encyclopedia

Entry

Pyramidal Systems in Resistance Training

Grégoire Hugues Cattan

Independent Researcher, 05601 Montpellier, France; gcattan@hotmail.fr

Definition: Pyramidal systems refer to a particular type of resistance training in which sets are performed with increasing (or decreasing) weight, in such a way that the number of repetitions is low when the weight is high (and vice versa). Multiple implementations exist such as the light-to-heavy, triangle or asymmetric triangle system. They are similar to traditional training, but with slightly different impact on training volume, endurance or power outcome. Therefore, pyramidal systems are ideal candidates for practitioners willing to tune their training routine.

Keywords: resistance training; pyramidal systems; pyramidal training; comparison; heavy-to-light pyramid; light-to-heavy pyramid; asymmetric pyramid

check for updates

Citation: Cattan, G.H. Pyramidal Systems in Resistance Training. *Encyclopedia* **2021**, *1*, 423–432. https://doi.org/10.3390/encyclopedia1020035

Academic Editor: Antonio Cicchella

Received: 17 March 2021
Accepted: 25 May 2021
Published: 28 May 2021

1. Introduction

Resistance training refers to a specialized method of conditioning which involves the progressive use of a wide range of resistive loads and a variety of training modalities designed to enhance health, fitness, and sports performance [1]. Muscular resistance exercises usually consist of one or multiple sets of repetitions spaced by resting time using the same or different resistance. Although one set requires less time to be executed than multiple sets, performing multiple sets results in greater strength and hypertrophy [2,3]. Fitness enthusiasts and researchers have created several multiset training systems, such as circuits, drop and strip, superset, and pyramidal training. A ubiquitous recommendation from domain references, such as the American College of Sports Medicine (ACSM) or National Strength and Conditioning Association (NSCA), is to perform two to three sets with 8 to 12 repetitions at 67–85% of the one-repetition maximum (1RM) [4,5]. The present research refers to such a style of training as *traditional training*. Traditional training varies according to athletes' level and trainability, such as age and previous training experience. In particular, regular variation of the training program, such as changing the training method or volume, is necessary to maintain the progression. This is because the body quickly adapts to resistance training, and thus changes are necessary for continual progression to occur [6]. Regarding age, experts recommend tailoring the physical activity to the subject's limitations and chronic conditions [7]. Having several resistance training methods to draw on allows the routine to be adapted to the practitioner's physical condition and avoids a plateau in progression. The pyramidal system of training refers to methods in which sets are performed with increasing (or decreasing) weights and repetitions, in such a way that the number of repetitions is low when the weight is high (and vice versa) [8]. In this article, we conduct a narrative review of the pyramidal method. Methodology for this review is presented in Section 2. Section 3 presents the physiological adaptations to pyramidal training, while Sections 4–6 define then draw comparisons of pyramidal systems, one to each other and with traditional training. The discussion and conclusion are presented in Section 7.

2. Method

In order to conduct this narrative review, studies were searched in Scholar (Google, Mountain View, CA, USA) and PubMed (NCBI, Bethesda, MD, USA) by using combinations of the following keywords: "Adaptation", "Cardiovascular", "Comparison", "Heavy-to-Light", "Light-to-Heavy", "Pyramid", "Pyramidal", "Resistance", "Sport", "Strength", "System", "Training", "Triangle". We then restricted the scope of the search to resistance and strength training and removed from the analysis all studies focusing on the domain of endurance sport, formation, and cognition. All types of publication, except for opinion and poster, were considered.

3. Physiological Adaptation to Pyramidal Resistance Training

The body's adaptation to pyramidal and, in general, resistance training occurs in many systems, including the cardiovascular, endocrine, nervous, and immune systems. An exhaustive literature review is presented in Fleck et al. [8] and Schoenfeld [9]. The following sections describe these adaptations.

3.1. Anaerobic Adaptations

Resistance training usually involves short and intense bouts of exercise (<2 min), and, therefore, relies heavily on the anaerobic pathway for energy production. Energy is produced through the degradation of creatine phosphate and glucose into ATP without the need of oxygen. These reactions are fast compared with the aerobic pathway, though they deliver significantly less energy. Resistance training results in the augmentation of the creatine, glycogen, and ATP concentration, leading to an improved anaerobic pathway [10].

3.2. Aerobic Adaptations

The mitochondria are micro-organisms that are present in the body's cells. They are responsible for the conversion of glucose and fat into ATP using oxygen. In general, training increases the number of mitochondria inside the muscular cells, which results in a higher proportion of energy expenditure from the aerobic pathway during exercise, thereby sparing muscle glycogen and creatine reserve. This effect is sustained by the redirection of blood flow to the working muscles while exercising, which, supported by an improved cardiac output function, ensures the continued delivery of oxygen, liver glycogen, and fat.

