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The General Adaptation Syndrome: Potential Misapplications to Resistance Exercise

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Abstract
Within the resistance training literature, one of the most commonly cited tenets with respect to exercise programming is the “General Adaptation Syndrome” (GAS). The GAS is cited as a central theory behind the periodization of resistance exercise. However, after examining the original stress research by Hans Selye, the applications of GAS to resistance exercise may not be appropriate. **Objectives:** To examine the original work of Hans Selye, as well as the original papers through which the GAS was established as a central theory for periodized resistance exercise. **Methods:** We conducted a review of Selye’s work on the GAS, as well as the foundational papers through which this concept was applied to resistance exercise. **Results/Conclusions:** The work of Hans Selye focused on the universal physiological stress responses noted upon exposure to toxic levels of a variety of pharmacological agents and stimuli. The extrapolations that have been made to resistance exercise appear loosely based on this concept and may not be an appropriate basis for application of the GAS to resistance exercise.

**Key Words:** Stress; Adaptation Energy; Periodization; Strength and Conditioning; Skeletal Muscle; Exercise Physiology
Introduction

Within the resistance training literature, one of the most commonly cited tenets with respect to exercise programming is the “General Adaptation Syndrome” (GAS). This concept was first introduced in the 1930s by Hans Selye, and later adapted for exercise programming by J Garhammer and Fred Wilt in separate publications. In 1961, Forbes Carlile published a perspective proposing the acceptance of the GAS as a basic philosophical guide to coaching. However, this concept did not appear to become widely accepted (regarding its applications for resistance exercise) until its incorporation and discussion in a “theoretical model of strength training” outlined by Stone et al. in 1982. Within this model, it is suggested that the GAS applied to resistance exercise provides us with three phases of adaptation: Alarm, Resistance and Overtraining. As a result, periodization was developed to maximize adaptation while avoiding overtraining. This concept (GAS) has since become very well accepted within the resistance training literature, cited in many papers as well as text books as an underlying theory behind the development of periodization. In fact the American College of Sports Medicine (ACSM) cites the work of Hans Selye as the central theory behind periodization, suggesting that the application of GAS through periodized programming can optimize performance and recovery. Our research group has recently critically evaluated the merit of periodization regarding its applications for muscle size and strength, concluding that there is little evidence to suggest that a periodized resistance-training program would augment changes beyond those observed in a non-periodized program utilizing progressive overload. This naturally led to the examination of GAS, with a specific focus on the original stress research conducted by Hans Selye. Thus, the purpose of this manuscript is to examine the original work of Hans Selye, as well as the original papers through which the GAS was established as a central theory for
periodized resistance exercise. In doing so, we wish to better understand the application or misapplication of the GAS to resistance exercise.

**The Foundation of the General Adaptation Syndrome**

The general adaptation syndrome is a concept based on a series of rodent studies testing the Stress response to sub-lethal doses of different drugs (e.g., morphine, atropine), and stimuli (e.g., temperature, exercise). Interestingly, Selye observed a similar phenomenon in all conditions: gastrointestinal ulceration, thymico-lymphatic atrophy and adrenocortical ulceration. In fact, the three stages of the GAS (alarm reaction, resistance and exhaustion) were developed based on observed tissue changes, mainly thymus involution and adrenal hyperplasia, which occurred during persistent treatment with damaging agents. Selye also found that pre-treatments (1/4 of the alarming/toxic dose) of different agents (adrenaline, atropine, morphine, cold, exercise) administered, followed by a full alarming dose of the same stimuli appeared to have a protective effect against a toxic dose of that agent. These experiments showed that: 1) specificity of adaptation appears to be important, as pre-treatment with a given stimulus was necessary to prevent thymus involution, and 2) an organism appears to possess a finite amount of “adaptation energy”, as adaptation to a certain stimulus appears to decrease resistance to other stimuli. This concept of “adaptation energy” is best described by Selye, as he explains: “…anything to which adaptation is possible eventually results in exhaustion, that is, the loss of power to resist”. In 1936 Selye published a letter in Nature providing a summary of his experimental findings. Since then, this basic understanding has been applied to a diverse range of fields. In the case of resistance training exercise, its application has played a large role in the development of periodization. Lee and Greenwood explain that: “Periodization gained its popularity and application from a physiological theory called the General Adaptation Syndrome or GAS.” However, it is our opinion that the extrapolations that have been made to the periodization (i.e., from toxic doses of drugs or exercise → normal exercise/training in humans) of resistance exercise are not fully supported by the original studies performed by Hans Selye and require
future research to better understand how his work on the stress response to different stimuli might apply in a human training model.

