug 14, 2020	5000	12:35.36	755.36	6.62	63%
10,000 Meters	Joshua Cheptegei	Oct 7, 2020	10000	26:11:00	1571	6.37	61%
15 Kilometers	Joshua Cheptegei	Nov 18, 2018	15000	41:05:00	2465	6.09	58%
10 Miles	Haile Gebrselassie	Sep 4, 2005	16093.44	44:24:00	2664	6.04	58%
20 Kilometers	Zersenay Tadese	Mar 21, 2010	20000	55:21:00	3321	6.02	58%
Half Marathon	Kibiwott Kandie	Dec 6, 2020	21097.5	57:32:00	3452	6.11	59%
30 Kilometers	Eliud Kipchoge	Sep 16, 2018	30000	1:26:45	5205	5.76	55%
Marathon	Eliud Kipchoge	Sep 16, 2018	42195	2:01:39	7299	5.78	55%
50 Kilometers	Thompson Magawana	Apr 12, 1988	50000	2:43:38	9818	5.09	49%
50 Miles	Jim Walmsley	May 4, 2019	80467.2	4:50:08	17408	4.62	44%
100 Kilometers	Nao Kazami	Jun 24, 2018	100000	6:09:14	22154	4.51	43%
100 Miles	Zach Bitter	Aug 24, 2019	160934.4	11:19:13	40753	3.95	38%

Table 2: Average intensities of various running distances. *99% (98% for running) is used in the loading system since 100% returns irrational values.

The following logical/polynomial equation provides the average intensity for a given distance (Meters)-

If(Distance<=200, 0.98,IF(Distance<=1000,1.014392 - 0.0002103175*Distance - 0.0000003634259*Distance^2 + 0.0000000002728175*Distance^3 + 1.653439E-14*Distance^4,IF(Distance<10000,0.8210159 - 0.000116174*Distance + 0.00000002843624*Distance^2 - 3.479014E-12*Distance^3 + 2.056282E-16*Distance^4 - 4.701684E-21*Distance^5,if(Distance<42200,0.6703234 - 0.00001028804*Distance + 0.0000000006520934*Distance^2 - 2.821337E-14*Distance^3 + 6.232006E-19*Distance^4 - 5.25563E-24*Distance^5,if(Distance<90000, 0.4387069 + (0.4905781 - 0.4387069)/(1 + (Distance/64964.33)^17.13222),12.65889 - 0.0005167442*Distance + 0.00000000867628*Distance^2 - 7.216263E-14*Distance^3 + 2.966529E-19*Distance^4 - 4.820545E-25*Distance^5)))))

5. Running Abstract Internal Training Load

Now that we have determined the (average) intensity and the number of reps for the standard distances, we can apply the Abstract Internal Training Load equation to these variables and arrive at the Abstract Internal Training Load for each standard distance. The results are in table 3.

To reiterate, the Abstract Load equation from the initial paper was-

$$Abstract\ Load= R/((100/(I>89\rightarrow 100,I>69\rightarrow 94^{\wedge(((LOG(100,94)-1)/(90-70))*((I-70))+1))},I<70\rightarrow 85^{\wedge(((LOG(94,85)-1)/(70-55))*((I-55))+1))})*100)-I)$$

Where:
R is Repetitions performed in the set, activity, workout, etc.;
I is the Intensity (% of 1 rep maximum) of the work.

The complete specific equation for running loading is:

$$(Dis/2.7)/((100/(I>89\rightarrow 100,I>69\rightarrow 94^{\wedge(((LOG(100,94)-1)/(90-70))*((I-70))+1))},I<70\rightarrow 85^{\wedge(((LOG(94,85)-1)/(70-55))*((I-55))+1))})*100)-I)$$

Where:

D is the distance of the run in Meters.

Race	Reps	Intensity	Abstract Load
100 Meters	37.04	98%	18.52
200 Meters	74.07	98%	37.04
400 Meters	148.15	89%	13.49
800 Meters	296.30	76%	10.42
1000 Meters	370.37	73%	11.17
1500 Meters	555.56	70%	14.74
Mile	596.05	69%	15.41
2000 Meters	740.74	67%	17.83
3000 Meters	1111.11	65%	24.81
2 Miles	1192.11	64%	25.84
5000 Meters	1851.85	63%	38.66
10,000 Meters	3703.70	61%	71.04
15 Kilometers	5555.56	58%	98.3
10 Miles	5960.53	58%	104.05
20 Kilometers	7407.41	58%	128.46
Half Marathon	7813.89	59%	139.21
30 Kilometers	11111.11	55%	179.07
Marathon	15627.78	55%	253.3
50 Kilometers	18518.52	49%	250.98
50 Miles	29802.67	44%	362.89
100 Kilometers	37037.04	43%	439.74
100 Miles	59605.33	38%	631.05

Table 3: Abstract Internal Training Load of Various Distances.

