The Challenge of Training for Strength and Endurance and Considerations for optimization

Dr. Micah Gross, Swiss Federal Institute of Sport, Magglingen, Switzerland

11. Dezember 2016

Michael Vogt Symposium, ICSS, St. Christoph am Arlberg

When training plans combine both endurance and strength sessions, this is referred to as concurrent training. Alpine skiing is a prime example of a sport in which high strength and muscle power demands coincide with considerable reliance on the aerobic energy system, but this is also the case for a number of other sports. The fact that strength training and endurance training are in nature divergent, setting different stimuli and leading to sometimes conflicting adaptations, poses challenges for coaches and athletes in sports in which concurrent training is nonetheless essential.

The first of two main challenges with concurrent training regimens is assuring that sufficiently strong training stimuli are sent to achieve optimal adaptation. Because physiological adaptation is not linear across an athletic career, well-trained athletes can expect increasingly small improvements with time, whereas novices often adapt rather quickly to any sort of training. This means that for high-level athletes, training methods must be specific and training stimuli must be especially rich. Setting strong training stimuli, however, requires time and energy, and the greater the number of training goals, the less time and energy one can devote to each of these. Thus, the problem sometimes arises that one training stimuli is “diluted” to make room for another, or cumulative fatigue and insufficient regeneration compromise training quality in general.

The second main challenge with concurrent training regimens is avoiding a situation in which training stimuli negate one another. Muscle tissue has trouble adapting structurally and metabolically simultaneously to strength and endurance training forms, respectively. Indeed, there is a myriad of evidence that myocellular signaling pathways leading to these divergent adaptations interfere with one another. At this point, it is worthwhile to emphasize that, in a concurrent training situation, the sort of adaptations expected from endurance training (e.g. improved $\dot{V}O_{2_{max}}$) are compromised to a much lesser extent than those expected from strength training (e.g. muscle size, or muscle power), if at all (8). It appears that, since strength training is characterized by a very high concentration of mechanical work, whereas endurance training involves an accumulation of (relatively low-intensity) work, combining the two steers the training stimulus in the direction of greater accumulation, and the endurance adaptations tend to win out in the end. Moreover, the degree to which strength training adaptations are compromised appears to be dependent on the volume and frequency of endurance training, and on the intensity of endurance training if the two are performed in close temporal proximity to one another.

From molecular biology studies, the main locale of interference appears to be the mTOR pathway, which is in charge of regulating muscle hypertrophy. This pathway is activated for a period of time following high mechanical loading and amplified by the amino acid leucine, but is inhibited by metabolic stress, such as that experienced during endurance (particularly high-intensity) training, or by a state of energy deficit. The window of inhibition for higher intensity endurance sessions appears to be between at least 3 hours before and 18 hours after a hypertrophy-oriented strength training session (1). Thus, such hypertrophy-oriented strength sessions should generally be performed in the afternoon of days containing endurance session (which should be performed in the morning). Further, adequate energy and leucine-containing protein should be consumed throughout the day. A good recommendation for athletes in training is ~1.5 g per day, per kg of body mass (7).

Regarding the planning of training on the micro- or mesocycle scale, two particular strategies appear especially clever for concurrent training situations. The first of these involves employing short, highly concentrated training blocks, each focused on improving only one physical capacity (commonly called block periodization) (4). Generally, blocks lasting 4 – 5 weeks with this sort of narrow focus are sufficient for improving capacities such as $\dot{V}O_{2_{max}}$, maximal strength, or explosive strength (i.e., muscular power) in concurrently training athletes (3). During each of these blocks, the training frequency and total volume are higher than normal for the training component in focus, whereas other training components are trained minimally in order to maintain condition; typically, this means one session per week for physically demanding training forms such as strength or endurance, but could easily be more for technical or tactical training sessions, for example.

The second optimization strategy for concurrent training situations is to temporally separate strength and endurance training forms that are most likely to interfere with one another. Strength training forms are not all alike, with middle-intensity forms aiming primarily to induce muscle hypertrophy and maximal-intensity forms aiming to improve neural activation. Endurance training also encompasses various intensity zones, one of which is generally preferable for developing either muscle metabolic or cardiovascular adaptations. Thus, the trained muscle is the place of interference in concurrent training situations, and it is therefore helpful to distinguish between central (neural, cardiovascular) and peripheral (muscular) adaptations, in order to pursue strength-relevant structural and endurance-relevant metabolic adaptations during separate training blocks (2). Concretely, this means that within the same training phase, middle-intensity strength training aimed at increasing muscle mass should be combined with lower-intensity endurance sessions, whereas maximal strength sessions can be combined with high-intensity interval training geared toward improving muscle oxidative capacity. Since maximal-strength training is best performed in a relatively fresh state, it is recommended that these take place after a rest day or in the morning on days containing endurance sessions.

For some sports, it is worthwhile to consider which training forms offer the greatest benefit for the smallest investment of time and energy. For strength- or power-oriented sports, it is recommended to perform most endurance training as intervals above the critical power threshold, as this leads to the fastest improvements in $\dot{V}O_{2_{max}}$. A novel idea for endurance athletes is terminating hypertrophy-oriented weight training sets prior to muscle failure, as this often yields similar improvements without the risk of compromising endurance training quality. In this case, it is important to maintain a maximal contraction velocity for the performed repetitions (5). However, for most cyclic endurance sports, it is recommended that strength training be mostly geared toward improving maximal strength.

Regarding nutrition, a crucial consideration in concurrent training situations is the importance of protein and sufficient energy intake. Generally, a positive energy balance and particularly the availability of dietary amino acids, favor an anabolic response to strength training. Whereas an energy deficit can be beneficial for some endurance training adaptations, it is detrimental for strength and power adaptations and should generally be avoided by athletes in non-endurance sports. Within a training day the availability of carbohydrate is particularly important in temporal proximity to strength or interval training sessions (6), whereas protein is best distributed evenly throughout the day with a larger portion in the evening of before bed (7). Leucine, which is a crucial amino acid for muscular adaptations is found in most common sources of protein, particularly in mild products and meats.

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