

NONLINEAR PERIODIZATION FROM THEORY TO PRACTICE

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Periodization of weight training is the manipulation of acute training variables over time in an attempt to bring about optimal training adaptations. There are several types of weight training periodization that have been examined in the scientific literature. Linear periodization follows a pattern of increasing training intensity and decreasing training volume as training progresses. Planned changes in training volume and intensity can occur due to manipulating the weight lifted, number of repetitions performed per set and number of sets of each exercise performed. However, manipulation of training can also include changes in any of the acute training variables, including the choice of exercise performed, rest periods between sets and exercises, and the number of training sessions performed per week. Daily nonlinear periodization is a relatively new type of resistance training periodization and has gained popularity among athletes and fitness enthusiasts. Although there are several manners in which training intensity and volume can be manipulated with daily nonlinear periodization there are typically three training zones used that change on a train-

ing session by training session basis. Although any number of training zones could be performed typical training zones are 4-6, 8-10 and 12-15 repetitions per set. In most studies to date a total body weight training program has been performed three days per week with each of the three training zones used one day per week. Additionally, although not examined in studies to date exercise choice, rest period length, number of training sessions per week and other acute training variables can be manipulated in a daily nonlinear periodization training model. Studies to date demonstrate daily nonlinear periodization can be safely performed in various populations, including children to seniors, and that it is effective in bringing about training adaptations in all of these populations. Studies have reported increased strength, increased lean body mass, positive effects on the blood lipid profile, and increased motor performance. This presentation will review the peer-reviewed studies in which daily nonlinear periodization has been used and the results shown. Additionally, how to implement a daily nonlinear periodization program will be discussed and described.

RESISTANCE TRAINING AND FUNCTIONAL CAPACITY IN PHYSICALLY FRAIL OLDER ADULTS

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Frailty has been defined as an age-associated medical syndrome with multiple causes and contributors that is characterized by diminished strength, endurance, and reduced physiologic function that increases an individual's vulnerability for developing increased dependency and/or death. This syndrome is strongly associated with low muscle mass and puts older individuals at special risk for disability, hospitalization, and death due to falls and many other causes when exposed to a stressor. As a consequence of impaired muscle function, the diagnosis of frailty involves physical impairments, such as low gait speed, fatigue, and low grip strength (1-3). Poor health, disability, and dependency do not need to be the inevitable consequences of aging. Indeed, older adults who practice healthy lifestyles, avoid being sedentary, participate in physical exercise (e.g., walking, strength training, or self-adjusted physical activity), use clinical preventive services, and continue to engage with family and friends are more likely to remain healthy, live independently, and incur fewer health-related costs. Due to the physical domains related to frailty, physical activity is one of the most important components in the prevention and treatment of frailty. Indeed, the benefits of physical exercise in improving the functional capacity of frail, older adults have been the focus of considerable recent research (1-3). The positive effects of exercise on functional capacity may be observed more often when multiple physical conditioning components (i.e., strength, endurance, or balance) are included in the exercise intervention compared to only one type of exercise. The absence of changes in functional or strength outcomes measured in certain previous studies indicates that the exercise prescription must be carefully adapted to provide a sufficient stimulus for improving not only maximal strength but also the functional capacity and muscle power output performance of frail subjects. Therefore, multicomponent exercise interventions should be included in the routines of institutionalized oldest old as these interventions appear to be the most effective for improving overall physical outcomes among frail elderly as well as for preventing disability and other adverse outcomes (2-3). Furthermore, several previous studies have observed positive training-induced muscle power enhancement in ambulatory, community dwelling older adults with or without self-reported limitations in physical functioning. Based on these results, it was suggested that functional capacity among frail elderly adults could be improved by performing resistance training at a high speed of motion with a loading stimulus that optimizes muscle power output. Recently, it has been reported

that 12 weeks of multicomponent exercise training including explosive resistance training improved muscle power output (96-116%), strength (24-144%), muscle cross-sectional area and muscle fat infiltration (4-8%), as well as functional outcomes and dual task performance (7-58%) in frail institutionalized nonagenarians (1). Interestingly, in another recent study, it has been shown that 4 weeks of high-speed resistance training combined with walking, cognitive and balance exercises improved the gait ability, balance, and muscle strength (15-30%), as well as reduced the incidence of falls in frail patients with dementia after long-term of physical restraint used in their nursing care (2). These novel results are especially relevant because it demonstrates that the exercise intervention including muscle power training may bring benefits even in frail patients with cognitive impairment at very poor physical condition. It should be mentioned that overall, these benefits were achieved only after the inclusion of the resistance training in the exercise intervention, because the walking, cognitive and balance exercises performed by 4 weeks previously the resistance training inclusion, only improved the balance performance.

