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The Truth on Fitness:
Are Decline Squats Beneficial?

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Squatting exercises, as staples to strength-building routines, are quite amenable to variation and modification. One such adaptation involves placing a performer's heels on blocks, wedges, or in some cases, weight plates, increasing plantar flexion at the ankle. In clinical parlance, this is referred to as a decline squat. Opinions abound about the relative efficacy of this custom, but as usual, opinions without factual evidence are often misleading. So the question before us is, are decline squats beneficial?

On one hand, passive plantar flexion is sometimes employed in order to compensate for poor lifting technique. People who fail to displace their pelvis effectively, for instance, will often create a motion in which their heels elevate from the floor. A wedge placed beneath the heel, in this example, will help to maintain an effective base of support, while at the same time, enabling poor mechanics. In this case, one could reasonably argue that the decline squat encourages poor movement habits, and may actually impede strength gains. This, however, is conjecture, as little evidence exists suggesting that decline squats, used in this context, actually limit strength development or induce substandard movement practices.

Another use of decline squats may be to compensate for physical limitations, such as tight plantar flexors. A restricted range of motion around the ankle may limit movement at the knees and hips, hindering strength gains in the extensors of those joints.

It would seem reasonable, therefore, to place someone with restricted dorsiflexion into some degree of plantar flexion during squatting, for the purpose of increasing the range of motion about the knee (Zwerver, Bredeweg,Hof, 2007) and hip.

On the other hand, altering the normal kinematics of an exercise may have undesirable effects. According to one analysis (Wolf, 2008), placing the ankle into plantar flexion may compromise the normal tibial and femoral rotation that occurs during a squat. The author describes the sequencing and timing of subtalar pronation, medial tibial rotation and medial femoral rotation during the eccentric phase of motion, and the ensuing supination and lateral tibial and femoral rotation during the concentric phase. Using a decline wedge, Wolf suggests, disrupts subtalar motion, and in a ground-up fashion, affects limb segment rotation and squat mechanics, resulting in excessive force production and potential overuse injuries.

It's certainly true that placing someone in plantar flexion changes the "normal" positioning and displacement of the joints, particularly in dorsiflexion at the ankle. But is this necessarily a bad thing? Do decline squats produce noxious forces? Are injury-producing muscle imbalances developed? And what about similar activities which deviate from neutral anatomical alignment? Rotating the leg externally during a squat, for instance, will likely alter limb segment alignment and joint motion sequencing, but is this a detriment? What does the evidence suggest about decline squats or, for that matter, other anatomical squat variations?

Biomechanically, the effects of performing decline squats are fairly predictable. Two studies in particular, measured sagittal plane knee forces in subjects performing squats at decline angles between 0° and 30° (Richards, et al, 2008; Zwerver and others, 2007). Both studies reported a slight reduction in ankle moments, with a concomitant suppression of plantar flexor activity. Conversely, they demonstrated an increased knee moment, especially at decline angles above 15°. In other words, as the decline angle increased, loading on the knee increased as well.

But increased knee loading is not necessarily detrimental. In fact, decline squats, and the associated increase in knee torque, have been used in the treatment of knee pain. Purdam and colleagues (2004), for example, used eccentric decline squats on a 25° wedge to successfully return six knee patients with painful chronic patellar tendinopathy to competitive athletics, reporting a significant reduction in knee pain over a 12-week treatment period. In a similar study, Young and others (2005) compared decline squats to level squats, and found the former to be more effective at reducing knee pain, with greater predicted outcomes over a 12-month span. Neither of these studies reported any residual noxious effects arising from the plantar flexed position.

A notable feature of these studies, including the biomechanical analyses, is that subjects maintained a vertical trunk posture throughout the squatting motion, effectively positioning the hip joint over the ankle and aligned with the line of force. This would certainly account for the significant increase in knee torque loading, since the knee is projected well forward of the ground reaction force vector. Had the subjects been instructed on proper pelvic displacement and squat mechanics, it is more than likely that the biomechanical profile would have assumed a more balanced load between hip and knee, thereby reducing peak torque at the knee. Nevertheless, the elevated knee loads proved only beneficial to the participants.

Joint forces have also been measured in other forms of squat and leg press variations, such as rotating the legs internally or externally. Admittedly, these are not decline squats, but one could make a case that any deviation from anatomical position, during a squat or leg press, might create similar challenges to the kinematic sequencing of joints and limb segments.

In one study, Escamilla and colleagues (2001) examined the biomechanics of squats and leg presses under a variety of modified forms, including narrow and wide stances, and with the feet pointed forward or 30° to the outside. None of the variations produced significant differences in knee forces in the sagittal plane. Unless those forces were significantly altered, and asymmetrical, it is difficult to argue that they would induce overuse injuries with repeated application.

Looking further up the kinetic chain, Kingma and associates (2004) compared back loading between standard squats and those in which subjects rotated their knees laterally. Interestingly, in this case, the authors noted a decrease in joint moments and lumbar compressive loading when the knees were rotated laterally. Thus, there was an actual benefit to this particular exercise modification.

