MONTHLY

THE S&C RESEARCH REVIEW

By Chris Beardsley

OCT 2019 EDITION

October 2019 Edition

Editorial by Chris Beardsley

Welcome to the October 2019 edition! This edition covers brand new studies in some very important areas of physiology and biomechanics. The overall theme is fatigue in its widest sense, including the effects of muscle damage. The first few studies in the strength training section reveal how fatigue differs both as a result of the type of fatiguing exercise and also as a result of the type of strength test we use to measure it. They also show how muscle oxygen levels are closely linked to fatigue. Other studies confirm the biochemical model of muscle damage, and show how fatigue of any kind can impair motor learning whenever it is present.

In the hypertrophy section, the concept of fatigue was also a key feature, since two of the reviewed studies involved detailed comparisons of light and moderate load strength training. As is well-known, fatigue is much greater when training with light loads than when training with moderate loads. A third study assessed the accuracy of the repetitions in reserve scale and its relationship with perceptions of fatigue.

Ultimately, as the studies in this edition show, any model of fatigue requires both a central nervous system (CNS) component and a peripheral component. Moreover, the peripheral component needs to be broken down further into a mechanism involving the excitation-contraction coupling process (and calcium ion handling, which leads to muscle damage) and a mechanism that involves metabolite accumulation (which is linked to oxygenation). Even so, peripheral fatigue of any kind can increase motor unit recruitment by means of increased effort, regardless of the mechanism in which that fatigue is created. Finally, fatigue models need to be clear about which muscle fibers are being affected by the exercise. With such a framework, we can largely explain the findings of most fatigue studies. Read on to learn more! See you next month.

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Contents

Front and back squats are more similar than many lifters realize, and while squat depth affects muscle activation, does this really matter?

Maximal effort exercise, high-intensity exercise, and moderate-intensity exercise all have different fatiguing effects on the force-velocity curve

Muscle deoxygenation increases muscle activation due to the fatigue it induces, which is why some studies have linked it to hypertrophy

Muscle damage occurs in certain individual regions of a muscle during training, but the effects spread to other regions during recovery

Force-velocity profiling can allow us to target training methods very effectively for different athletes

Like fatigue, muscle damage stops us from learning motor skills effectively.

Electromyography is not often an effective tool for assessing muscle activation during fatigue.

Light load training does not cause greater hypertrophy of type I muscle fibers than heavy load training, but it may have other endurance-related adaptations!

In contrast to normal strength training, we know very little about the effects of volume during eccentric training...

Using reps in reserve is now a popular way to alter the intensity of a set of strength training. But how accurate are our estimates typically?

S&C RESEARCH REVIEW

Comparing isometric front and back squats at different depths

The front and back squat are common exercises in many strength and conditioning programs for athletes, and are also used by bodybuilders for developing the quadriceps muscles. While it is often assumed that the differences between front and back squats are substantial, and that the back squat involves far more hip extensor muscle involvement than the front squat, research has shown that such differences are actually quite small. Squat depth is also sometimes varied, either to match joint angles used in sport or to target certain muscles. However, the research examining the effects of squat depth is often quite conflicting.

