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A Practical Comparison of Different Lower Body Resistance Training Modes

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Exercise selection for a resistance training program begins with the specificity principle, which means the chosen exercise should imitate the activity as closely as possible. Also known as the transfer of training effect, Stone and associates (4) stressed the selected resistance exercise determines the extent of adaptation that will occur following a training program.

An obvious part of applying the specificity principle is to match an exercise with the movement patterns of an activity, but comprehending the forces placed on the body along with the musculoskeletal functions associated with resisting those forces may not be as obvious. In other words, this "line of resistance" consists of muscular efforts that are required to oppose the forces or loads applied to the body. By measuring the moment arm or perpendicular distance between the line of resistance and any major joint involved with the exercise, it can be concluded how much stress will be placed on a joint. For instance, the further a weight is held away from the body while standing, the harder it is to resist the forces. The same thing applies to the moment arm distance when comparing different joints in relation to the line of resistance. Obviously this means the muscle effort associated with the joint furthest away from the line of resistance will require greater effort than those with a shorter moment arm. Altogether, appreciation for the musculoskeletal efforts occurring during an exercise is dependent upon recognition of the line of resistance and moment arms, which enables the fitness professional to differentiate between resistance exercises that appear to have identical movements.

The rest of this article will explore numerous lower extremity multiple-joint exercises known to train the large muscle groups associated with the triple extensors (Table 1). Although the exercises have similar movements and coincide with daily lifting activities or performing jumping activities, Abelbeck (1) reported muscle recruitment is influenced by the depth achieved and the actual foot placement. Since the deepest position of lower extremity triple extensor exercises places the most stress on the muscles, all the exercises examined within this article will be portrayed at the depth traditionally achieved. Foot placement will also be discussed along with the effects of machines and free weights relative to muscle recruitment. All this will be accomplished while differentiating between common lower extremity triple extensor resistance exercises.

FIGURE 1: Line of resistance (- - -) and joint moment arm (↔) demonstrate knee extensor emphasis during the (A) wall sit and (B) stability ball wall sit.

Lower Extremity Triple Extensor Exercise Comparisons

Wall Sit

A common strengthening exercise is the fundamental wall sit. The wall sit involves holding the squat position while leaning against the wall as portrayed in Figure 1A. The line of resistance in this position will be based on gravity, but it will be directed through the hips as the feet push forward with limited movement due to friction. The stress on knee stability then results in higher forces produced by the knee extensors. A modification

Table 1

Lower Extremity Triple Extensors	
Movement	**Primary Movers**
Hip Extension	Gluteus Maximus and Hamstrings
Knee Extensors	Quadriceps
Ankle Plantar Flexors	Gastrocnemius and Soleus

that can minimize the stresses placed on the knee extensors might be to place the stability ball between the low back region and the wall. This permits the hips to move backward while minimizing the stress placed on the knees as observed during the stability wall squat (Figure 1B).

Leg Press and Hack Squat

Some dynamic exercise like the leg press can be used to strengthen the hip, knee, and ankle musculature through a greater range of motion. Note that the range of motion can vary depending on the angle of the platform in comparison to the torso, as evidenced by both versions of the leg press or hack squat machine (Figure 2). Interestingly, the deepest position for the lying leg press (Figure 2A) and hack squat (Figure 2C) are very similar, resulting in a major emphasis placed on the knee extensors. When referring to the line of resistance produced at the deepest position for an incline leg press (Figure 2B), a lack of friction at the feet causes the forces to travel perpendicular from the platform, resulting in greater forces directed through the hip extensors. In other words, if the goal is to solely strengthen the knee extensors, selecting the lying leg press or hack squat are optimal modes, whereas the incline leg press is a great hip extensor exercise.

Smith Machine

Another dynamic option is the Smith machine, where foot placement is important. Alelbeck (1) found that when the torso remains erect underneath the barbell, placing the feet directly underneath the hips emphasizes the knee extensors, whereas the hip extensor emphasis occurs when the foot placement results in a right angle at the knee when the thigh is parallel to the floor. As represented by the line of resistance in Figure 3, equal hip and knee extensor recruitment occurs when the feet are in-between the previously described positions, as long as the torso remains vertical (1). Smith machine hip and knee extensor recruitment can also be modified to match the traditional squat or lunge, and the next section discusses those muscle demands.

Back Squat and Lunge

Once body control appears to be mastered, the traditional squat and lunge are logical selections because they require balance. Note that a partial squat (Figure 4A) and lunge (Figure 4B) place equivalent stresses on the hips and knees, whereas the full squat (Figure 4C) emphasizes the hip extensors at the greatest depth. The interesting observation is that partial and full squats produce different demands on the joints when the deepest position is achieved. It should not be a surprise though, because Abelbeck (1) recognized that targeting specific muscle groups can be accomplished by varying the depth of the squat.

Dumbbells and barbells may be added once body control can be achieved, but be careful to watch for inward (varus) or outward (valgus) rotation at the knees because of instability due to a lack of hip stabilization. In addition, valgus forces at the knees put additional stress on the ligaments like the ACL (3), which can be attributed to weak hamstring activity compared to the quadriceps (5). Even though this observation is more common among women (5), recognition is crucial since hamstring activity is expected to be greater during squats when compared to the leg press (2). If these instability concerns arise, Youdas and associates (5) suggest avoiding single leg squat activities (i.e., lunge), meaning wall squats and body weight squats might be a beneficial neuromuscular training technique to facilitate stability development.

Conclusion

Only the line of resistance and moment arms of common lower extremity triple extensor resistance exercises were identified in this article. In addition, lower extremity single-joint exercises combined with all the trunk and upper extremity options provide even more opportunities to add variety to workouts, but that will require self motivation to discover applicable line of resistance and moment arms.

Keep in mind that the line of resistance changes with exercise depth, foot placement, and body dimensions. While it is easy to manipulate the exercise depth and foot placement, body dimensions such as tall individuals with longer extremities or trunks are permanent characteristics. When the length of extremities and trunks are longer, moment arms are extended making it more challenging for the muscles to generate force. It is these physical characteristics that require individualized exercise selections to accommodate specific goals and capabilities. ■

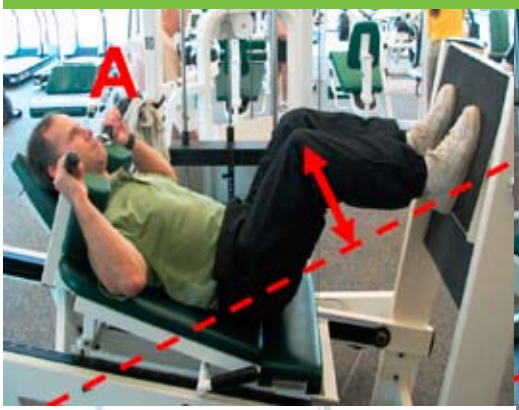

FIGURE 2: Line of resistance (- - -) and joint moment arm (↔) demonstrate knee extensor emphasis during the (A) lying leg press and (C) hack squat, and hip extensor emphasis during the (B) incline leg press.

FIGURE 3: Line of resistance (- - -) and joint moment arm (↔) demonstrates equal distribution between hip and knee extensors during the stability ball wall squat.

FIGURE 4: Line of resistance (- - -) and joint moment arm (↔) demonstrates equal distribution between hip and knee extensors during the Smith machine squat.

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