Although the improvement in fat metabolism and the aerobic pathway is less pronounced in resistance versus endurance training, it is known that resistance training enhances local muscle endurance [8]. This results in an increased ability to perform repetitions during a set, which in turn produces higher hypertrophy and strength, as these training outcomes tend to increase as a function of the training volume.

Pyramidal methods likely enhance aerobic energy mechanisms, thereby enhancing local endurance more so compared with traditional training, as first sets are performed with less weight, which allows for more repetitions to be performed. Mohammadi et al. [11] and Omidbakhsh et al. [12] demonstrated that pyramidal methods efficiently enhance wrestling athletes' endurance. However, to the best of our knowledge, endurance outcome in traditional versus pyramidal resistance training was never compared.

3.3. Neural Adaptations

The expected effect of the pyramidal method and, in general, resistance training is an increase in strength due to neural and muscular adaptation. Neural adaptations occur first in beginners, causing changes in the motor unit firing pattern [13]. In practice, this means that strength depends on the number of myofibers that motor units can recruit to perform a movement while releasing antagonist muscle and protecting joints.

3.4. Muscular Adaptations

High-intensity training, such as training to failure, causes micro-myofiber lesions, which results in soreness and muscle catabolism. This sets off a chain of myogenic events leading to an increase in myofiber size (hypertrophy) and—to a lesser and controversial extent—an increase in their number (hyperplasia). Hypertrophy is likely mediated by satellite cells, which activate when sufficient mechanical stimuli are imposed on skeletal muscles. Satellite cells then proliferate and fuse to existing cells or create new myofibers [9,14].

Blood occlusion through asphyxia during exercise likely contributes to hypertrophy [15]. It is possible that blood occlusion inhibits myostatin [16], which is known to play a role in cachexia. Although pyramidal training is suspected of impacting microvascular oxygenation during exercise, recent findings suggest that microvascular oxygenation is similar in pyramidal and traditional training [17].

Resistance training also changes muscle composition by stimulating type IIA and type IIX myofibers. Both allow for quick force production and muscle contraction but are less resistant to fatigue compared to type I fibers, which are typically associated with endurance. However, type IIA fibers incorporate more mitochondria and, therefore, are more resistant to fatigue than type IIX fibers. Hypertrophy applies to all fiber types, although type I fibers are impacted to a lesser extent.

As demonstrated in Section 6.1, muscular adaptations to resistance and pyramidal training are similar.

3.5. Endocrinal Adaptations

Hormones and cytokines, such as insulin, growth hormone, or testosterone, are upstream regulators of muscle anabolism. In general, hormonal regulation of hypertrophy is complex and the importance of hormones in the physiological adaptations resulting from exercise should be considered with caution [9,10].

For example, although testosterone is a well-known anabolic hormone, the testosterone level of elite athletes is lower than the reference range for non-elite men. Further, powerlifters have a lower testosterone level on average compared with levels recorded in other sports, such as skiing or basketball [18]. These surprising findings suggest that it is rather the sensitivity threshold to testosterone that increases in training. Ribeiro et al. [19] have shown that, for older women, blood concentration of testosterone and insulin was similar in pyramidal and traditional training. Results are hardly generalizable, though, because only older women participated in the study. Nevertheless, to the best of our knowledge, hormonal response induced by pyramidal and traditional training are comparable.

3.6. Cardiovascular Adaptations

Although resistance training is not a type of cardiovascular training, the compression of blood vessels along with the Valsalva maneuver produces extreme blood pressure [20]. This response is attenuated in trained athletes during exercises [21]. The impact of resistance training on cardiovascular function was outlined in recent studies, with positive effects on blood pressure noted at rest [22], although the underlying mechanisms for this remain under investigation [23]. One study [24] found that the pyramidal method specifically reduced blood viscosity, thereby diminishing cardiovascular risk factors.

Despite these positive effects, there is an increase in aortic stiffness when performing high-intensity resistance training [25–27]. Aortic stiffness is associated with lower muscular strength [28] and is an established risk factor for cardiovascular morbidity. The mechanisms that underlie the loss of aortic compliance following strength training are not clear [15], though this can be compensated for by adding an aerobic component to the training [29,30]. In this respect, the effects of pyramidal training on aortic compliance deserve further investigation, particularly because of its impact on endurance, that is, aerobic capacity.

4. Classification of Pyramidal Training Systems

To our knowledge, there are five common pyramidal systems, which are defined as follows:

- Half-triangle pyramid:
    - Heavy-to-light (HL): the practitioner decreases the weight between sets while increasing the number of repetitions.

