Applied Science of Physical Training 6: Force-Structure-Vegetative Ability Continuum Potencies

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06/09/2022

1. Executive Summary

This paper will detail the protocol for determining the training potency of a set for the Abilities of the Force-Structure-Vegetative (F-S-V) Physiological Ability Continuum. This work will complete the picture of the ability potency concept for training sets of resistance exercises (barbell, dumbbell, odd object lifting) that began in paper four and continued in paper 5.

In the previous paper, I defined the Velocity-Power-Force ability continuum and its constituent abilities. I will do the same in this installment for the Force-Structure-Vegetative Continuum. The abilities of this continuum are primarily related to Muscular Endurance. I will use the work of Naglak to determine the intensity zones to define the abilities numerically. I will detail the equations to define their potencies as well.

Endurance is developed by doing extensive Work, which is related to the development of the Structural (muscle mass) and Vegetative (energy storage) aspects of the organism; this lends itself to defining specific Physiological *attribute* potencies which lie alongside the *ability* potencies. I will list and describe these attributes and detail the equations to determine their potencies.

Success in athletic endeavors often requires high levels of work capacity at a certain intensity. The critical nature of work capacity requirement for athletic success makes the information in this paper very valuable for strength & conditioning coaches. By the end of this paper, a complete schema for determining the adaptive potencies of training sets for the development of various types of muscular endurance and attributes critical for work capacity will be in place.

2. Introduction

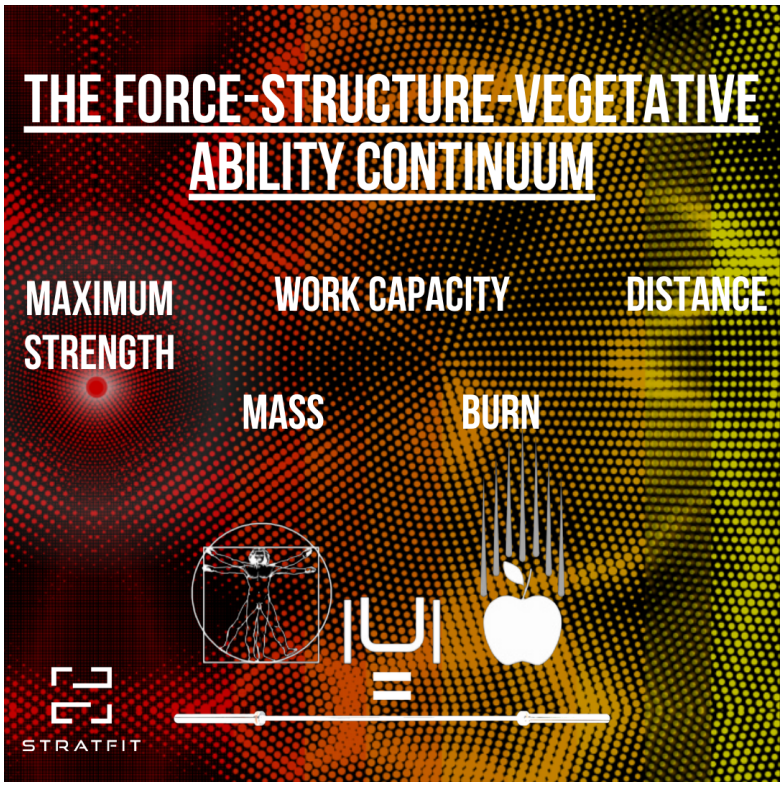
My previous paper dealt with abilities for which velocity was the determining factor. The development and display of Speed, Speed-Strength, Power, and Strength-Speed depend on velocity and the *rate* of the work being done. These abilities are highly neurological in nature and are negatively affected by accumulating fatigue in a set.

On the other hand, the F-S-V's abilities depend on Fatigue. A high level of fatigue is necessary to develop any form of endurance and increase work capacity. The concept is simple, the more (intensity specific) fatigue developed in a set, the greater the adaptational effect for (intensity specific) endurance. When an athlete takes training sets to full (or near to full) fatigue, they will adapt to the fatiguing training, and the amount of work required to reach full fatigue will increase for the future; this results in the ability to extend effective performance.

Maximum-Strength is the fulcrum ability of the entire spectrum of abilities. It lies at the right extremity of the V-P-F continuum and the left extremity of the F-S-V continuum. Maximum-Strength is the most fundamental of all abilities, and its development positively affects all other abilities (generally). Maximum-Strength represents an athlete's Force maximum, so any display of power or work is dependent on it.

