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Do Single-Joint Exercises Enhance Functional Fitness?

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SUMMARY

FUNCTIONAL TRAINING PROGRAMS TYPICALLY FOCUS ON MULTIJOINT MOVEMENTS. HOWEVER, FUNCTIONAL TRANSFER EXISTS ON A CONTINUUM, WHERE DIFFERENT EXERCISES IMPART VARYING DEGREES OF FUNCTIONAL IMPROVEMENTS DEPENDING ON THE PARTICULAR DEMANDS OF THE TASK. THIS ARTICLE WILL DISCUSS THE POTENTIAL ROLE OF SINGLE-JOINT MOVEMENTS IN FUNCTIONAL TRAINING PROGRAM DESIGN.

Training for functional fitness has become an increasingly popular approach for personal trainers and strength coaches alike. According to Okada et al. (15), functional movement can be defined as the ability to produce and maintain a balance between mobility and stability along a kinetic chain while carrying out fundamental patterns with accuracy and efficiency. Given this definition, the primary goal of functional training is to optimize the ability for individuals to carry out activities of daily living, recreational pursuits, and/or sports performance (4).

A common tenet among functional fitness practitioners is that movement patterns should be trained as opposed to individual muscle groups. Hence, functional training programs typically focus on multijoint movements carried out in a multiplanar environment. Because single-joint exercises are rarely performed as part of daily activities or sport actions, they are often dismissed as "nonfunctional" and therefore excluded from functional program design (4).

There is substantial evidence to support the use of multijoint movements as a means to improve functional ability (4). Positive transfer is best achieved when specific muscle activation patterns reinforced through training are similar to those required in the alternative task (5). Conceivably, a greater association between movement similarities results in retaining relevant firing patterns and discarding irrelevant patterns, thereby strengthening the desired movement pattern (5). A substantial degree of task specificity has been found to occur in response to strength training adaptations, with multijoint movements showing the greatest applicability to activities of daily living (9,10).

It can be misguided, however, to view exercises simply as "functional" or "nonfunctional." Rather, functional transfer exists on a continuum, where different exercises impart varying degrees of functional improvements depending on the particular demands of the task (19). Conceivably, performing a combination of exercises along this continuum may produce a synergistic effect on functional transfer, improving an individual's ability to carry out desired tasks. The purpose of this article will be to discuss the potential role of single-joint movements in functional training program design.

SINGLE-JOINT EXERCISES IN FUNCTIONAL TRAINING

Although multijoint movements better simulate performance of specific activities, they tend to favor certain muscle groups at the expense of others. This may lead to muscle imbalances, which potentially can hasten the onset of injuries and impair the optimal performance of other tasks. For this reason, an optimal program should use "core program exercises" as the backbone of the program consisting of multijoint and multimuscle movements, in addition to "assistant exercises" consisting of targeted movements, which provide balance to the program and increase the program's overall efficacy. For example, during performance of the squat, the hamstrings have been shown to produce only half the electromyographic activity as that of the leg curl and stiff legged deadlift (21). This is consistent with the biarticular structure of the hamstrings, which allows the muscle complex to function as both hip extensors and knee flexors. Thus, the hamstrings' length remains fairly constant throughout the performance of multijoint exercises that require simultaneous hip and knee extension. Weak hamstrings may be associated with greater risk of lower-body injury (6,16), possibly as a result of decreased muscle coactivation (2). Hence, single-joint exercises that directly target the hamstrings may be beneficial to optimize functional development of the muscle (21). Although it is true that most sport actions are multiple joint in nature, the same principle described above holds true for sports; imbalances may be created from sport participation that needs to be addressed in the athletes' programming to provide structural balance.

Similarly, multijoint upper-body exercises may fail to optimally work the upper arm musculature because of disadvantageous length-tension relationships (3,17). For example, in the start position of a chin-up (hanging from the bar with arms straight), the biceps are in a fully lengthened position at the elbow joint while maximally shortened at the shoulder joint. During dynamic movement, these aspects reverse so that the biceps shorten at the elbow while lengthening at the shoulder. Thus, there is a little functional change in muscle length throughout the range of movement, thereby limiting force output. In the same way, the optimal length-tension relationship of the long head of the triceps occurs when the shoulder joint is flexed to approximately 180° (12). Because shoulder joint position changes throughout the range of motion during the performance of multijoint pushing exercises, such as the bench press and push-up, these movements fail to promote complete development of the long head of the triceps. Performing single-joint arm exercises allow the muscles to be trained at their optimal length, increasing upper-body strength and potentially improving the ability to carry out functional tasks.