  - Light-to-Heavy (LH): the practitioner increases the weight between sets while decreasing the number of repetitions.
- Triangle pyramid: a combination of HL and LH protocols, as follows:
  - Double progressive system or reversed pyramid (RP): a combination of an HL pyramid followed by an LH pyramid, except that only the number of repetitions increases in the first phase while the weight remains the same.
  - Symmetric pyramid (SYM): a combination of an LH pyramid followed by an HL pyramid in which sets from the LH phase are applied in reverse order in the HL phase.
  - Asymmetric or diagonal pyramid (ASYM): similar to SYM pyramid, except the number, weight, and repetition number of sets differ between the first and second phases.

Examples of pyramidal training protocols are described in Table 1.

Table 1. Training volume difference * between pyramidal and resistance training, depending on if the training targets strength endurance (green), hypertrophy (orange) or maximum strength (red).

Training	Traditional	LH **	HL **	SYM **	ASYM **	RP **
Set 1	12 × 75	15 × 65	6 × 85	15 × 65	15 × 65	6 × 65
Set 2	12 × 75	10 × 75	10 × 75	10 × 75	10 × 75	10 × 65
Set 3	12 × 75	6 × 85	15 × 65	6 × 85	6 × 85	15 × 65
Set 4				10 × 75	15 × 65	10 × 75
Set 5				15 × 65		6 × 85
Volume ***Total***	2700	2232	2232	3960	3210	3275
Volume ***Strength endurance***	0	975	975	1950	1950	2015
Volume ***Hypertrophy***	2700	750	750	1500	750	750
Volume ***Maximum strength***	0	510	510	510	510	510

* For simplification purposes, we only compare the training volume for a same practitioner and exercise. Therefore, we only report the amount of lifted weight (i.e., repetition × kg) because the displacement of the weight is the same for all training volume values. Weight is indicated here as a percentage of the 1RM. ** This table uses the abbreviation defined in Section 3: light-to-heavy (LH), heavy-to-light (HL), symmetric pyramid (SYM), asymmetric pyramid (ASYM), reversed pyramid (RP).

5. Training Volume of Pyramidal Methods

Training volume refers to the amount of work (in joules) performed during a given period, such as one training session or one week [8]. For example, an exercise performed once a week, consisting of 10 squats at 100 kg, results in 9800 N/week. Assuming that the vertical distance traveled by the weight during the exercise is around 0.5 m, the resulting amount of work is equal to 4900 J/week. When comparing training volumes produced by a practitioner on the same exercise, such traveled distance is always identical and thus the training volume can be estimated by only multiplying the weight with the number of repetitions—that is, 9800 N/week in our example.

There is a clear relationship between training volume and outcomes, such as increases in strength and power, decreases in body fat, and improved motor performance. It has been suggested that the training volume is more important than the training frequency and number of sets in terms of strength gains [8]. A recent meta-analysis [31] demonstrated that an increase in resistance training volume produced higher hypertrophy and concluded that a dose-dependent effect was responsible. The same conclusion has also been applied to endurance training [32], although this is more controversial [33]. Costill et al. [33] studied the implication of short versus long training sessions on swimming performance (assessed by the 25 and 400 yard tests). Training consisted of intermittent bouts of exercise (i.e., interval training) in all four of the swimming strokes. The study showed that swimmers who trained 3 h per day did not improve their performance compared to swimmers who trained only 1.5 h per day. However, it could be that the test was not adapted to the training provided, or swimmers from the first group were overtrained. In sum, all training outcomes are dose-dependent on training volume unless the training volume exceeds athletes' capacity to rest and compensate. Table 1 illustrates the training volume across the different types of pyramidal training. The table adopts the training volume classification of the NCSA [5], that is, maximum strength (for repetitions ≤ 6 and weight $\geq 85\%$ 1RM), hypertrophy (for repetitions and weight respectively in the ranges 6–12 and 67–85% 1RM) and strength endurance (for repetitions ≥ 12 and weight $\leq 67\%$ 1RM).

6. Comparison of Pyramidal Training Systems

Training with heavy or light weights results in different muscular adaptations: endurance, strength, hypertrophy, or power. Therefore, pyramidal training is a priori a very complete method of producing all these adaptations within a single exercise compared with traditional training. Having said that, there are significant differences between different pyramidal systems.