Thus, routine multicomponent interventions that include muscle power training should be prescribed to institutionalized oldest old because such interventions improve the overall physical status of frail elderly individuals and prevent disability and other adverse outcomes. This result is especially important in frail subjects, who urgently need to improve their functional capacities to prevent adverse outcomes such as falls, hospitalizations, disability, or even death. Additionally, it should be highlighted that resistance exercise does not only help to reduce the risk and incidence of falls in seniors, but may also help to prevent injuries when these falls occur (1-3).

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ARE TRAINING VELOCITY AND MOVEMENT PATTERN IMPORTANT DETERMINANTS OF MUSCULAR RATE OF FORCE DEVELOPMENT ENHANCEMENT?

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In many sporting and daily living tasks the time available for force production is relatively short when compared to the time required to develop maximal muscle tension (>300 ms). Thus, successful task completion requires the rapid development of muscular (contractile) force, i.e. a fast rate of force development (RFD). The muscular rate of force development can be estimated during a maximal isometric muscle contraction, where the rate of force rise measured at a point on the skeleton depends on the rate of increase in muscle activity and the subsequent rate of tension rise within the muscle-tendon unit. This measurement is not synonymous with the rate of dynamic force development (RFD_{dyn}), where forces are measured at a point on the skeleton during a dynamic movement and thus where the muscle's capacity to develop forces during fast muscle shortening and lengthening impact notably on the measured rate of force rise. In this presentation, the effects of training movement velocity and kinematic pattern on contractile (i.e. isometric) rate of force development will be examined with a view to (1) determining appropriate training strategies and (2) examining the requirements of future research.

Given the principle of training specificity, it could be hypothesised that the optimum stimulus for RFD enhancement involves the performance of training exercises at fast movement speeds, or at least with the intent to develop force as rapidly as possible. However, numerous studies have reported significant improvements in RFD after traditional, heavy-load (i.e. slower-velocity) or isometric strength training in muscle groups including the knee extensors, elbow flexors, plantar flexors, dorsiflexors and trapezius, as well as in an isometric leg press. In such studies, the mean improvement in RFD was >40% (over periods of several weeks to months), and thus a reasonable conclusion is that fast movement speeds are not required for signifi-

cant improvements in RFD to be attained. In fact, studies examining changes in RFD after 'explosive' strength training report more modest improvements (~10%), indicating that heavy (and slow) strength training may be a superior stimulus. Such a conclusion is contrary to current practice and suggests that an important and under-utilised strategy for improving RFD is to use heavy-resistance training exercises.

A reflection on the factors influencing RFD, including increases in muscle activation, peak contractile force and muscle-tendon stiffness, may provide some indication as to why such training is beneficial.

Nonetheless, the movement pattern (or body position) adopted during training appears to be an important factor influencing the influence of exercise training on RFD: much smaller increases in RFD are obtained after heavy strength training when the test movement pattern (or body position) is different from the training movement pattern. Moreover, when the testing and training tasks are kinematically similar, increases in RFD are still commonly observed after higher-speed training or when isometric forces are attained rapidly during training. Such findings indicate that a complex interplay exists between training movement pattern and velocity and RFD enhancements, where heavier (slower) training may elicit greater increases in RFD when the training and testing movement patterns are similar but that a greater transfer of RFD improvements to dissimilar tasks may occur when higher-speed (lower load) training is performed. Nonetheless, despite the increase in the number of studies measuring RFD after periods of exercise training in recent years, further research incorporating both kinematically similar and dissimilar tasks is still required to more accurately determine the effects of movement pattern and velocity on RFD and its transfer to tasks with different movement patterns.

THE APPLICATION OF THE YO-YO INTERMITTENT TESTS TO ELITE SOCCER POPULATION

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The Yo-Yo intermittent tests are probably the most used test in football, and it is clear that the higher the level of football the better the players perform in the tests. In both the Yo-Yo intermittent endurance and Yo-Yo intermittent recovery test maximal heart is reached demonstrating that the tests have a high aerobic component which is maintained over a long period in the Yo-Yo intermittent endurance test, whereas the anaerobic component is large in the Yo-Yo intermittent recovery test demonstrated by high rate of muscle lactate production.

For elite players the tests are carried out at the level 2. The tests are able to evaluate changes in performance for elite players. From the start to the end of the pre-season improvements of around 30% are seen for both tests, in

contrast to change of less than 5% in the maximum oxygen uptake, illustrating that the Yo-Yo intermittent tests are sensitive to detect changes related to football performance. Also the effect of changes related to alterations in training volume and intensities have been evaluated with the tests.

Thus, Gunnarsson et al. (2012) found an 11%-increase in Yo-Yo intermittent recovery test performance when speed endurance training was added to the normal football training for 30 min every week for a 5-week period, and, similarly, Randers et al. (2007) found a 15%-increase in Yo-Yo intermittent recovery performance when during supplementary aerobic high intensity training for 30 min in a 8-week period in the middle of the season.