As we move rightward on the F-S-V continuum, force (intensity- the percentage of one-rep maximum) decreases while the reps per set and work increases. Energy production moves from purely Anaerobic ATP (adenosine tri-phosphate) at the rightmost extremity to Aerobic at the leftmost extremity.

Various physiological attributes are developed by the training modalities of this continuum. Athletic competition requires the development of different bioenergetic functional systems and structural characteristics of the athlete's organism. This paper will provide an exact schema for defining and calculating these adaptations' training metrics and potencies.



3. The Abilities of F-S-V Continuum

The abilities on the extremities of the F-S-V continuum are Maximum-Strength (extreme left) and Distance (Extreme right). Distance refers to the ability of an athlete to display a high level of low general intensity/resistance endurance, the ability required to run/cycle/swim a long distance. This paper will deal with the F-S-V abilities related to higher general intensity/resistance, meaning those trained by barbell work. I will deal with the training potency of running and other primarily extensive training in a separate paper.

Maximum-Strength is the physiological ability that corresponds to the maximum *force* capacity of the athlete, while Distance refers to Maximum *work capacity*. The continuum grades from Maximum Strength (maximum force-minimal total work) to maximum endurance (maximum work-minimal force). All intermediate abilities are combinations of the two to various degrees.

For this reason, the continuum has two overlapping general ability concepts: Strength and Work Capacity.
I dealt with the concept of strength in detail in my fourth paper- "Applied Mathematical Science of Physical Training Part 4: Strength Potency", but I will touch upon the idea of strength again here.

The basic definition of strength is an organism's ability to produce force. A more fully comprehensive description is-

Strength: The product of muscular action initiated and orchestrated by electrical processes in the body's nervous (Central and Peripheral) System of the Body. It is the ability of a given muscle or a group of muscles to generate muscular force under specific conditions.

This definition reflects the primarily neurological (functional) nature of the phenomenon of strength. Still, strength is also affected by structural factors such as muscle mass, bone density, joint integrity, and vegetative (energetic) factors like cellular energy storage. Strength training has a positive adaptational effect on all of these factors. The Strength Potency value concept in the fourth paper reflects the development potency of a training set for all of them.

3.1 Strength Potency

To iterate from the fourth paper, the Strength Potency Equation is-

$$I + ((AMRAP * (I / 100)) * F)$$

Where
I = Intensity
AMRAP = As Many Reps As Possible
F = Percentage of Fatigue Accumulated

From the same paper, Verkhoshansky's AMRAP equation (from Supertraining) is-

*173.5249 - 6.31*I + 0.095759*I^2 - 0.0006742*I^3 + 0.00000174962*I^4 + 9.927033E-17*I^5*

Where
I = Intensity

Continuing, the Percentage of Fatigue (F) equation is-

*(e^(-1/R*AMRAP))/(e^(-1/AMRAP*AMRAP))*

Where
e = Euler's number, 2.718
R = Reps in the set

The Strength potency equation returns a value representing a set's effectiveness for developing Maximum-Strength and strength in general. The strength potencies of AMRAP for all intensities (12-99%) are in tables 1-3.

Intensity	AMRAP	Strength Potency
99	1	99%
98	1	98%
97	2	98%
96	2	97%
95	2	96%
94	3	96%
93	3	95%
92	3	94%
91	4	94%
90	4	93%
89	4	92%
88	5	92%
87	5	90%
86	5	89%
85	6	89%
84	6	88%
83	7	88%
82	7	87%
81	7	86%
80	8	86%
79	8	85%
78	8	83%

Table 1: AMRAP Strength Potencies- Int. 78-99%.

77	9	83%
76	9	82%
75	9	81%
74	10	81%
73	10	80%
72	10	78%
71	11	78%
70	11	77%
69	12	77%
68	12	75%
67	13	75%
66	13	74%
65	14	73%
64	14	72%
63	15	72%
62	15	71%
61	16	70%
60	16	69%
59	17	68%
58	17	67%
57	18	67%
56	19	66%
55	19	65%
54	20	64%
53	21	64%
52	22	63%
51	23	62%
50	24	62%
49	25	61%
48	26	60%
47	27	59%
46	28	58%
45	29	58%

Table 2: AMRAP Strength Potencies- Int. 45-77%.