6. Actualizing The Running Load

As we saw in the first paper with the competitive exercises of Weightlifting and Powerlifting, the Abstract Training Load is just that: *abstract*. A Spatial Form Stress Factor must be applied to *actualize* the Load.

All the competitive distances in competitive running essentially have the same spatial form: running. Strides will look somewhat different according to the intensity, but we will use a common stress factor for all distances for practical programming purposes.

Since we used Usain Bolt's 100 Meter dash to define maximum intensity, we will also use it to determine a running stress factor (the same protocol used with lifting world records in the first work). I concluded that three primary factors determine the stress of a rep for lifting exercises. Those factors are the total Work done (measured in Newton-meters), the time under tension (amount of time the lifter was opposing/producing the Force, measured in Newton Seconds), and the amount of power produced (Measured in Watts). We will calculate these quantities for a maximal stride (2.7 Meters) of Bolt's 100 Meter world record to determine a universal running spatial form stress factor.

6.1 World Record Work

When running, the lower body muscles oscillate the Center Of Mass (CoM) vertically with each stride. Concerning Work, the lower body muscles produce a small amount of Newton-meters by vertically displacing the upper against gravity with each stride. To calculate the Work, we must determine the amount of Force overcome and the upward vertical Distance it is moved through with each stride.

Bolt vertically displaced his Co CM 4.9 (0.049 Meters) with each stride. The Force overcome was the weight of his upper body multiplied by Gravitational Acceleration. The results are in Table 4.

Body Weight	% Body Wieght Lifted	Body Weight Lifted	Force	Vertical Displacement	Work Per Stride
94.00	0.59	55.46	543.51	0.049	26.63

Table 4: World Record Work Per Stride.

6.2 World Record Power

The second stress factor determinant is the rep Power. The minimum time between the ground and Bolt's foot during a stride in his world record performance was 86 Milliseconds (0.086 seconds). Since the interaction of Bolt's foot and the track generated all the Force, the ground contact time was the amount of time he took to produce the Work of each rep. To determine each rep's Power (Watts), we divide the Work per rep by the contact time. The results are in Table 5.

Work Per Stride	Contact Time	Power
26.63	0.086	309.67

Table 5: World Record Power Per Stride.

6.3 World Record Time Under Tension

The most significant Force dealt with when running is the Ground Reaction Force. Forces applied to the ground by the foot with each contact return to the body in equal magnitude but in the opposite direction; this is Ground Reaction Force. This Force is exceptionally high during sprinting. During his world-record performance, Bolt generated a GRF of 3932 N with each contact (average). His contact time with the ground with each stride was 86 Milliseconds (0.086 seconds). The product of the GRF and the contact time is the GRF Newton Seconds per stride; this comes to 338.15 NS. The results are in table 6.

Grouond Reaction Force	Contact Time	GRF Newton Seconds Per Stride
3932.00	0.086	338.152

Table 6: World Record Time Under Tension

6.4 Running Spatial Form Stress Factor

At this point, all necessary quantities from the all-time best human performance for the running spatial form (in terms of speed) are known (Newton Meter, Newton-Seconds, Watts). It is now possible to determine a stress-related value to relate running training to the broader loading schema. We sum the world record Work, Power, and TUT to do this. The results are in table 7.

Work Per Stride	Power	Newton Seconds	NM + Watts+ NS
26.63	309.67	338.15	674.46

Table 7: Running World Record Physics Sum.

To make this sum relevant for determining an Actual Internal Training Load, it is necessary to mathematically relate it to Prilepin's Table, as was done in the initial paper for all lifting exercises. The table is the foundation of the *Abstract Internal Training Load equation*.

Since Prilepin's table came from an extensive study of elite-level Weightlifting (the sport which consists of the competitive lifts of the Snatch and the Clean & Jerk), the average of the physics quantity sums of the Snatch and the Clean is a Stress Factor equivalent to 1. We divide the running quantity sum by the Snatch-Clean quantity sum average value to arrive at the running Spatial Form Stress Factor. The result is in table 8.