HUMAN THERMOREGULATION AND THE CARDIOVASCULAR SYSTEM

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A key but little understood function of the cardiovascular system is to exchange heat between the internal body tissues, organs and the skin to maintain internal temperature within a narrow range in a variety of conditions that produce vast changes in external (exogenous) and/or internal (endogenous) thermal loads. Heat transfer via the flowing blood (i.e. vascular convective heat transfer) is the most important heat-exchange pathway inside the body. This pathway is particularly important when metabolic heat production increases many-fold during exercise. During exercise typical of many recreational and Olympic events, heat is transferred from the heat-producing contracting muscles to the skin surrounding the exercising limbs and to the normally less mobile body trunk and head via the circulating blood. Strikingly, a significant amount of heat produced by the contracting muscles is liberated from the skin of the exercising limbs. The local and central mechanisms regulating tissue temperature in the exercis-

ing limbs, body trunk and head are essential to avoid the deleterious consequences on human performance of either hyperthermia or hypothermia.

This presentation will focus on recent literature addressing the following topics: (i) the dynamics of heat production in contracting skeletal muscle; (ii) the influence of exercise and environmental heat and cold stress on limb and systemic haemodynamics; and (iii) the impact of changes in muscle blood flow on heat exchange in human limbs. The presentation will highlight the need to investigate the responses and mechanisms of vascular convective heat exchange in exercising limbs to advance our understanding of local tissue temperature regulation during exercise and environmental stress.

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NEURAL ADAPTATIONS IN STRENGTH TRAINING: WHAT, WHY AND HOW?

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Although the force capacity of muscle is directly related to its cross-sectional area, it is possible to increase muscle strength in the absence of a change in muscle size. Such strength gains are attributed to changes in muscle activation caused by an intervention, such as a training program or aging. This presentation will consider three questions: what is the evidence that changes in muscle activation can increase muscle strength, why does modulation of muscle activation matter, and how are intended changes in muscle activation achieved? The evidence supporting a significant role for adaptations in muscle activation contributing to strength gains includes differences in the relative increases in muscle size and strength, the phenomenon of cross education, and the specificity of increases in muscle strength. The functional significance of changes in muscle activation can be demonstrated by both its association with declines in motor function with age and the gains that can be achieved with training. For example, a worsening of manual dexterity, as indicated by the time taken to complete a pegboard test, is evident in middle-aged adults whose hand strength does not differ from that of young adults and the strongest predictor of the variance in pegboard times is the steadiness of a submaximal isometric contraction. Moreover, training programs that emphasize steady contractions with submaximal loads can elicit increases in muscle strength and improvements in motor function in older adults. Similarly, speed training with moderate loads can increase motor unit discharge

rate and the maximal rate of force development in young and old adults. These findings indicate that changes in the quality of muscle activation, as indicated by force steadiness and rate of force development, can impact both muscle strength and motor function. Of course, increases in the quantity of muscle activation can also contribute to strength gains. Despite this evidence, our understanding of the underlying adaptations remains rudimentary. The potential adaptations that could influence muscle activation include the level of voluntary activation, the responsiveness of spinal reflexes, and the amount of motor unit activity.

Although the neuronal adaptations associated with strength training seem to be more focused in the spinal cord than in the cerebral cortex, the early strength gains that occur when a person is learning new exercises likely involve the reorganization of cortical networks that encode various actions. Both spinal and cortical adaptations, however, can be manifested as an increase in the rates at which motor units discharge action potentials, which has been observed after training with ballistic contractions and with conventional heavy-load training programs. Nonetheless, the adaptations responsible for the changes in motor unit activity are largely unknown and potential directions for future research will be discussed. Understanding the neural adaptations that can be elicited by different conditions is critical to developing appropriate training interventions.

NEURAL AND STRUCTURAL ADAPTATIONS TO ELECTRICAL STIMULATION STRENGTH TRAINING

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Neuromuscular electrical stimulation (NMES), which consists in the artificial activation of superficial skeletal muscles by means of intermittent stimuli, has received increasing attention in the last few years both as a strength training modality for healthy subjects and athletes (because its repeated use may induce neuromuscular adaptations that are complementary to voluntary strength training) and as a rehabilitation/preventive strategy for partially- or totally-immobilized patients (because its chronic application may preserve skeletal muscle mass and function during prolonged periods of reduced muscular use).

In this presentation I will describe the main physiological specificities of NMES exercise, in particular with respect to the muscle recruitment pattern, the acute physiological response and the time-course and mechanisms of adaptations induced by NMES (re)training in both healthy and patient populations. Special emphasis will be given to the acute and chronic changes in neural function that may occur with NMES, as they seem to mediate the majority of NMES training-induced adaptations. I will also illustrate some recent methodological advances that have the potential to favor a more physiological, efficient and effective utilization of NMES.