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Kinetics and Benefits of an Unique Assisted Free Bodyweight Squatting System: The DB Method®™

Gerard C. Gorniak

Anatomy & Biomechanics, The University of St Augustine for Health Sciences, St. Augustine, Florida, USA
Email: gcgorniak@gmail.com

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Abstract

Squatting movements are used frequently in the activities of daily living and squatting exercises are used to strengthen abdominal core and lower limb muscles. However, many individuals cannot perform a traditional squat. An alternative is to hire a physical trainer or coach for supervision which can be prohibitively expensive. The DB Method® machine is unique and affordable. A product satisfaction descriptive survey to owners of The DB Method machine describes increased gluteal, core, pelvic floor and lower body strength, an improvement in gluteal region shape, and an increase in activity and energy level. A surprising result of the survey was that this DB Method also seemed to strengthen the pelvic floor muscles and, in some cases, to lessen urinary incontinence. In this article, the results of this survey are described as the kinetics of this machine relative to the lower limbs and the pelvic floor muscles. A comparison between traditional squats and The DB Method and the benefits of using The DB Method are discussed.

Keywords

Squats, Kinetics, Gluteus Maximus, Pelvic Floor, Posterior Pelvic Tilt, Functional Applications

1. Introduction

Squatting movements and the associated muscles actions are used in everyday activities, such as sitting and standing, crouching to pick up items off the floor or under a cabinet, going to the bathroom, stooping to hug a child, and during many recreational activities. As we age, the ability to squat is more difficult because of gluteal and quadriceps muscle weakness, limited joint movement, knee, hip and back pain and decreased balance [1] [2] [3] [4].

While there are many types of squats and squatting techniques that target the muscles of the lower limb, back, abdominal wall and pelvic floor muscles, choosing a type of squat can be confusing and even dangerous [5] [6] [7] [8] [9].

Squats are commonly categorized into: 1) traditional; 2) barbell loaded squats; 3) free standing bodyweight squats, 4) wide and narrow stance; and 5) unilateral ([8] [10]-[20]; **Table 1**). The freestanding bodyweight includes assisted free body weight squats that use a machine such as The DB Method. The type of squat is chosen on the basis of training/rehabilitation goals, with each type of squat having different biomechanics that require varying degrees of mobility, strength, balance and coordination. While each squat will generally challenge muscles of the lower body, core and trunk, each variation will have certain emphases ([8] [9] [11] [12] [14] [15] [18] [19] [21]-[31] **Table 1**).

The kinematics of proper squatting are complex and vary with the type of squat. If not properly performed squatting "can lead to a wide range of maladies, especially in combination with the use of heavy weights" [5] [8] [9] [16] [20]. These complexities can be especially challenging to home users who do not have the benefit of coaching or personal supervision to ensure correct form and safety, and to those with gluteal muscle and quadriceps weakness, lower limb joint and back pain, and balance problems. While many kinetic analyses have been done for traditional, barbell loaded and unilateral squats, the variations in body and weight positions, the depth and velocity of the squat, and the patterns of squatting movements, these analyses can be confusing and comparisons among these complicated [5] [9] [10] [12] [14] [15] [16] [19]-[38].

A high percentage of females suffer from disorders of the pelvis that have a major effect on a person's quality of life [10] [39]-[50]. The literature reports that as many as 40% - 50% of the female population had episodes of urinary incontinence but less than half seek treatment. About 16% of males have pelvic dysfunction. There are many exercises to strengthen the pelvic floor muscles to treat urinary incontinence, including Kegel exercises, bridges, bird dog movement, marches, and diaphragmatic breathing [39] [51]-[71]. While squatting is associated mainly with muscle strengthening in athletes, weightlifters, recreational activities and in physical rehabilitation, studies show that modified squats and wall squats squatting can also be beneficial in those with pelvic floor dysfunction, especially urinary incontinence [51] [52] [56] [57] [66] [67] [72] [73] [74] [75] [76]. Studies have also described co-activation of the pelvic floor muscles and abdominal muscles as both are affected by internal abdominal pressure [44] [77] [78] [79] [80]. The kinetics of how squatting strengthens on the pelvic floor are unclear [41] [62] [74] [81].

In this article, the results of a multiple-choice descriptive owners' product satisfaction survey taken by 191 users of The DB Method are reported. The kinetics of The DB Method assisted free bodyweight machine are described during the descent (eccentric phase) and ascent (concentric phase) of the squat. Based on the kinetics, the actions of the hip, knee and leg muscles are described, and

Table 1. Common types of squats and purpose.

Squat Type	Target Area/Purpose
Traditional Freestanding Bodyweight	Overall lower body strength, core stability, trunk stability and lower body mobility
Loaded Barbell (Front or Back) Squat	Greater loading for more increased lower body strength, core and trunk stability
Wider Stance	Increased hip adductor work plus overall hip mobility due to increased hip abduction and external rotation
Narrow Stance	More quadricep emphasis and greater ankle mobility
Unilateral Split Squats, Step Ups, Pistol Squats, Cossack Squats, Side Lunges	Increased stability, balance and complexity of movement patterns

The DB Method is compared to traditional squatting. Finally, a kinetic assessment of how The DB Method may strengthen the pelvic floor is presented and discussed.

2. Methods

2.1. Surveys

A descriptive product satisfaction survey of 18 multiple choice questions and 1 open question were emailed to owners of The DB method (inclusion criteria) using Monkey Survey. There were no exclusion criteria. Two questions asked age and gender, 2 questions asked on the use of The DB method, 2 questions about not using traditional squats, 10 questions on what they experienced using The DB method, 1 recommendation question and 1 question open to general comments. There were 191 respondents (a 2% return) and for each choice in a question the range, mean percentages and standard deviations calculated. For 1 question, the answers were ranked. The open-end questions were grouped and summarized.