44	30	57%
43	31	56%
42	32	55%
41	34	55%
40	35	54%
39	37	53%
38	38	52%
37	40	51%
36	41	50%
35	43	50%
34	45	49%
33	47	48%
32	49	47%
31	51	47%
30	53	46%
29	55	45%
28	58	44%
27	60	43%
26	63	42%
25	65	41%
24	68	40%
23	71	39%
22	74	38%
21	77	37%
20	80	36%
19	83	35%
18	87	33%
17	90	32%
16	94	31%
15	98	30%
14	102	28%
13	106	27%
12	110	25%

Table 3: AMRAP Strength Potencies- Int. 12-44%.

4. Resistance/Intensity Zones

Concerning the F-S-V continuum, Strength and Work Capacity are relative to the grade of resistance of the work.

To clearly define the abilities of the continuum, we must look at the resistance zone schema of Naglak from “The Science of Sport’s Training” by Thomas Kurz and see how it relates to AMRAP (As Many Reps As Possible; maximal reps per set) with all intensities. Naglak’s schema is in figure 1.

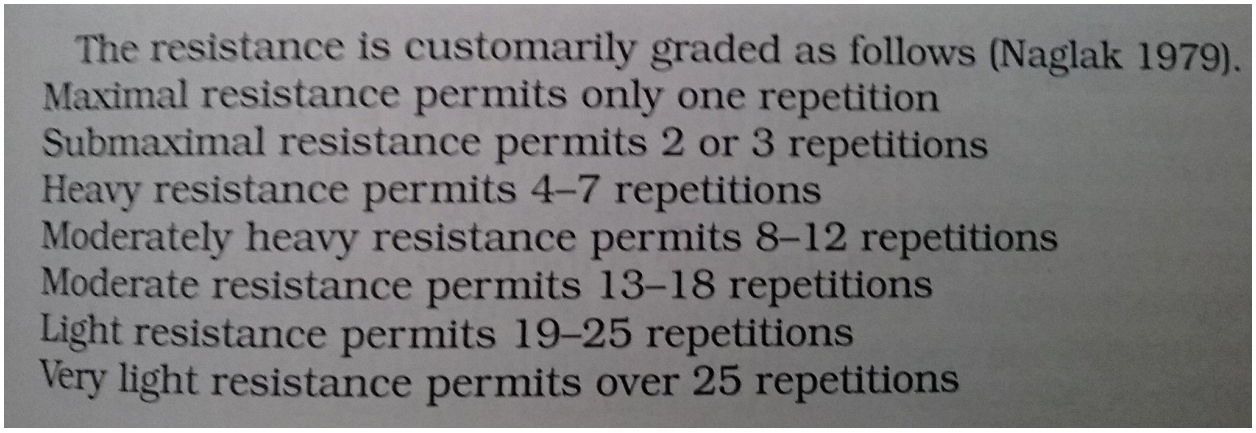


Figure 1: Resistance Zones according to Naglak.

Naglak broke the gradation of resistance into the following zones-

- Maximal: AMRAP = 1 rep
- Submaximal: AMRAP = 2-3 reps
- Heavy: AMRAP = 4-7 reps
- Moderately-Heavy: AMRAP = 8-12 reps
- Moderate: AMRAP = 13-18 reps
- Light: AMRAP = 19-25 reps
- Very-Light: AMRAP > 25 reps

With the AMRAP equation from the previous section, we can align Naglak's grades with exacting intensity zones. The results are in table 4.

Intensity Zone	Resistance Grade
98-99%	Maximal
92-97%	Submaximal
81-91%	Heavy
68-80%	Moderately-Heavy
57-67%	Moderate
40-56%	Light
<40%	Very Light

Table 4: Intensity Zones and Resistance Grades.

The information in table 1 allows us to place a resistance grade on any training set according to the intensity. For the Abilities terms of the F-S-V continuum, we then call label any intensity

according to the resistance grade. For instance, in the F-S-V continuum, 70% intensity is labeled Moderately-Heavy since it falls under that grade of resistance.