Key findings

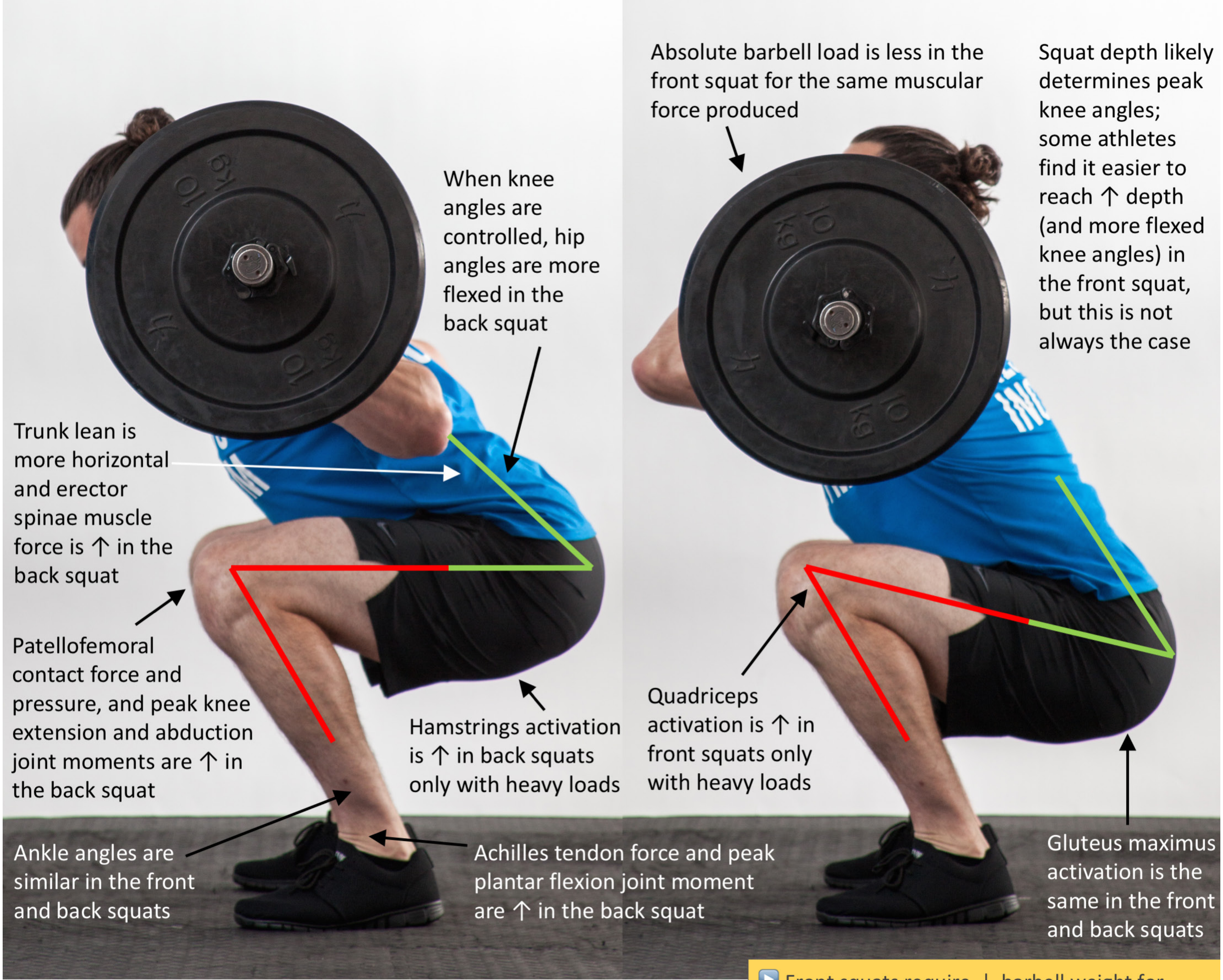
In strength-trained males, shallower squats involve greater external forces than deeper squats, most likely due to the shorter external moment arms. At a knee angle of 90 degrees, there are no differences in the muscle activation of the hip and knee extensors between front and back squats. Moreover, gluteus maximus muscle activation is greater at a knee angle of 90 degrees than at 60 or 120 degrees in both front and back squats.

Practical implications

Back and front squats can be used to produce very similar training effects in strength-trained subjects, with minimal differences in the muscular development that results. While the activation of certain muscles may be greater with shallower depths, hypertrophy is usually greater when using deeper squats, due to the greater mechanical tension afforded by the length-tension relationship.

A comparison of muscle electromyographic activity during different angles of the back and front squat. Trindade, T. B., de Medeiros, J. A., Dantas, P. M. S., de Oliveira Neto, L., Schwade, D., de Brito Vieira, W. H., & Dantas, F. F. O. (2019). *Isokinetics and Exercise Science*, (Preprint), 1-8.

Differences between back squat and front squat are small



Front squats require ↓ barbell weight for similar leg muscle forces, involve ↓ trunk lean and erector spinae muscle force, ↓ hamstrings activation (with heavy loads), ↓ Achilles tendon muscle force, ↓ patellofemoral contact force, and ↑ quadriceps activation (with heavy loads).

OBJECTIVE

To compare the muscle activation of the hip and knee muscles during maximal voluntary isometric contractions in the back squat and front squat at three different knee angles, in strength-trained males.

INTERVENTION

Subjects first did maximum voluntary isometric contractions (MVICs) for each relevant muscle (rectus femoris, vastus lateralis, vastus medialis, biceps femoris, gluteus maximus, and erector spinae). Thereafter, the subjects undertook two separate sessions in which they did MVICs in both the front squat and back squat positions, using 60◦, 90◦ and 120◦ of knee flexion. The subjects were encouraged to produce maximum force in each of the six different conditions for a 10-second period.