Conversely, single-joint exercises can be employed to bring about active insufficiency–the condition where a 2-joint muscle is shortened at one joint while a muscular contraction is initiated by the other joint. Because of the weak contractile force of a muscle when its attachments are close together, the muscle is at its lowest point on the length-tension curve, and therefore, its capacity to produce force is diminished. Trainers and strength coaches can use this concept to target muscle imbalances. For example, when training the plantar flexors of the ankle joint, performing calf raises with knees bent will cause the gastrocnemius to become slack, thereby shifting the majority of work to the soleus (8). Given that the soleus has been shown to produce more mechanical work than the gastrocnemius in a countermovement jump, this may justify an assistant exercise that targets the soleus if increased countermovement jump height is sought (14).

The ability for single-joint exercises to favorably affect length-tension relationships has implications beyond simply enhancing muscle development. Single-joint movements such as seated leg curls, incline arm curls, and overhead triceps extensions place the hamstrings, biceps brachii, and long head of the triceps brachii, respectively, into a position that exceeds resting length, allowing them to be trained while actively stretched (18). Leonard and Herzog (13) found that when activated muscle fibers were stretched to the point where no cross bridges remained, titin stiffness contributed significantly to passive tension, thereby protecting against eccentric damage. The authors theorized that titin actually binds to actin, which increases the tension on the unbound titin filaments. This increased stiffness can promote greater functional benefits through increased reactive strength and enhanced joint stability. For example, the soccer throw-in, baseball pitch and throw, and volleyball spike involve overhead elbow flexion. Hence, athletes in each of these sports may directly benefit from the inclusion of overhead triceps extensions to target the long head of the triceps.

Training at long muscle lengths also can enhance tendon stiffness, thereby increasing muscle activation through a full range of joint motion. Kubo et al. (11) showed that isometric leg extensions at long muscle lengths (i.e., 100° knee flexion) resulted in greater increases in tendon stiffness than isometric leg extensions at shorter muscle lengths (i.e., 50° knee flexion). These adaptations were accompanied by significant increases in maximal voluntary contraction at all joint ranges, whereas training at short muscle lengths only showed increases in maximal voluntary contraction at or near the specific training angle.

Moreover, training at long muscle lengths during single-joint exercises can increase the optimum length at which muscles produce peak force as evidenced by a shift in the peak torque angle curve. Aquino et al. (1) found that performing seated leg curls improved stretch tolerance in those with tight hamstrings. These results were attributed to an increase in fascicle length via addition of sarcomeres in series because no change in hamstring flexibility was observed. Augmenting the optimal length of a muscle has both injury prevention and enhanced performance implications.

Single-joint training can be used to mimic sport-specific actions and vectors that can improve power production. For example, the 4-way hip machine can be used to mimic the action of the hips during sprinting. Given that Guskiewicz et al. (7) showed a strong relationship between hip flexion and hip extension strength and sprint speed as measured on a 4-way hip machine; it makes sense to perform targeted training for the hip musculature if speed improvements are sought.

Finally, single-joint exercises can be used to increase the relative contribution of a particular muscle toward a particular multijoint movement pattern. For example, increasing gluteal activation through simple low-load activation drills (such as a body weight glute bridge) has been shown to increase hip extension strength and hamstring flexibility while decreasing the incidence of hamstring cramping (20). The researchers theorized that their protocol increased gluteal activation during running, thereby relieving the hamstrings and preventing overuse and fatigue-related cramping. Strengthening certain muscles, such as the gluteus maximus, psoas, serratus anterior, rotator cuff, and mid/low trapezius, through targeted single-joint training may provide a valuable "prehab" effect and thus decrease the likelihood of injury.

CONCLUSIONS

Exercise selection should not be viewed as an either/or decision. Although the principle of specificity dictates that multijoint movements should comprise the basis of functional training programs, evidence suggests that single-joint exercises can also play an important additive role. Augmenting traditional functional training programs with single-joint exercises can promote synergistic improvements in muscle strength that ultimately transfer into increased performance of daily activities and sports performance, over and above that which can be achieved with multijoint training alone.

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