We then attach the appropriate resistance grade label to the two ability categories of the continuum and arrive at two overlapping ability lists-

Strength

- Maximum Strength
- Submaximum Strength
- Heavy Strength
- Moderately-Heavy Strength
- Moderate Strength
- Light Strength
- Very-Light Strength

Work Capacity

- Maximal Resistance Work Capacity
- Submaximal Resistance Work Capacity
- Heavy Resistance Work Capacity
- Moderately Heavy Resistance Work Capacity
- Moderate Resistance Work Capacity
- Light Resistance Work Capacity
- Very-Light Resistance Work Capacity

5. Work Capacity Potency

The Work Capacity Potency of a set is relative to the resistance grade of the set and is determined by the degree of intensity-specific set-level fatigue. The set-level fatigue equation is in section 3. To define the Work Capacity potency of a set, we label the work capacity of the set with the appropriate grade of resistance label and place the percentage of fatigue beside it. Table 5 shows the results for AMRAP (100% fatigue) with various intensities.

Set Metrics			Adaptation	
Intensity	Reps	Fatigue	Ability Developed	Potency
95	2	100.0%	Submaximal Resistance Work Capacity	100%
90	4	100.0%	Heavy Resistance Work Capacity	100%
85	6	100.0%	Heavy Resistance Work Capacity	100%
80	8	100.0%	Moderately-Heavy Resistance Work Capacity	100%
75	9	100.0%	Moderately-Heavy Resistance Work Capacity	100%
70	11	100.0%	Moderately-Heavy Resistance Work Capacity	100%
65	14	100.0%	Moderate Resistance Work Capacity	100%
60	16	100.0%	Moderate Resistance Work Capacity	100%
55	19	100.0%	Light Resistance Work Capacity	100%
50	24	100.0%	Light Resistance Work Capacity	100%
45	29	100.0%	Light Resistance Work Capacity	100%
40	35	100.0%	Light Resistance Work Capacity	100%
35	43	100.0%	Very-Light Resistance Work Capacity	100%

Table 5: Resistance grade-specific manifestations of Work Capacity and its potency from AMRAP sets.

Table 6 shows the results for non-AMRAP sets with various intensities.

Set Metrics			Adaptation	
Intensity	Reps	Fatigue	Ability Developed	Potency
75	8	88.3%	Moderately-Heavy Resistance Work Capacity	88%
70	9	80.1%	Moderately-Heavy Resistance Work Capacity	80%
65	11	76.1%	Moderate Resistance Work Capacity	76%
60	12	71.7%	Moderate Resistance Work Capacity	72%
55	14	70.0%	Light Resistance Work Capacity	70%
50	17	66.3%	Light Resistance Work Capacity	66%
45	19	59.1%	Light Resistance Work Capacity	59%
40	20	47.2%	Light Resistance Work Capacity	47%
35	23	41.9%	Very-Light Resistance Work Capacity	42%

Table 6: Resistance grade-specific manifestations of Work Capacity and its potency from non-AMRAP sets.

To optimize athletic strength & conditioning training programs, a coach must determine what grade of work capacity is most important for an athlete's performance according to the objective of a particular preparation or competitive period. Once a coach makes this critical determination,

they can use the work capacity potency calculations to optimize the development (by integrating with the Loading calculation system of the first paper) of work capacity to ensure the fulfillment of the period's objectives.

5.1 Determining the primary F-S-V Ability Trained in a set

To determine whether a set falls into the strength or work-capacity category, we can compare the Strength Potency and Work Capacity Potency; whichever value is higher determines how we label the set in terms of the primary Ability trained. Of course, there is quite a bit of overlap in terms of the adaptive effects of Strength and Work Capacity (and with the Abilities of the Velocity-Power-Force Continuum as well), so coaches should view all the ability potencies of each set to get a fully comprehensive view of the effect(s) of the set.

The purpose of the"ability trained" label of sets is to give the coach an excellent topographical bird's-eye view of the training program; to know approximately what an athlete's qualitative/quantitative physical preparedness will look like at any moment in the future according to a training program. A more detailed view is obtained by zooming in and viewing the exact potencies of training units.

6. F-S-V Continuum Attributes

Work Capacity refers to the performance/functional modality of the F-S-V continuum. The "S" stands for "structure" and refers to structural developments from training and the structural *attributes* of the athlete's organism. For performance, our primary concern in training is to develop the athlete's functional abilities, but functional factors are largely dependent on structural factors. For this reason, physiological attribute training potencies are very valuable for training programming.

6.1 Mass

The structural attribute that most concerns strength & conditioning coaches is muscle Mass. For this reason, it is crucial to create a Mass potency equation to develop a complete potency schema for the whole physiological ability spectrum.