6.1. Comparison with Traditional Training

Evidence suggests that half-triangle pyramids and traditional training are equivalent in terms of strength gains and muscle hypertrophy. Angleri et al. [34] conducted a randomized intrasubject study over 12 weeks of leg training. Participants trained one leg with traditional training and the other leg using the drop-set or LH system. The study showed that LH and drop-set systems did not result in a significantly greater increase in 1RM or muscle cross-section area compared with traditional training. All subjects in the study were already well trained. However, interestingly, the same results were observed in another population. In an eight-week full-body randomized training crossover study [35], Ribeiro et al. showed that there was no difference between the increase in muscle quality between an 8-weeks traditional or LH training. Muscle quality is defined by the maximal force produced per unit of muscle mass [36] and was computed by dividing the heaviest weight lifted in 1RM by the skeletal muscle mass (estimated by dual X-ray absorptiometry). Regardless of muscle hypertrophy and composition, this indicates that the amount of strength relative to the size of the muscle improved similarly between the two kinds of trainings. In another analysis of the same experiment [19], Ribeiro et al. showed that both trainings similarly impacted muscular strength (1RM) and hypertrophy (estimated by dual X-ray absorptiometry). However, only older women participated in the study, and the impact of contraction types (eccentric, concentric, plyometric, or isometric) was not discussed in these studies.

For a practitioner willing to spare time, half-triangle pyramids have a lower workload than traditional training or triangle pyramids (Table 1). In fact, by working at a higher intensity, pyramidal methods recruit an increased number of fast-moving motor units, which compensated for the loss of training volume. Triangle pyramids have the same or a slightly higher training volume than traditional training. However, the number of repetitions performed at low intensity and high frequency is higher in triangle pyramids than in traditional or half-pyramidal training. That is, a greater endurance outcome can be expected in triangle pyramids versus traditional training.

In contrast, Costa et al. [37] showed that pyramidal training led to a decrease in performance in the lower (but not the upper) limbs of the body during a training session. Compared with traditional training, this suggests that pyramidal training leads to more rapid failure, leading to reduced training volume and increased rest between sessions.

Although this finding should be approached with caution, it suggests that pyramidal methods offer fewer benefits compared with traditional methods of resistance training.

6.2. Comparison between HL and LH Protocols

In a study by Leighton et al. [38] that was reported in Fleck et al. [8], the effectiveness of eight different protocols was evaluated by comparing isometric strength outcomes. In particular, the authors compared the HL (Oxford) and LH (Delorme) protocols. They found a significant increase between pre- to post-training strength in (1) elbow flexion for Delorme and (2) in elbow flexion and extension for Oxford. Improvement of elbow flexion strength was comparable between the two protocols, but HL was superior to LH for increasing isometric elbow extension and back and leg isometric strength (measured by means of a leg dynamometer). This suggests that the two methods may have different impacts on the upper or lower limbs of the body.

In theory, fatigue occurs earlier in LH pyramids, as the practitioner is already exhausted when reaching series with heavy weight. It has been reported (e.g., [11]) that the use of maximal loads and low repetitions exerts pressure on the muscular nervous system by calling on fast-moving motor units and changes the nervous activity of the muscle, thereby increasing muscle strength. This suggests that LH may produce lower strength outcomes than HL. However, in practice, HL also requires an extensive warm-up before reaching the highest workloads.

Miller [39] compared the HL and LH methods and concluded that the most important training bout should be performed first to reduce the effects of fatigue and allow for a greater number of repetitions to be performed. However, the protocol only included bench press as an exercise; though, as previously discussed in the present work, the effects may differ between the upper and lower limbs. The protocol also comprised only three sessions and five volunteers and only compared the number of repetitions between the two methods.

In sum, comparisons between HL and LH concerning strength gains are equivocal. This could mean that they produce different gains based on the type of contraction, as only isometric strength was evaluated in Leighton et al. [38]. Moreover, the effect size is high in Miller [39], as only a few participants were included in the study.

6.3. Comparison between Half-Triangle and Triangle Pyramids

Increasing, decreasing, and triangle pyramids affect strength, hypertrophy, and power similarly, but only triangle pyramids are likely to improve endurance. However, workload is lower in half-triangle versus triangle pyramids (Table 1).

6.4. Comparison of Triangle Methods

As pointed out by Mohammadi et al. [11], research outputs on triangle pyramids are conflicting. Previous studies have suggested that two different triangle pyramidal exercises lead to similar strength, endurance, hypertrophy, and anaerobic power outcomes, and also that different pyramidal patterns produce different outcomes based on which body limb is trained. Triangle pyramids can be compared as follows:

- Mohammadi et al. [11] showed that ASYM versus SYM pyramids produced higher absolute power gains when the movement was executed at the same speed in the two methods. Other variables, such as strength, endurance, body weight, and hypertrophy of the upper and lower limbs, were similar.
- As the diet was not controlled in this study, the lack of a significant difference between the body weight in ASYM versus SYM pyramidal training was discussed, and it was suggested that SYM pyramids may produce leaner athletes.
- ASYM and SYM pyramids (Table 1) offer a similar training volume at high intensity and endurance, except that the overall training volume is lower in ASYM versus SYM pyramidal training.

