Barbells, Dumbbells, and Kettlebells

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Introduction

There are five acute programming variables, including choice of exercise, order of exercise, volume (sets & repetitions), intensity, and rest intervals. Selection of exercises is governed by the transfer of training principle. Strength and conditioning professionals are often inundated with literature and videos promoting the use of non-traditional exercises and exercise implements. However, little comparative research exists to support or refute the use of these training modalities. Development of metabolic qualities, such as work capacity, and neuromuscular qualities, such as power and rate of force development, is essential for athletes. This article examines the physiologic considerations related to exercise selection and reviews the available research related to barbell, dumbbell, and kettlebell training.

Exercise Implements

Resistance exercise can be performed on a variety of implements that range on a continuum based on the degrees of freedom available. The implements allowing the greatest degrees of freedom are free weights, specifically those that allow unilateral training. Many implements are available for unilateral free weight training, including dumbbells and kettlebells. At the other extreme, machines minimize the degrees of freedom by fixing the path through which exercise can be performed. Towards the center of the continuum are free weights that require bilateral arm and/or leg involvement.

In examining the history of resistance training over the last century, the pendulum has swung between each end of the continuum. Unilateral free weight training was popular in the early 1900's and included in the sport of weightlifting at the Olympic Games until 1928[12]. Towards the 1960's and 1970's, when bodybuilding and health & wellness training gained popularity, the pendulum shifted towards a greater dependence on machine training[24]. In recent years, the pendulum has shifted again towards unilateral free weight training, no doubt due to the rise in popularity of "functional training"[23]. Throughout this time, bilateral free weight exercises were common, although often overshadowed by marketing of implements from either of the extreme ends of the continuum.

In examining the literature, no comparative long-term investigations have been performed to investigate the relative effectiveness of exercises performed with dumbbells and kettlebells versus barbells. Therefore, it is prudent to examine the biomechanics and physiology of exercises performed with these implements, specifically in light of the transfer of training principle, to determine their benefit for enhancing performance.

Transfer of Training

Training can elicit improvement in performance through direct or transfer mechanisms. In regards to skilled movement, the direct mechanism is improvement in the motor skill itself. A transfer phenomenon occurs when exercise is performed to improve a physiologic characteristic that is associated with the skilled movement. Improvement in this physiologic characteristic transfers to the skilled movement, therefore improving performance. Physiologic characteristics can generally be categorized as either metabolic or neuromuscular. Metabolic characteristics, such as VO_2max and anaerobic threshold, are those that affect energy and substrate utilization. Neuromuscular characteristics are those that influence muscle force generation.

Metabolic characteristics are either aerobic or anaerobic. Aerobic metabolism is important for long duration activities. However for a given activity, once minimum aerobic levels are reached, additional improvements do not further enhance performance[14,20]. Anaerobic metabolism is important for high intensity activities where there is a large energy de-

mand over a short period of time. In addition to energy production, both aerobic and anaerobic metabolism are important for recovery from activity.

Neuromuscular characteristics influence muscle force generation which leads to mechanical movement. Many sports involve tasks related to running and jumping. In analyzing the biomechanics of running and jumping tasks, the following neuromuscular characteristics are important: 1) maximal strength (MS[1,5,6,19,32]), 2) explosive strength (ES[1,2,6,25,34,35]) and 3) reactive strength (RS[33]). The proportional importance of these three qualities depends on the specific type of running or jumping performed. Training that increases MS, ES and RS will transfer to improved performance during running and jumping tasks. MS training alone does not appear to improve running and jumping performance[9,15], however, the combination of MS training with either ES or RS training appears to be optimal[15,18,29].

Both metabolic and neuromuscular characteristics should be considered when applying the transfer of training principle to manipulate acute programming variables. Metabolic characteristics are relevant when considering total energy expenditure, work density, and work capacity. Neuromuscular characteristics are relevant when considering speed, motor control and effectiveness of movement.