For this purpose, it is necessary to understand first what the physiological attribute of "Mass" means.

> **Mass:** Refers to muscular hypertrophy of the muscles of one's body.
> *Athletic Example: Physique Development for Bodybuilding competition.

Muscle mass development depends on muscular protein degradation, which occurs through lifting. After a training session, degraded proteins recover and hypertrophy to secure a higher work capacity for future action.

> **Hypertrophy** [hīˈpərtrəfē] NOUN — physiology
> 1. **the enlargement of an organ or tissue from the increase in its cells' size.**

The level of protein degradation from a single rep depends on the amount of force overcome. Naturally, the maximum amount of degradation from a single rep occurs with 100% intensity (99% in the StratFit loading system).

The total amount of degradation of a set of multiple reps (Repetition Method) depends on the total amount of work done *above a certain critical intensity*. If the intensity is too low, the force overcome will not be enough to damage the working muscle fibers significantly; thus, no hypertrophy will occur. This is why muscle mass does not increase from distance running; the total work is high, but the force overcome is low.

Serious bodybuilders have known for decades that weights that allow 6-12 reps per set, with the final rep being challenging to complete, are most effective for developing lean mass. Performing AMRAP in this rep range is highly potent for developing mass. Traditionally, this wisdom led to the intensity range between approximately 60-80% being the most used in bodybuilding training.

Therefore, to determine the set's mass potency, an equation that takes the intensity and number of reps into account must be created, with more emphasis on the number of reps. The following equation provides a logical value:

$$R * I^3$$

Where

R = *Reps*

I = *Intensity as a % (not as a whole number)*

The highest value occurs with AMRAP (rounded) for 77% intensity, a quantity of **4.10.** This finding corresponds perfectly to traditional bodybuilding wisdom. Table 7 shows the quantities of AMRAP (rounded) with 77-99% intensities.

Intensity	AMRAP	Rep * Int. * Int. * Int.
99	1	**0.970299**
98	1	**0.941192**
97	2	**1.825346**
96	2	**1.769472**
95	2	**1.71475**
94	3	**2.491752**
93	3	**2.413071**
92	3	**2.336064**
91	4	**3.014284**
90	4	**2.916**
89	4	**2.819876**
88	5	**3.40736**
87	5	**3.292515**
86	5	**3.18028**
85	6	**3.68475**
84	6	**3.556224**
83	7	**4.002509**
82	7	**3.859576**
81	7	**3.720087**
80	8	**4.096**
79	8	**3.944312**
78	8	**3.796416**
77	9	**4.108797**
76	9	**3.950784**

Table 7: Mass potencies for AMRAP of intensities 76-99%.

Table 8 shows the quantities for AMRAP (rounded) for the whole traditional bodybuilding intensity range: 60-80%.

Intensity	AMRAP	Rep * Int. * Int. * Int.
80	8	**4.096**
79	8	**3.944312**
78	8	**3.796416**
77	9	**4.108797**
76	9	**3.950784**
75	9	**3.796875**
74	10	**4.05224**
73	10	**3.89017**
72	10	**3.73248**
71	11	**3.937021**
70	11	**3.773**
69	12	**3.942108**
68	12	**3.773184**
67	13	**3.909919**
66	13	**3.737448**
65	14	**3.84475**
64	14	**3.670016**
63	15	**3.750705**
62	15	**3.57492**
61	16	**3.631696**
60	16	**3.456**

Table 8: Mass quantities for AMRAP of the traditional bodybuilding intensity range.

To determine the Mass potency of any set, we divide the Mass quantity of the set by the Mass quantity maximum maximorum: **4.108797**

The potencies of several sets with various intensities and numbers of reps are in table 9.

Intensity	Reps	Mass Potency
99	1	**23.62%**
95	1	**20.87%**
90	3	**53.23%**
84	5	**72.13%**
77	9	**100.00%**
70	10	**83.48%**
55	16	**64.79%**
40	36	**56.07%**
20	81	**15.77%**

Table 9: Mass potencies for AMRAP of intensities 76-99%.
*Note: Not all examples are AMRAP.

The calculation of Mass Potency for all training sets allows for the optimization of any bodybuilding program or a mass gaining phase in any strength & conditioning program.