- In theory, RP training offers the same advantage as ASYM pyramids but with a slightly higher endurance training volume (Table 1). In practice, the first sets appear to be warm-up sets because they are not conducted to fatigue. The limited research on this method suggests that it should be avoided [8].

7. Discussion and Conclusions

Pyramidal and, in general, resistance training induce cardiovascular, endocrinal, and neural adaptations, as well as changes in muscle composition and size. This results in an increase in strength, power, hypertrophy, and local muscle endurance. Strength and hypertrophy outcomes are comparable between traditional and pyramidal training [17], except that triangle pyramids likely produce greater endurance as regards the dose-dependent relationship between outcomes and training volume. However, to our knowledge, this has not been investigated experimentally to date.

Endurance outcomes in resistance training are surprising in terms of the specificity principle, which holds that two different kinds of training produce distinct adaptations. In accordance with this principle, resistance training tends to improve anaerobic filial and increase myofiber size and their contractile properties, while endurance training results in an improvement in the aerobic filial with a decrease in myofiber size and contractile properties [40]. Reiss et al. [10] suggested that concurrent methods of training interfere with each other, overwhelming the body's capacity to compensate for the stimulation. In practice, interferences occur in the repetition zone of five to ten RMs, when the anaerobic threshold is greater than 75% to 85% of the VO_2max. In other words, strength and cardiovascular training are compatible, but intense cardiovascular training should be avoided while training for muscular hypertrophy.

In contrast, the impact of strength training for endurance athletes is not clear. Tanaka et al. [40] found that resistance training improved short- and long-term endurance in beginners and well-trained athletes. The authors suggested that both types of training, aside from their different adaptations mentioned above, resulted in the same changes from type IIX to type IIA myofibers. In addition, resistance training improved the lactate threshold in untrained individuals, thereby delaying the onset of fatigue in endurance training. However, the authors stated that resistance training should be specifically adapted to each endurance sport, reporting that a resistance training method used in cyclists was inefficient on swimmers. In addition, it is possible that strength training may limit the development of maximal aerobic capacity [41].

In short, the pyramidal method is an effective method for training for strength, hypertrophy, and power while having the added benefit of enhancing muscular endurance. This suggests that the pyramidal method is a good candidate for athletes who practice wrestling because combat training involves aerobic training interspersed with anaerobic effort [11]. Although the use of resistance in addition to endurance training is an interesting topic, the practice of resistance training should be carefully considered in light of the type of endurance performed, the training experience of the athlete (an improvement in the lactic threshold was only observed for beginners), the intensity of the endurance session (lower than 75 to 85% of VO_2max), and its potential on the maximal aerobic capacity. Further research could investigate the benefits of pyramidal training compared with periodization, including separate endurance and strength training.

Research has shown that different triangle pyramidal methods, such as flat or narrow pyramids, result in similar adaptations as resistance training [11]. However, the resulting power is significantly higher in ASYM pyramids compared with SYM pyramids, while it was shown (though the finding is controversial) that athletes following a SYM pyramid training were leaner [11]. Among the triangle pyramidal methods, only reverse pyramids should be avoided, although studies on RPs are rare [8]. A reasonable hypothesis is that first series in RP protocol should be conducted to fatigue in order to maximize endurance gains.

From a practitioner's point of view, half-triangle pyramids are more efficient than traditional and triangle pyramids because they produce similar strength and hypertrophy outcomes with a lower training volume. However, they also likely result in less local muscle endurance in light of the dose-dependent relationship with training volume. HL and LH are two ubiquitous half-triangle methods in which the weight is increased or decreased between each set. The differences between the two methods are equivocal, which could be due to the different effect sizes in prior studies. To the best of our knowledge, the impact of contraction type in HL versus LH pyramids has not been investigated to date. Ambiguity in terms of strength gains between these two types of pyramidal trainings could also mean that, from the practitioner's perspective, differences between the two methods are undetectable.

The effect of pyramidal training on body limbs was investigated by Costa et al. [37], Leighton et al. [38], and Mohammadi et al. [11]. Costa et al. [37] showed that pyramidal training decreased lower limb activity during a single bout of pyramidal training compared with traditional training. This is consistent with Leighton et al. [38], who showed that LH Delorme training and Oxford HL training significantly affected the upper limbs but not the legs and back. However, encouragingly, Mohammadi et al. [11] suggested that the impact of different types of pyramidal training on the body and upper limbs did not differ significantly.