**The Application of GAS to Sport and Exercise**

A review by Russell Viner discusses the “marginalization” of Selye’s original findings, suggesting that his work has “become a ‘rallying cry’ for proponents of modern concepts of disease as a controllable interaction between humans and their environment”\(^\text{17}\). It is our opinion that this may also be the case with its application to sport and exercise. Fred Wilt was the first (to our knowledge) to point out the importance of Selye’s work regarding the training of athletes.\(^7\) In his short communication, Wilt cites a lecture given by Forbes Carlile which discussed the importance of “adaptation energy” when training athletes. This brief communication stresses the idea that the “mixing of training routines with sufficient rest” is important to produce “optimum amounts of specific adaptation and adaptation energy.” This communication, however, does not thoroughly discuss how the concept of adaptation energy would specifically apply to training. One year later, Forbes Carlile published a perspective in the journal of Track Technique proposing the acceptance of the GAS as a “scientific basic philosophy to guide the coach”.\(^8\) However, no experimental work was specifically performed to test the hypothesis that the concept of GAS makes sense in a human model, or that the application through periodization is an appropriate use of this concept. This is important, as the original model of adaptation energy discussed by Selye showed that a resistance (or adaptation) to one drug may limit the ability to adapt to another (i.e., morphine, atropine).\(^14\) Meaning, if a rat is treated with Drug A (building up a tolerance against a toxic dose), their ability to withstand a toxic dose of Drug B is decreased. The extrapolations made within the resistance training literature are somewhat vague, but Selye’s original work seems to suggest that training for sport may limit one’s ability to adapt to other stressors, such as resistance exercise (and vice versa). Thus, this concept itself may be a potential argument against strength training for sport.

**The Bridge to Periodization**
Periodization has been defined as a “training plan, whereby peak performance is brought about through the potentiation of biomotors and the management of fatigue and accommodation.” John Garhammer was the first to apply the principles of GAS to periodization. In his perspective, Garhammer suggested that the total load of a training program should be divided up into unequal portions (cycles), with the ultimate goal of avoiding exhaustion. This suggestion, at a basic level, makes sense. Selye’s findings would suggest that a single alarming dose of a stimulus can be toxic, if not proceeded by a period of habituation using smaller doses. However, it is important to note that the original rodent studies were examining the effects of toxic doses of both drugs and exercise as stressors. Thus, it is difficult to determine how applicable these studies are for training protocols that would typically be performed in humans. In addition, when a rodent is exposed to a toxic dose of exercise, the results are confounded due to the involuntary nature of forced exercise in the stress models. Moraska et al. highlights this important distinction, explaining that forcing an animal to run (loss of control), with adverse motivation (foot shock, physical prodding, water spray) may create a great psychological stress. Thus, it is difficult to discern how much of the “Stress” is caused from exercise and how much is coming from other psychological factors. As such, we question how these models may relate to regular, non-toxic, voluntary exercise in humans. If the stress models did apply in a human model, it would support periods of rest to avoid exhaustion.

The Potential Misapplication of GAS

The original application of GAS to resistance exercise was to avoid overtraining. The application of such principles seems sensible for athletes, where the manifestation of stress from everyday life, stress from sport, and stress from supplemental exercise could lead to overtraining. Thus, the original model of linear periodization may help account for sports training during the year, as it decreases resistance training volume over time as the sports season progresses. This sensible concept may (on some levels) be a loose application of the principles of GAS. However, periodization has become the gold standard of programming, taking on an identity outside its original purpose of managing “adaptation energy” and
avoiding overtraining. Recent studies on periodization have focused on searching for the “optimal” training method for muscle size and strength,19,20 far removed from the original meaning of periodization and the basis of Selye’s work. In fact, the majority of current research examines adaptations in muscle size and strength independent of sport practice.20-23 If the concept of GAS does in fact exist in a human model with regular resistance exercise, we believe it is unlikely that they are relevant when adaptation energy is not spread over other strenuous activities (such as sport). This is important as periodized resistance training should be training that attempts to account for the totality of stress in an individual’s life. In an experimental sense, in line with Selye’s work, the most effective periodized program would produce the least amount of thymus involution and adrenal hyperplasia. However, the focus of periodization has shifted towards the optimization of strength, muscle size and performance.20,21 Interestingly, studies on periodization do not discuss the principle of adaptation energy, which might suggest that hypertrophy training may hinder strength performance (and vice versa). This may be a moot point, as it is presently unclear if the original application of the GAS principles were ever appropriate; however, the current applications seen within the literature (large focus on “optimal” resistance exercise adaptation outside of sport) largely fail to acknowledge this foundational concept while continuing to cite the work on GAS as justification for this type of training. Future research is essential to fully understand the concept of GAS and how it may best (if at all) apply to resistance exercise practice.

**Conclusion**

Undoubtedly, the early work of Hans Selye has applications in the understanding of any stressful stimuli, including exercise. However, his original work seems rarely re-visited regarding its analysis, interpretation and application to resistance exercise. Notably, Selye’s work focused on the universal physiological stress responses noted upon exposure to toxic levels of a variety of pharmacological agents and stimuli, rather than normal levels of exercise. Russell Viner discusses how the modern use of the concept proposed by Hans Selye “rejects the physiological postulates which formed Selye’s original conceptualization of stress.”17 Consequently, additional research is necessary to elucidate the true
application of the GAS to resistance exercise training. It makes sense that an athlete faced with demands of sport, society and other factors in addition to resistance training may be faced with an extraordinary level of stress. Thus, early models of linear periodization may help account for some of this (decreasing intensity as sport demand increases). However, more recent models have become far more complex and removed from this original thesis. In addition, it is unknown how a toxic dose of exercise would compare to anything actually practiced in strength training. Incidentally, the principles of GAS may ultimately support the concept of periodization as a guide to optimal programming for muscle size and strength. However, the universal acceptance of the GAS is not adequate without submitting it to the strenuous rigor of appropriate scientific research, particularly given the foundational role and influence this theory has acquired within the strength and conditioning literature.

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