Spatial Form	World Record Quantities Sum	Stress Factor
Average Snatch-Clean	25688.83	1
Running	674.46	0.03

Table 8: Running Spatial Form Stress Factor.

7. **Actual Running Internal Training Loads**

We can now apply the running Spatial Form Stress Factor to the Abstract loads of various training/competition distances from table 3. We multiply the abstract Load by the Spatial Form Stress Factor to determine the Actual Internal Training Load. In the previous paper, I concluded that the average abstract Load of a lifting warm-up was 0.14. For rigor, we will add this warm load to each abstract running load. The results are in table 9.

Race	Meters	Reps	Intensity	Main Abstract Load	Warm-Up Abstract Load	Actual Load
100 Meters	100	37.04	98%*	18.52	0.14	0.56
200 Meters	200	74.07	98%*	37.04	0.14	1.12
400 Meters	400	148.15	89%	13.49	0.14	0.41
800 Meters	800	296.30	76%	10.42	0.14	0.32
1000 Meters	1000	370.37	73%	11.17	0.14	0.34
1500 Meters	1500	555.56	70%	14.74	0.14	0.45
Mile	1609.344	596.05	69%	15.41	0.14	0.47
2000 Meters	2000	740.74	67%	17.83	0.14	0.54
3000 Meters	3000	1111.11	65%	24.81	0.14	0.75
2 Miles	3218.688	1192.11	64%	25.84	0.14	0.78
5000 Meters	5000	1851.85	63%	38.66	0.14	1.16
10,000 Meters	10000	3703.70	61%	71.04	0.14	2.14
15 Kilometers	15000	5555.56	58%	98.3	0.14	2.95
10 Miles	16093.44	5960.53	58%	104.05	0.14	3.13
20 Kilometers	20000	7407.41	58%	128.46	0.14	3.86
Half Marathon	21097.5	7813.89	59%	139.21	0.14	4.18
30 Kilometers	30000	11111.11	55%	179.07	0.14	5.38
Marathon	42195	15627.78	55%	253.3	0.14	7.60
50 Kilometers	50000	18518.52	49%	250.98	0.14	7.53
50 Miles	80467.2	29802.67	44%	362.89	0.14	10.89
100 Kilometers	100000	37037.04	43%	439.74	0.14	13.20
100 Miles	160934.4	59605.33	38%	631.05	0.14	18.94

Table 9: Actual Running Loads. *In order to return to loading values that correspond to real-world training praxis, 98% is used in place of 99% intensity.

We can now compare some actual running loads to the actual lifting loads from table 32 ("Various Actual Internal Training Loads") from the initial paper and see compelling synchronicities that validate the overall Actual Internal Training Load schema. Examples of various actual loads from table 32 of the initial article and competitive and workout running loads are in table 10.

Activity	Actual Internal Load
1: 100 M Sprint	0.56
Prilepin Optimal Activity	0.94
1: 200 M Sprint	1.12
Competive Bench Press	1.58
Competitive Snatch	1.89
Competive Powerlifting Squat	2.71
1: 10,000 M Run	2.95
Medium Session	3.04
Competitive Clean & Jerk	3.11
15 Kilometers Run	3.13
Sprintingworkouts.com	3.62
Large Session	3.74
Half Marathon	4.18
Large Training Day	4.52
Modern Weightlifting Meet	5.00
Very Large Training Day	5.23
30 Kilometers Run	5.38
Historic Weightlifting Meet	6.60
Standard Powerlifting Meet	6.94
Marathon	7.60
Powerlifting Meet w/ Strict Curl	7.90

Table 10: Various Actual Training Loads- White: Training, Light Blue: Sprinting, Purple: Weightlifting, Red: Powerlifting, Yellow: Endurance Running. All examples include a 0.14 abstract load for the warm-up.

There are some interesting observations to be made from table 10. Note that the Load (2.95) of a 15 Kilometer run (36% of a full Marathon distance) is very close (only a 0.09

difference) to what I previously established (in the first paper, table 32) to be a Medium session load, 3.03. This finding is consistent with expert praxis in the running world, where 14.4-19.2 kilometers is considered a standard marathon runner's medium session.