From all studies presented in this review, only Costa et al. [37] suggested a decrease in performance of pyramidal versus resistance training. However, it should be emphasized that only immediate responses to resistance training were considered in Costa's study. Therefore, medium- and long-term effects of pyramidal versus traditional training are highly hypothetical and require an analysis over a longer period. Despite everything, this study demonstrates that different training methods (i.e., pyramidal, drop set or traditional training) may be used to modulate fatigue in line with the program objectives.

Elsewhere, studies have demonstrated that pyramidal training is an alternative to traditional training for disabled or aging individuals [19,35,42], though muscle electrical activity differs significantly between the pyramidal methods depending on the repetition zones [43]. The suitability of pyramidal training for disabled or aging individuals, as well as for well-trained athletes [17], suggests that pyramidal training is an effective method of resistance training for program variation across these populations. Nevertheless, it should be noted that the impact and comparison of training variables such as rest between series, speed of execution, amplitude of movement and diet on pyramidal methods was, in our opinion, insufficiently covered by the existing literature.

Funding: This research received no external funding.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflict of interest.

Entry Link on the Encyclopedia Platform: https://encyclopedia.pub/8691.

References

1. Faigenbaum, A.D.; Kraemer, W.J.; Blimkie, C.J.R.; Jeffreys, I.; Micheli, L.J.; Nitka, M.; Rowland, T.W. Youth Resistance Training: Updated Position Statement Paper From the National Strength and Conditioning Association. *J. Strength Cond. Res.* **2009**, *23*, S60–S79. [CrossRef]
2. Peterson, M.D.; Rhea, M.R.; Alvar, B.A. Maximizing Strength Development in Athletes: A Meta-Analysis to Determine the Dose-Response Relationship. *J. Strength Cond. Res.* **2004**, *18*, 377–382. [CrossRef]
3. Krieger, J.W. Single vs. Multiple Sets of Resistance Exercise for Muscle Hypertrophy: A Meta-Analysis. *J. Strength Cond. Res.* **2010**, *24*, 1150–1159. [CrossRef]
4. Westcott, W. Acsm strength training guidelines: Role in Body Composition and Health Enhancement. *ACSM's Health Fit. J.* **2009**, *13*, 14–22. [CrossRef]
5. *National Strength & Conditioning Association NSCA's Guide to Program Design*; Hoffman, J. (Ed.) Human Kinetics: Champaign, IL, USA, 2011; ISBN 978-1-4925-8277-9.
6. Ratamess, N.; Alvar, B.; Evetoch, T.; Housh, T.; Kibler, W.; Kraemer, W. Progression Models in Resistance Training for Healthy Adults [ACSM Position Stand]. *Med. Sci. Sports Exerc.* **2009**, *41*, 687–708.