6.2 Burn

In StratFit terminology, "Burn" training Refers to the physical processes/adaptations of delaying the Onset of Blood Lactate Accumulation during exercise and the improvement in the rate at which one's system removes lactate as well as the increase in the efficiency with which lactate is converted to glucose. “Burn” is also associated with the general development of anaerobic endurance and a high amount of calorie burning in training for body-fat loss.

Like Mass set potency, intensity and reps directly determine the set potency for Burn, but in this case, the total reps done is most critical. To determine the Burn potency of a set, a quantity that takes both intensity and reps into account but places much more emphasis on the reps done is needed.

Multiplying the number of reps by intensity provides a logical quantity.

$$R * I$$

Where

$R = Reps$

$I = Intensity\ as\ a\ \%\ (not\ as\ a\ whole\ number)$

The highest quantity is returned by multiplying 24% intensity by AMRAP (for 24%, 69 reps, [rounded]), **16.56.** This finding corresponds to actual training practice. Everyone knows that the most significant level of "the burn" happens when a lifter performs a very high number of reps with light or very-light resistance.

To determine the burn potency of any set, we divide the burn quantity of the set by the burn quantity maximum maximorum: 16.56. The burn potencies of AMRAP (rounded) sets with various intensities are in table 10.

Intensity	Reps	Burn Potency
65	14	**55%**
60	16	**58%**
55	19	**63%**
50	24	**72%**
45	29	**79%**
40	35	**85%**
35	43	**91%**
30	53	**96%**
24	69	**100%**

Table 10: “Burn” attribute potency with various intensities, AMRAP sets.

The Mass and Burn attribute potency equations give a coach more precise insight into the adaptational effects from a set in which work capacity of any grade is the primary ability developed.

Summary

This paper defined the two overlapping ability concepts of the Force-Structure-Vegetative continuum: Strength and Work Capacity.

I reiterated several important concepts from my previous work on Strength Potency (Applied Mathemetical Science of Training Part 4). I provided the equations for calculating AMRAP, the percentage of intensity-specific set-level fatigue, and finally, the Strength Potency of a training set.

I defined the grades of resistance zones according to Naglak and, using the AMRAP equation, alligned them with exact intensity ranges to provide more utility and clarity to the grade of resistance concept.

I detailed how to use the grade of resistance zone labels to define the grade of work capacity developed in a set and how to combine this will the percentage of fatigue accumulated to determine the resistance grade-specific work capacity potency of a set.

I described how the more extensive nature of training sets of the F-S-V continuum (relative to the V-P-F continuum) lends itself to developing and defining specific physiological attributes alongside the abilities.

I defined these attributes as Mass and Burn and detailed the specificities of these attributes and the equations for determining their training potencies from a set.

Conclusion

Many sports present an athlete with a demand for continuous work. Sports like Rugby, Jui-Jitsu, Judo, Sambo, Greco-Roman, and freestyle wrestling require sufficient work capacity, primarily in the Moderately-Heavy to Submaximal zones. Distance running/cycling/swimming requires very extensive work capacity in the light and very-light zones and development of the Burn attribute to sustain effective action.

These sports can present a high degree of work capacity variability to the athlete in competition, so work capacity grade versatility is often a requirement for success.

Excellent strength & conditioning coaches can analyze the competitive activities of an athlete, determine the ratios of the intensity zones encountered, and use the work capacity potency equation to develop the precise adaptive endurance profile through training to ensure success.

Integration of the Force-Structure-Vegetative continuum system with the Strength potency and the Velocity-Power-Force continuum system provides coaches with the mathematical tools to secure precise full-spectrum development of an athlete's abilities from Speed to Power to Strength to Work Capacity. The ability potency concepts and calculation system increases not only the athletic potency of athletes but also the effective potency of the coach as a variable in the process of athletic preparation.

Works Cited

Verkhoshansky, Yuri V. & Mel C. Siff. *Supertraining*. Verkhoshansky.com, 2000

Kurz, Thomas, Science of Sports Training, Stadion Publishing Company, Incorporated, 1991

McKee, Daniel. *Applied Mathematical Science of Physical Training Part 4: Strength Potency.* Stratfit.net, 2022

McKee, Daniel. *Applied Mathematical Science of Physical Training Part 1: Barbell Loading.* Stratfit.net, 2021

McKee, Daniel. *Applied Mathematical Science of Physical Training Part 5: Velocity-Power-Force Continuum Potencies.* Stratfit.net, 2021