POPULATION

10 healthy males, aged 30.7 ± 7.9 years, and with 13.1 ± 8.1 years of strength training experience

MEASUREMENTS

Maximum squat force: By two load cells, each attached between one end of the barbell and the ground.

Muscle activation: By surface electrodes over the relevant muscles being measured, normalized to levels in the MVICs.

N.B. in the version of the paper available at the time of writing this review, the results reported in the text of this study differed from the data presented in the main table. The table data are assumed to be correct.

RESULTS

Maximum squat force was greater in the back squat compared to in the front squat at all three knee joint angles. In addition, maximum squat force increased with decreasing squat depth, such that the greatest force was produced in the most shallow squat position. This was expected, due to the shorter external moment arm lengths at the knee and hip joints in the shallow squat position, which allow a greater squat force to be produced for a given set of knee and hip net joint moments (and muscle forces).

Comparing front and back squat

Compared to the back squat, the front squat displayed less gluteus maximus, biceps femoris, and vastus lateralis muscle activation at 60 degrees of knee flexion, and less vastus lateralis and rectus femoris muscle activation at 120 degrees of knee flexion. There were no differences between the front and back squats for any muscle at 90 degrees of knee flexion.

Comparing joint angles

Gluteus maximus muscle activation was greater at 90 degrees than at either 60 or 120 degrees. Erector spinae muscle activation increased progressively with increasing squat depth. Biceps femoris muscle activation increased very slightly with increasing squat depth, but only in the front squat.