7. Nelson, M.E.; Rejeski, W.J.; Blair, S.N.; Duncan, P.; Judge, J.O.; King, A.C.; Macera, C.A.; Castaneda-Sceppa, C. Physical Activity and Public Health in Older Adults. *Med. Sci. Sports Exerc.* **2007**, *39*, 1435–1445. [CrossRef]
8. Fleck, S.J.; Kraemer, W.J. *Designing Resistance Training Programs*, 4th ed.; Human Kinetics: Champaign, IL, USA, 2014; ISBN 978-0-7360-8170-2.
9. Schoenfeld, B.J. The Mechanisms of Muscle Hypertrophy and Their Application to Resistance Training. *J. Strength Cond. Res.* **2010**, *24*, 2857–2872. [CrossRef] [PubMed]
10. Reiss, D.; Prévost, P. *La Bible de la Préparation Physique—1re Édition: Le Guide Scientifique et Pratique Pour Tous*; Amphora: Paris, France, 2016; ISBN 978-2-7576-0124-2.
11. Mohammadi, M.; Siavoshy, H.; Rahimi, S. Comparison of the effect of two selected resistance training patterns on some physical and physiological factors of elite freestyle wrestler young boys. *Natl. J. Physiol. Pharm. Pharmacol.* **2017**, *8*, 1. [CrossRef]
12. Omidbakhsh, G.A.; Fathi, M.; Hejazi, K. Comparison the Effect of Eight Weeks Pyramid Resistance Training With two Patterns on Bio-motor Ability and Anthropometrical in Wrestlers. *J. Sport Biomech.* **2020**, *6*, 110–121. [CrossRef]
13. Gabriel, D.A.; Kamen, G.; Frost, G. Neural Adaptations to Resistive Exercise. *Sports Med.* **2006**, *36*, 133–149. [CrossRef]
14. Bruusgaard, J.C.; Johansen, I.B.; Egner, I.M.; Rana, Z.A.; Gundersen, K. Myonuclei acquired by overload exercise precede hypertrophy and are not lost on detraining. *Proc. Natl. Acad. Sci. USA* **2010**, *107*, 15111–15116. [CrossRef]
15. Tagawa, K.; Ra, S.-G.; Kumagai, H.; Yoshikawa, T.; Yoshida, Y.; Takekoshi, K.; Sakai, S.; Miyauchi, T.; Maeda, S. Effects of Resistance Training on Arterial Compliance and Plasma Endothelin-1 Levels in Healthy Men. *Physiol. Res.* **2018**, *67*, S155–S166. [CrossRef] [PubMed]
16. Laurentino, G.C.; Ugrinowitsch, C.; Roschel, H.; Aoki, M.S.; Soares, A.G.; Neves, M.; Aihara, A.Y.; Fernandes, A.D.R.C.; Tricoli, V. Strength Training with Blood Flow Restriction Diminishes Myostatin Gene Expression. *Med. Sci. Sports Exerc.* **2012**, *44*, 406–412. [CrossRef] [PubMed]
17. Angleri, V.; De Oliveira, R.; Biazon, T.M.P.C.; Damas, F.; Borghi-Silva, A.; Barroso, R.; Libardi, C.A. Effects of Drop-Set and Pyramidal Resistance Training Systems on Microvascular Oxygenation: A Near-Infrared Spectroscopy Approach. *Int. J. Exerc. Sci.* **2020**, *13*, 1549–1562. [PubMed]
18. Sonksen, P.H.; Holt, R.I.G.; Böhning, W.; Guha, N.; Cowan, D.A.; Bartlett, C.; Böhning, D. Why do endocrine profiles in elite athletes differ between sports? *Clin. Diabetes Endocrinol.* **2018**, *4*, 3. [CrossRef] [PubMed]
19. Ribeiro, A.S.; Schoenfeld, B.J.; Fleck, S.J.; Pina, F.L.; Nascimento, M.A.; Cyrino, E.S. Effects of Traditional and Pyramidal Resistance Training Systems on Muscular Strength, Muscle Mass, and Hormonal Responses in Older Women: A Randomized Crossover Trial. *J. Strength Cond. Res.* **2017**, *31*, 1888–1896. [CrossRef]
20. MacDougall, J.D.; Tuxen, D.; Sale, D.G.; Moroz, J.R.; Sutton, J.R. Arterial blood pressure response to heavy resistance exercise. *J. Appl. Physiol.* **1985**, *58*, 785–790. [CrossRef]
21. Fleck, S.J. Cardiovascular adaptations to resistance training. *Med. Sci. Sports Exerc.* **1988**, *20*, S146–S151. [CrossRef]
22. Fagard, R.H. Exercise is good for your blood pressure: Effects of endurance training and resistance training. *Clin. Exp. Pharmacol. Physiol.* **2006**, *33*, 853–856. [CrossRef]
23. Melo, S.; Júnior, N.S.; Baraúna, V.; Oliveira, E. Cardiovascular Adaptations Induced by Resistance Training in Animal Models. *Int. J. Med Sci.* **2018**, *15*, 403–410. [CrossRef] [PubMed]
24. Ghanbari-Niaki, A.; Behzad Khameslo, M.; Tayebi, S.M. Effect of Pyramidal Training on Plasma Lipid Profile and Fibrinogen, and Blood Viscosity of Untrained Young Men. *Ann. Appl. Sport Sci.* **2013**, *1*, 47–56.
25. Miyachi, M. Effects of resistance training on arterial stiffness: A meta-analysis. *Br. J. Sports Med.* **2012**, *47*, 393–396. [CrossRef] [PubMed]
26. Cavalcante, J.; Lima, J.A.; Redheuil, A.; Al-Mallah, M.H. Aortic Stiffness. *J. Am. Coll. Cardiol.* **2011**, *57*, 1511–1522. [CrossRef] [PubMed]
27. Bertovic, D.A.; Waddell, T.K.; Gatzka, C.D.; Cameron, J.D.; Dart, A.M.; Kingwell, B.A. Muscular Strength Training Is Associated With Low Arterial Compliance and High Pulse Pressure. *Hypertens.* **1999**, *33*, 1385–1391. [CrossRef] [PubMed]
28. Fahs, C.A.; Heffernan, K.S.; Ranadive, S.; Jae, S.Y.; Fernhall, B. Muscular Strength is Inversely Associated with Aortic Stiffness in Young Men. *Med. Sci. Sports Exerc.* **2010**, *42*, 1619–1624. [CrossRef] [PubMed]
29. Burr, J.F.; Beck, J.L.; Durocher, J.J. The relationship of high-intensity cross-training with arterial stiffness. *J. Sport Health Sci.* **2019**, *8*, 370–375. [CrossRef]
30. Kawano, H.; Tanaka, H.; Miyachi, M. Resistance training and arterial compliance: Keeping the benefits while minimizing the stiffening. *J. Hypertens.* **2006**, *24*, 1753–1759. [CrossRef] [PubMed]
31. Schoenfeld, B.J.; Ogborn, D.; Krieger, J.W. Dose-response relationship between weekly resistance training volume and increases in muscle mass: A systematic review and meta-analysis. *J. Sports Sci.* **2016**, *35*, 1073–1082. [CrossRef]
32. Tudor, O.B.; Carlo, B. *Periodization-6th Edition: Theory and Methodology of Training*; Human Kinetics: Champaign, IL, USA, 2018; ISBN 978-1-4925-4480-7.
33. Costill, D.L.; Thomas, R.; Robergs, R.A.; Pascoe, D.; Lambert, C.; Barr, S.; Fink, W.J. Adaptations to swimming training: Influence of training volume. *Med. Sci. Sports Exerc.* **1991**, *23*, 371–377. [CrossRef]
34. Angleri, V.; Ugrinowitsch, C.; Libardi, C.A. Crescent pyramid and drop-set systems do not promote greater strength gains, muscle hypertrophy, and changes on muscle architecture compared with traditional resistance training in well-trained men. *Graefe's Arch. Clin. Exp. Ophthalmol.* **2017**, *117*, 359–369. [CrossRef]