I calculated the Load from what sprintingworkouts.com considered a large speed-endurance load (a high-amount sprinting workout). I considered the warm-up to be a 0.14 abstract load as I did with all other activities, and applied the loading equations to the prescribed main runs: 1 * 200 M, 1 * 180, 1 * 150, 1 * 120 (All runs are =<200 M, so all intensities are 98%). The actual Load came to 3.62; the difference between this and the previously established large (lifting) session load (3.74) is only 0.12; this is another exciting correspondence between conventional lifting and running training prescriptions.

The Actual Load (4.18) of a half marathon (21 KM) lies just about right between the established loads of a large session (3.74) and a large training day (4.52); it is 0.44 greater than a large session and 0.34 less than a large day. A 30-kilometer run load (5.38) is very close to the established very-large training day load (5.23), a difference of only 0.15.

Perhaps the most exciting correspondence from table 10 is between a full Marathon (an extreme running day) and a Powerlifting meet plus the Strict Curl (an extreme lifting day). The Marathon comes to a 7.6 actual load, while the meet comes to 7.9, a difference of only 0.3; this shows close synchronicity between the sport of Maximum Strength and the sport of Maximum Endurance that was previously unknown.

Summary

In this work, I detailed how to determine the actual loading of running training.

I provided the logic and method to define a functional running "rep" to calculate the Load. I also provided the protocol for determining the maximum possible intensity for certain running distances.

With the two fundamental variables of training loading in hand, I showed how the Abstract Internal Training Load equation applies to running.

After delineating the process for determining the abstract internal Load of running, I provided the method for determining the running Spatial Form Stress Factor. I used the 100-meter dash world record of Usain Bolt in the same fashion as I used lifting world records in the first paper.

I fully developed the application of the stress factor to the competitive distances of running, which showed the precise actual internal load of each of the individual competitive activities.

Finally, the actual internal loading of standard lifting and running training sessions and days was determined and compared with the loading of running and lifting competitions to provide the reader a direct orientation of this loading calculation system to their own cross-training/competition process.

Conclusion

In this work, I expanded the Actual Internal Training Loading schema from its genesis in the world of serious lifting (Weightlifting, Powerlifting, Bodybuilding, special strength preparation for sports) to another vital area of physical training: running. Having an in-common foundational training value to govern the prescription and regulation of both lifting and running training provides strength & conditioning coaches and their athletes an invaluable tool for perfecting physical fitness. This paper significantly furthered the agenda of creating a complete system of applied science for physical training.

Addendum: Climbing and Slope Running

To complete the "body across terrain" training picture, we must account for movement against a slope. In the main body of this paper, I considered the terrain's inclination to average zero degrees across the distance (like a standard track) and the probable average of a standard marathon. In the case of zero degree inclination training, the loading calculation system is complete.

For training on a terrain against a specific degree of slope, the determination of loading will require further calculation; this is the case for all sloped terrain movement from slightly inclined hill runs to straight vertical climbing. We will keep the 2.7 meters distance definition of rep consistent with the running example, utilizing this distance as a universal "body across terrain" rep.

To account for the increase in internal loading due to terrain inclination, we will increase the Spatial Form Stress Factor according to the degree of slope that the athlete encounters during the performance. To this end, we will first determine a vertical climbing Spatial Form Stress Factor. Just as with lifting and running, we will turn to the world record for that activity.

Speed climbing competition governed by the International Federation of Sport Climbing (IFSC) takes place on 15m artificial walls. To determine the number of reps in a standard competitive speed climb, we divide 15 meters by 2.7 meters. The quotient is 5.55555556 reps per climb.

The current world record time is 5.208 seconds, set by Veddriq Leonardo at the World Cup in Salt Lake City on May 28, 2021.

1. **Climbing Quantities**

Data for Veddriq Leonardo's body weight is not readily available, but as an elite climber, we can be sure that his body weight would be "ideal" for his sex, height, and age.

Leonardo is 1.62 Meters tall, and at the time of his world-record performance, he was 24 years of age. Robinson (1983), Miller (1983), Devine (1974), and Hamwi (1964) each developed an equation that determines the ideal weight of an individual according to sex, age, and height. Using Leonardo's biometric data at the time of his record-setting performance, we arrive at an average weight from all the equations of 60 KG; this will be our Mass for determining the climbing Spatial Form Stress Factor.

1.1 World Record Work

We multiply Leonardo's bodyweight by gravitational acceleration to determine the force overcome in the performance. The product is the Newton of Force overcome during the climb.

60 KG x 9.8 MPS = 588 N

To determine the total Work of the climb, we multiply the Force overcome by the distance. The product is the Newton Meter produced.