Metabolic Cost

A potential benefit often proffered for kettlebell training is the metabolic benefit from performing high volume training. No investigations have directly compared the metabolic cost of kettlebell versus barbell exercise. However, preliminary research[3,17] indicates that the metabolic cost of kettlebell exercise (5 sets of 10 repetitions for 3 exercises) is approximately 4.97kcal/min-1 performed at 33% VO_2max. In contrast, weightlifting exercise with a barbell has a metabolic cost of 11.5kcal/min-1 performed at 58% VO_2max[22]. Thus, weightlifting exercise with a barbell appears to be more effective for increasing total energy expenditure and for stimulating increases in work capacity. The training loads likely influence the large difference in metabolic cost between kettlebell and barbell training[22]. Larger training loads increase mechanical work performed, thus increasing metabolic cost.

Training Load

Training load or exercise intensity contributes to the neuromuscular characteristics being trained[9,13,15,18,29,31]. Heavier training loads are typically required for MS training, whereas ES training uses a range of sub-maximal loads performed with the maximum intent to accelerate. Neuromuscular adaptations are stimulated by placing tension on skeletal muscles. However, adaptations are only stimulated if muscular tension exceeds a minimum threshold. Increasing muscular tension can be achieved either by lifting heavy loads, or lifting relatively lighter loads rapidly. In either case, as adaptation ensues, progression of training load is important for continued improvement.

This is the largest limitation of dumbbell and kettlebell training, where the maximum load possible is less than for barbell training. For developing MS and hypertrophy, training at or above 85% 1 RM is required[13]. Maximum loads utilized by athletes for traditional strength exercises such as the squat typically exceed 2.0 times body mass[21]. For a 90kg (198lb) athlete, this would be a minimum of 180kg (396lb), although elite athletes may lift considerably more. It would be difficult to replicate these loading conditions utilizing dumbbells or kettlebells (i.e. a minimum of two 90kg/198lb dumbbells/kettlebells would be required). Commercially available kettlebells do not typically exceed 40kg (88lb).

The optimal loading for developing ES is controversial. Stone et al.[26] suggested that the optimal load started at 10% 1 RM for novices and increased as high as 40% for elite athletes. This corresponds to Wilson et al.[31] who recommended an optimal load of 30% of maximum isometric force. Typical training loads for weightlifting exercises, such as the clean and snatch are approximately 40-70% of an athletes 1 RM squat[6,21]. Training with these heavier loads[29] may be more effective for improving ES than lower load training. For the 90kg (198lb) athlete above, training loads for exercises such as the power snatch and power clean would range from 72-126kg (158-277lb). At best, dumbbells and kettlebells would meet the lower end of this range, however, the ability to progress to greater loads would not be possible. For example, non-weightlifter athletes[8] have been reported to clean or power clean 140-180kg (328-396lb).

The large disparity in load selection for barbell exercises compared to dumbbell and kettlebell exercises suggests that variation and progression of training load is better accomplished with barbell exercises. For kettlebells specifically, progression of training loads is difficult, as the typical step in kettlebell load is 4kg (8.8lb). This is in contrast to barbell exercises, where, with recent rule changes in the sport of weightlifting[27], 0.5kg (1.1lb) plates are available, allowing increments of 1kg (2.2lb). Further, barbells can be loaded with weights that exceed known human potential.

Technical Execution

RS training is typically accomplished with plyometric or shock training[30] incorporating the stretch-shorten cycle. A stretch-shorten cycle action is present in weightlifting exercises during the pull[11] (second knee bend) and jerk (transition from dip to drive). During the weightlifting pull[11], the second knee bend is required as the barbell must pass in front of the knees. The action of the weightlifting pull can be described as pushing the knees backwards (first pull), shifting the knees under the bar (second knee bend) and extending the knees (second pull). These actions, however, are not required during a dumbbell/kettlebell snatch or clean, as the implements are lateral to the legs, or sometimes between the legs. Since the implements do not cross in front of the legs, the second knee bend action[7] is not present and only knee extension is required, eliminating the RS element of the weightlifting pull.

Practical Applications

Exercises performed with dumbbells and kettlebells may provide variation in otherwise monotonous training situations. However, application of available research indicates the training stimuli elicited by these implements is less effective compared to barbells. The basis of strength & conditioning is developing neuromuscular (MS, RS & RS) and metabolic characteristics. While dumbbells and kettlebells may be utilized for assistance exercises, the currently available evidence indicates that barbell exercises should form the foundation of performance training programs. Strength & conditioning professionals should consider the transfer of training principle when designing resistance exercise programs for improving performance.

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