One of Wolf's contentions, though, is that taking someone out of their normal anatomical alignment affects the relationship between subtalar pronation and supination, movements which occur in the frontal plane, and which induce movements of the tibia and femur in the frontal and transverse planes. The author suggests that this may be the catalyst for overuse injuries stemming from excessive force production. Unfortunately, there is nothing in the literature examining the effects of decline wedges on subtalar motion and the ensuing frontal or transverse plane kinetics.

Extending the search beyond squatting studies may help to draw a connection. One might, for example, look to running literature for parallels in the research. Studies in this domain, for instance, examine the effects of orthoses on ground reaction forces and joint torques. Orthotics have long been used to control rear foot motion, thus studies in this arena may lend some insight into Wolf's claims.

A recent study by Franz and others (2008) demonstrated that the introduction of a flexible arch support produced a 4% increase in knee varus torque in runners, causing an increase in compressive loading at the medial tibiofemoral joint. Consequently, the authors advised discretion in the prescription of orthotic insoles. If a connection could be made between stabilization against excessive pronation and foot mechanics on a decline board, and a correlation could be established between running and squatting, then there may be reason to use caution when performing decline squats.

In another study, however, Williams, et al (2003), measured the effects of medially posted, inverted orthotics on lower extremity mechanics in runners. The authors did report an increase in the peak knee abduction moment, consistent with Franz, et al, but also noted a reduction in rear foot pronation, as well as limited tibial rotation, two factors which, when excessive, may contribute to patellofemoral pain syndrome (PFPS). Coincidentally, Souza and colleagues (2010) report that a primary factor relating to PFPS, is medial femoral rotation. If, therefore, the inclusion of a decline wedge during squatting restricts internal tibial and femoral rotation, then this squat variation may not only benefit those with patellar pain, but may also help to prevent PFPS in the first place.

From a different perspective, one might question whether decline squats alter the balance of activity between key muscle groups. Muscles operating in a state of imbalance, may, over time contribute to overuse injuries. One could presume, for example, that if wedges increase knee joint torque, then the muscle activity of the quadriceps would also be accentuated. This is precisely what was reported by Richards and colleagues (2008), who demonstrated a direct linear relationship between increasing decline angles and myoelectric activity. But this is not an imbalance, and frankly, is no great revelation, since muscle activity naturally increases in response to elevated torque levels. Besides, as previously noted, increased knee torque and muscle activity has resulted in positive outcomes in clinical knee populations.

To examine the effects of frontal plane deviation on muscle activity, Hung and Gross (1999) had subjects perform one-leg squats on level ground, a 10° medial wedge, and a 10° lateral wedge. While these are not decline wedges, they effectively place the foot in either an inverted or everted position. Electromyography was used to measure the activity of the vastus medialis oblique and vastus lateralis muscles. The authors reported no differences in muscular activity between the three platform positions. Apparently, a frontal plane deviation in the support platform does not result in harmful muscle imbalances at the knee.

No other studies have reported on the effects of foot platform deviations on leg muscle activity. Drawing from the earlier example, one can look at other squat variations in order to deduce whether muscles are affected by deviations from the neutral position. In this context, the results are highly consistent. Studies by Escamilla, et al (2001), Signorile, et al (1995), and Ninos and others (1997) examined quadriceps and/or hamstring activity when squats were performed in a neutral position or with the legs externally rotated. In all three studies, there was no difference in muscle activity between the experimental conditions. It is unlikely, therefore, that such modifications would result in injury-producing muscle imbalances.

There are two ways to interpret the results of the available literature. On the one hand, decline squats have been proven beneficial without introducing potentially harmful side effects. For those with range of motion limitations, these may offer an excellent solution for building strength with squats. Keeping in mind that a vertical posture during decline squats will reduce plantar flexor activity, one should account for this by including additional exercises for the calves. Better yet, performing the squats with a more appropriate mechanical technique will ensure balanced joint loading at the hips, knees, and ankles.

On the other hand, the evidence suggests that some modifications to squat and leg press mechanics do little to change ground reaction forces or muscle activity. Enacting those modifications in the interest of changing muscle emphasis, therefore, will have little to no effect. As with any exercise practice, one should consider the performer's capabilities and limitations in order to make necessary adjustments, but one should also confirm, through scientific evidence, that those adjustments will have the intended outcomes.

Finally, it's fair to say that the human musculo-skeletal system is not perfect, and is sometimes susceptible to minor imbalances or movement restrictions. Arguably, however, it is a highly malleable and adaptable mechanism, designed to function, even with physical limitations or in variable environmental conditions. Taking the position that it's undesirable to move over a declined surface because it alters the mechanical sequencing of the foot, ankle, and leg, is tantamount to suggesting that we should avoid running down hill for fear that the body will operate outside of its ideal state.

The truth is that under normal circumstances, the foot and leg exhibit a consistent pattern and sequence of motion. But just because the system operates in that mode under normal, controlled, or neutral conditions, we should not assume, nor insist, that it function that way in all settings. Neither should we restrict the conditions within which it is operating in order to achieve some ideal result, especially, when the evidence suggests otherwise.

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