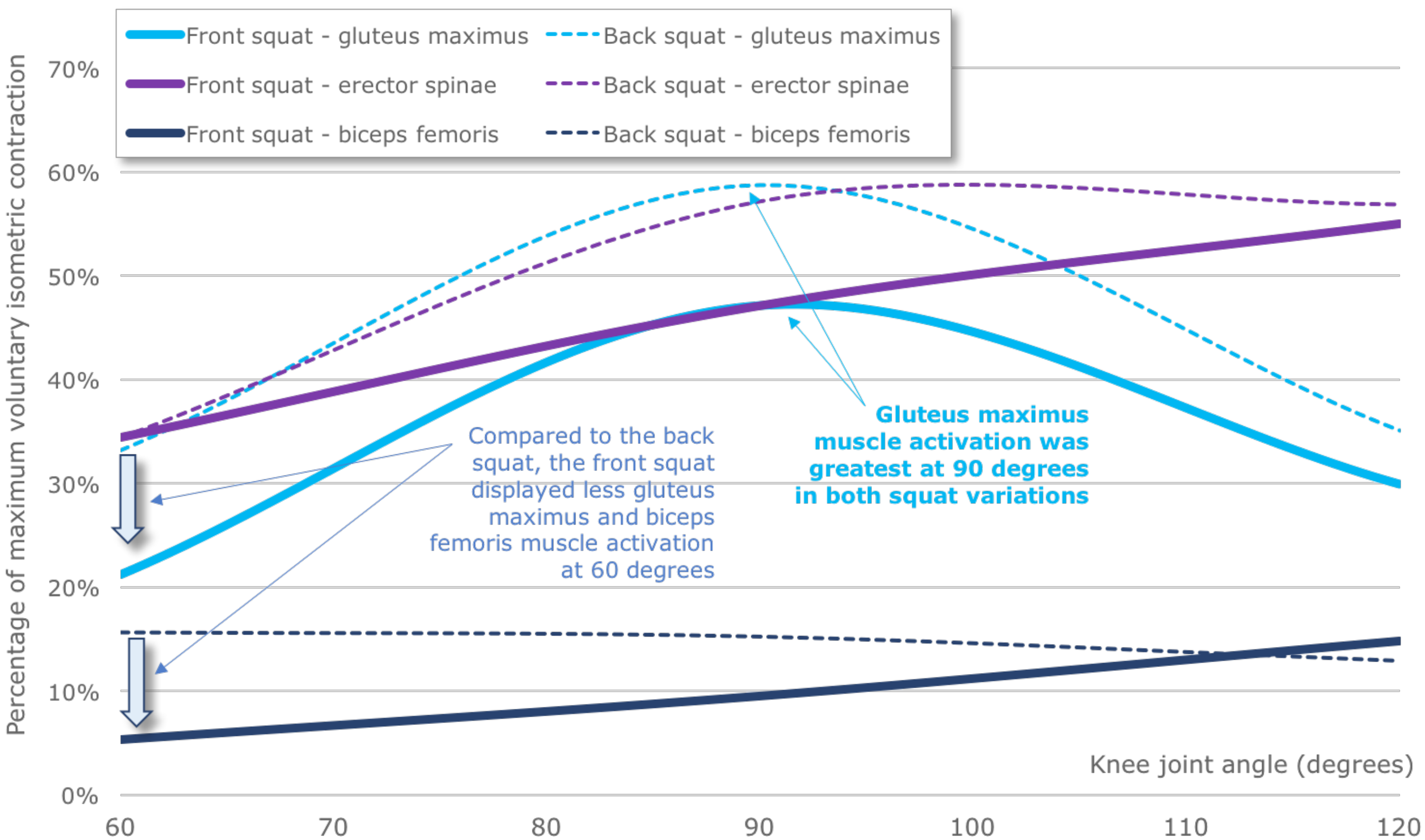
SUMMARY

In strength-trained males, shallower squats involve greater external forces than deeper squats. At a knee angle of 90 degrees, there are no differences in the muscle activation of the hip and knee extensors between front and back squats. Moreover, gluteus maximus muscle activation is greater at a knee angle of 90 degrees than at either 60 or 120 degrees in both front and back squats.

This study found no differences in hip and knee extensor activation between front and back squats, when taking measurements at a knee angle of 90 degrees. This fits reasonably well with much of the previous literature, which has reported minor differences in the activation of the hip and knee extensors between dynamic front and back squats (1 – 4). Yet, the study also found that gluteus maximus muscle activation was greater at a knee angle of 90 degrees compared to at either 60 or 120 degrees, in front and back squats.

Previous research has found either little effect of squat depth on gluteus maximus muscle activation (3) or has shown that partial squat positions (20 – 90 degrees) involve greater gluteus maximus activation than deeper (140 degrees) squat positions (5,6). This latter research is in agreement with the basic behavior of the gluteus maximus during hip extension, wherein muscle activation increases with increasing proximity to full hip extension (7,8). Exactly why the gluteus maximus displayed much lower-than-expected activation at 60 degrees in this study is therefore unclear.

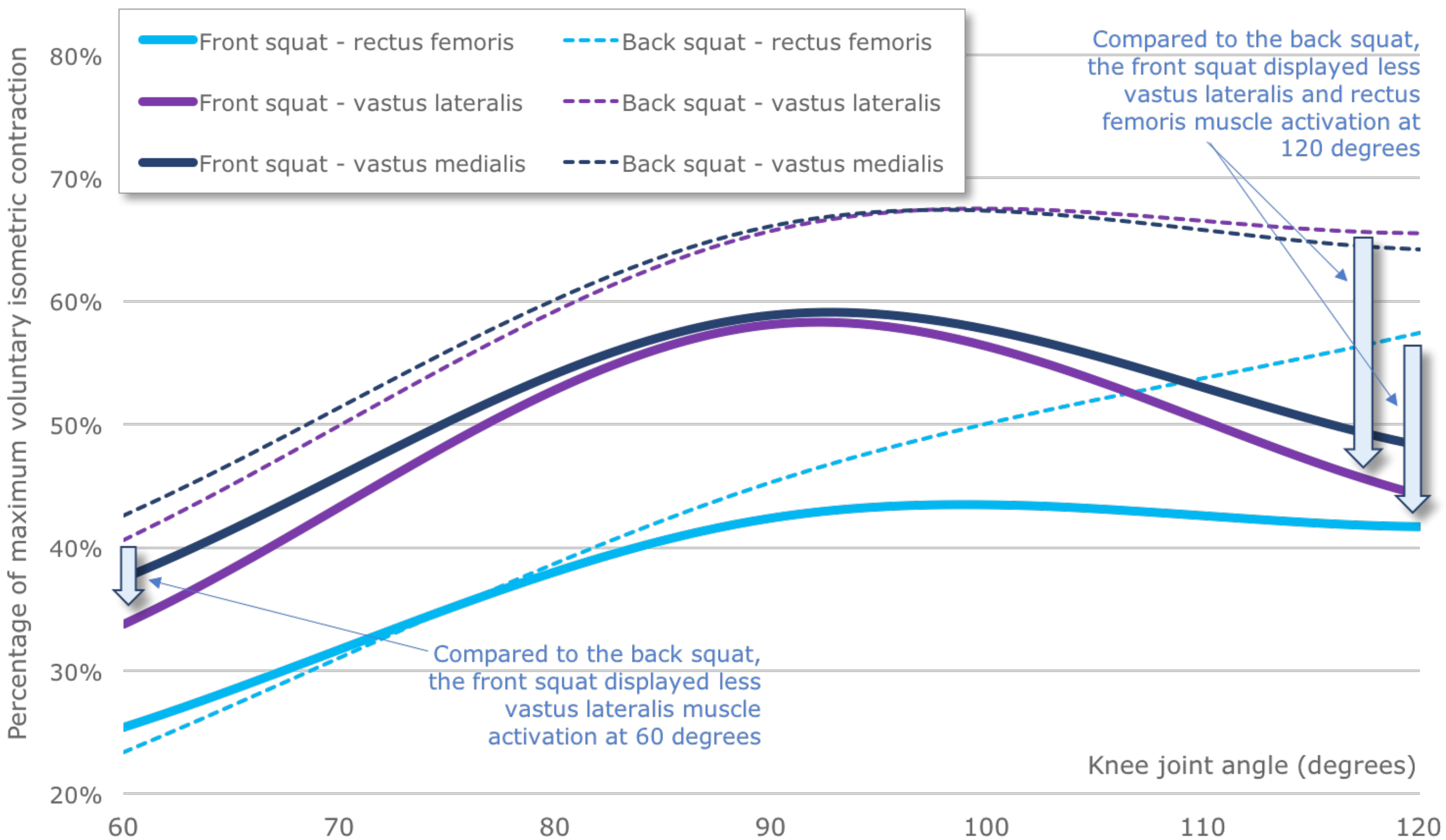
Muscle activation of **certain hip extensors** during isometric front and back squats at different knee joint angles, measured by surface electromyography, in strength-trained males