35. Ribeiro, A.S.; Schoenfeld, B.J.; Souza, M.F.; Tomeleri, C.M.; Venturini, D.; Barbosa, D.S.; Cyrino, E.S. Traditional and pyramidal resistance training systems improve muscle quality and metabolic biomarkers in older women: A randomized crossover study. *Exp. Gerontol.* **2016**, *79*, 8–15. [CrossRef] [PubMed]
36. Fragala, M.S.; Kenny, A.M.; Kuchel, G.A. Muscle Quality in Aging: A Multi-Dimensional Approach to Muscle Functioning with Applications for Treatment. *Sports Med.* **2015**, *45*, 641–658. [CrossRef] [PubMed]
37. Costa, B.D.D.V.; Ferreira, M.E.C.; Gantois, P.; Kassiano, W.; Paes, S.T.; de Lima-Junior, D.; Cyrino, E.S.; Fortes, L.D.S. Acute Effect of Drop-Set, Traditional, and Pyramidal Systems in Resistance Training on Neuromuscular Performance in Trained Adults. *J. Strength Cond. Res.* **2021**, *35*, 991–996. [CrossRef]
38. Leighton, J.R.; Holmes, D.; Benson, J.; Wooten, B.; Schmerer, R. A study on the effectiveness of ten different methods of progressive resistance exercise on the development of strength, flexibility, girth and bodyweight. *J. Assoc. Phys. Ment. Rehabil.* **1967**, *21*, 78–81.
39. Miller, J. Comparison of Ascending and Descending Pyramidal Loading Using the Bench Press. *Int. J. Exerc. Sci. Conf. Proc.* **2013**, *2*, 41.
40. Tanaka, H.; Swensen, T.C. Impact of Resistance Training on Endurance Performance. A New Form of Cross-Training? *Sports Med.* **1998**, *25*, 191–200. [CrossRef] [PubMed]
41. Glowacki, S.P.; Martin, S.E.; Maurer, A.; Baek, W.; Green, J.S.; Crouse, S.F. Effects of Resistance, Endurance, and Concurrent Exercise on Training Outcomes in Men. *Med. Sci. Sports Exerc.* **2004**, *36*, 2119–2127. [CrossRef] [PubMed]
42. Andzik, N.; Cannella-Malone, H.I. A Review of the Pyramidal Training Approach for Practitioners Working With Individuals with Disabilities. *Behav. Modif.* **2017**, *41*, 558–580. [CrossRef] [PubMed]
43. Dos Santos, L.; Ribeiro, A.; Gobbo, L.; Nunes, J.; Cunha, P.; Campa, F.; Toselli, S.; Schoenfeld, B.; Sardinha, L.; Cyrino, E. Effects of Resistance Training with Different Pyramid Systems on Bioimpedance Vector Patterns, Body Composition, and Cellular Health in Older Women: A Randomized Controlled Trial. *Sustainability* **2020**, *12*, 6658. [CrossRef]