588 N x 15 M = 8820 NM

To determine the Work per rep, we divide the total Work by the number of reps in the climb.

8820 NM / 5.56 = 1586.33 NM Per Rep

1.2 World Record Power

Leonardo completed each rep in an average of 0.94 seconds (total time/reps). To determine the Power per rep, we divide the Work Per Rep by the Time Per Rep; the quotient is the Watts per rep.

1586.33 NM / 0.94 Sec. = 1692.19 Watts

1.3 World Record Time Under Tension

To determine the Newton Seconds of each rep, we multiply the Force by the time per rep.

588 N x 0.94 = 551.21 NS

2. Climbing Spatial Form Stress Factor

Just as with all other spatial forms (lifting, running), we first sum the Newton Meter, Watts, and Newton Seconds of a rep from the world-record performance to determine the Stress Factor. All the quantities, along with the sum, are in table 1.

Body Weight	Force	Distance	Work	Time	Power	Newton Seconds	Quantities Sum
60.00	588.00	2.700	1586.331	0.94	1692.19	551.21	3829.74

Table 1: Climbing Quantities Sum.

To arrive at the climbing Spatial Form Stress Factor, we again divide the climbing world-record quantities sum by the average of the snatch and clean world-record sums. The climbing Spatial Form Stress Factor is 0.15. The result is in table 2.

Climbing Quantities Sum	Average Snatch, Clean Quantities Sum	Climbing Stress Factor
3829.74	25688.83	0.15

Table 2: Climbing Spatial Form Stress Factor.

3. Slope Running

Now that we have the Spatial Form Stress Factors for flat running (0.03) and vertical climbing (0.15), we can now logically determine the stress factor for every degree of gradient between them. An exponential rate of increase of the stress factor can be used for every degree from 0 to 90, increasing from the flat running stress factor of 0.03 to the vertical climbing factor of 0.15. According to the slope encountered, the following polynomial returns the correct stress factor for every "body across terrain" movement.

Body Across Terrain Spatial Form Stress Factor = 0.03007145 + 0.0005466243*Slope + 0.000003466119*Slope^2 + 6.83977e-8*Slope^3 - 3.236162e-10*Slope^4 + 2.409869e-12*Slope^5

Table 3 has this stress factor equation applied to various "body across terrain" examples with different distances and slopes. The table also shows the Actual Internal Training Loads of the different examples.

	Distance	Reps	Intensity	Abstract Load	Slope	Stress Factor	Actual Load
40 Yard Dash	36.6	14	98%	6.77	0	0.03	0.20
	31.2	12	98%	5.77	23	0.04	0.26
	25.8	10	98%	4.78	45	0.07	0.32
	20.4	8	98%	3.78	68	0.10	0.38
Competitive Speed Climb	15.0	6	98%	2.78	90	0.15	0.42

Table 3: Actual Internal Training Loads of various actions.

Conclusion

The practical utility of this system for the prescription and regulation of the training process is clear. It is now possible to fully integrate all "body across terrain" training modalities from sprinting to distance running to climbing against slopes of any degree into a broader cross-training program with the exercises and methods of weightlifting, powerlifting, and bodybuilding. The possibilities for precisely peaking athletes' preparedness for all sorts of competitive and non-competitive goals have never been greater.

Works Cited

"Applied Mathematical Science of Physical Training Part 1: Loading."
Daniel McKee, 01/03/2021

"Running World Records." — *runhive.com/running/world-records*

"Naglak Resistance (intensity) Zones." *Thomas Kurz— Science of Sports Training: How to Plan and Control Training for Peak Performance, 1991*

"Usain Bolt" — *Wikipedia*

"Usain Bolt Physics Quantities." *Milan Čoh, Kim Hébert-Losier, Stanko Štuhec, Vesna Babić, and Matej Supej, —KINEMATICS OF USAIN BOLT'S MAXIMAL SPRINT VELOCITY*

"Large Speed-Endurance Session." *100 Meter Dash Training-Sprinting Workouts —SprintingWorkouts.com*

"Medium Session Load." *Jane, The Power Of The Medium Long Run In Marathon Training —readysetmarathon.com*

"Competitive Climbing Standard Distance and World Record" *—Wikipedia*

" Veddriq Leonardo Height and Age" *—(ifsc-climbing.org)*

"Ideal Body Weight" —Ideal Weight Calculator