The greater muscle growth that occurs in the gluteus maximus after training with a deeper squat depth (140 degrees) instead of a shallower depth (90 degrees) (9) need not arise due to differences in muscle activation, however. Muscle fibers grow when they are exposed to mechanical tension, and not merely when they are activated. Greater ranges of motion can (but do not always) cause greater fiber stretch and thus greater tension (10), if the fibers are compelled to work on the descending limb of the length-tension relationship.

Although we do not have readily available data for the working sarcomere lengths in the muscle fibers of the gluteus maximus (as we do for many other muscles), it seems likely that this muscle does contain muscle fibers that work on the descending limb of the length-tension relationship (like many lower body muscles) (11). Thus, the gluteus maximus most likely attains greater hypertrophy after training with deeper squat depths (9) through the greater stretch-induced mechanical tension, rather than due to greater muscle activation.

Muscle activation of **certain knee extensors** during isometric front and back squats at different knee joint angles, measured by surface electromyography, in strength-trained males



In practical terms, the findings of this study regarding the differences in muscle activation at different squat depths do not really alter training recommendations for bodybuilders and other physique athletes, since long-term studies have shown that the gluteus maximus is developed to a greater extent by using deeper squats than by using shallower squats (9). It is likely also the case that the quadriceps muscles are developed to a greater extent during deeper squats, because they too work on the descending limb of the length-tension relationship (11), but long-term studies have not always confirmed this finding (9). Yet, there may still be reasons for using shallower squats with athletes. Some (but not all) studies have shown that athletic performance can be enhanced to a greater degree with partial ranges of motion, likely due to the similar joint angles used in the exercise and in the movements (12,13).

Although the rectus femoris was reported as being activated in the current study, it is unlikely that it was as strongly activated as the data suggest, since it is very easy to produce crosstalk between the other quadriceps muscles and the rectus femoris. Moreover, other research has shown that the rectus femoris has poor mechanical leverage in the squat (14) and does not increase in size after long-term squat training (9,15,16). This is why bodybuilding training programs benefit from including both squat or leg press variations and knee extensions. The knee extension is very effective for training the rectus femoris but is much less effective at training the other quadriceps (17). Similarly, athletes can benefit from targeting the rectus femoris with the reverse Nordic curl (18,19) to enhance sprinting performance (20) and also to reduce muscle strain injury risk (21).

Conclusions

In strength-trained males, shallower squats involve greater external forces than deeper squats. At a knee angle of 90 degrees, there are no differences in the muscle activation of the hip and knee extensors between front and back squats. Moreover, gluteus maximus muscle activation is greater at a knee angle of 90 degrees than at 60 or 120 degrees in both front and back squats.

Practical implications

Back and front squats can be used to produce very similar training effects in strength-trained subjects, with minimal differences in the muscular development that results. While the activation of certain muscles may be greater with shallower depths, hypertrophy is usually greater when using deeper squats, due to the greater mechanical tension afforded by the length-tension relationship.

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