2.2. Kinetic Analysis

A kinetic analysis of this assisted free weight machine, the DB Method (Figure 1), during the descent or eccentric phase and ascent or concentric phase determined from sagittal and frontal photographs during the start, mid squat, and deep (end) squat. This analysis included the Center of Mass (CM), Line of Gravity (LOG), Ground Reaction Forces (GRF), Center of Pressure (COP), Weight (resistance) Arm for the hip, knee and ankle, External Moments for the hip, knee and ankle, and the Lines of Actions of 17 hip, knee, and ankles muscles. The muscle lines of Action were used to assess the Internal Moments at each joint.

Because users described strengthening of the pelvic floor and some even the decrease and stoppage of urinary incontinence (Table 2), a kinetic analysis was performed on the effects of The DB Method on the Pelvic Floor Muscles and fascia.

Table 2. Survey results from the DB Method users.

Age	78% (30 - 59); 40% (45 - 59); 38% (30 - 44)
Gender	96% female; 4% male
Time of use	92% (3 months - 2 yrs); 43% (4 months - 1 yr.); 23% (1 - 2 yrs.)
Frequency of use per week	69% (1 - 4 X/wk); 35% (3 - 4 X/wk); 34% (1 - 2 X/wk)
% able to do traditional squats before using DB Method	56% could; 44% could not
Top 7 reason users could not do traditional squats in rank order with the most common	1) Knee pain (35%); 2) confusion about proper squat form (16%); 3) fear of injury (14%); 4) balance problems (12%); 5) back pain (12%); 6) hip pain (11%); 7) lower limb weakness (11%)
% describing improvement in gluteal muscle strength	85% Yes; 15% No
% describing improvement in gluteal region shape	82% Yes; 18% No
% describing an increase in overall lower body strength	84% Yes; 16% No
% describing an increase in core strength	75% Yes; 25% No
% describing an increases in pelvic muscle floor strength	70% Yes; 305 No
% describing a change in urinary incontinence	15% Lessened; 4% stopped; 20% unchanged; 60% Not App.
% describing improvement in overall activity level and enjoyment	82% Yes; 18% No
% describing an increase in energy	71% Yes; 29% No
% describing an improved mental health attitude	49% Yes; 33% unchanged; 17% Not App.; 1% declined
% describing changes in their sex life	21% Improved; 2% declined; 43% unchanged; 34% Not App.
% recommending the DB method	99% Yes; 1% No

The machine is constructed of steel with some plastic and rubber (non-latex) components and has met global safety standards set for fitness equipment issued under the ASTM F2276. These guidelines set standards for (1) stability, (2) support, (3) edges, corners, and tube ends, and (4) moving parts in accessible areas (5) squeeze, shear, and crush points, (6) adjustment and locking means, (7) handgrips and foot support, (8) load development and transmitting components (ropes, belts, chains, and other means, and chain or gear drives), (9) intrinsic, extrinsic, and endurance loading, and (10) documentation that includes assembly instructions, list of equipment parts, operational instructions, and maintenance instruction.

The DB Method machine is composed of four primary mechanical elements which, together, guide the user's squatting experience to align with the machine's intended biomechanics. These are the Handrails,Foot Ramps, and an assistance system composed of the Seat Guide and Tension Rod.

The Seat Guide used to accommodate different heights with a minimum height of 5'0" and maximum height of 6'3". There is a suggested user body weight limit of 250 lbs.

Seat Guide and Tension rod direct the hips of users in a gentle arc and provide resistive feedback and support throughout the squat descent and ascent, based on the principle of reactive neuromuscular training to prompt correct muscle engagement.

Figure 1. Is a photograph of the DB Method®™ device showing components and adjustments on which the kinetic analysis was based.

3. Results

Survey results are shown in Table 2. In summary, most users were female between 30 - 59 years of age and use The DB Method 2 - 4 times a week for 4 months to 1 year. 55% could do traditional squats but 44% could not because lower limb joint pain and muscle weakness; balance problems and fear of injury, and confusion about how to properly perform the squat. Between 70% and 85% of the users described increases in gluteal strength and shape, core strength, overall lower limb strength, pelvic floor muscle strength, and improvement in overall activity levels and energy. 99% recommended The DB Method.

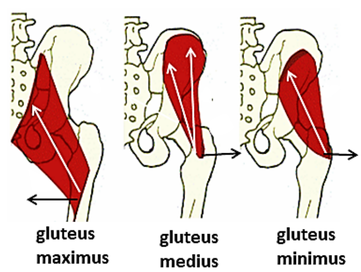
There were 98 open question responses that were divided by content into the following 5 categories: 1) 67% were very positive (3 responses described its use by the family and 23% "loved" the method); 2) 8 % were negative (2% about the hardware, 4% said it did not help; 2% complained about the cost apps); 3) 10% were new and inconsistent users with nothing positive or negative to say; 4) 4% asked questions; 5) 11% had no added comments.

3.1. Description of the Muscles Involved in Squatting

During the descent phase of the squat, the gluteus maximus and the quadriceps femoris contract eccentrically to control range of motion while these same muscles contract concentrically during the ascent phase (**Figure 2**, **Figure 3**). The hamstrings may show eccentric action during the descent to control the position of the tibia (**Figure 4**). Hip rotators, adductors and abductors act mainly concentrically to stabilize the hip in the frontal and transverse planes (**Figure 5**). The muscles of the leg also act concentrically as stabilizers of the ankle (**Figure 6**).

3.2. Kinetics of Squatting with the DB Method®™

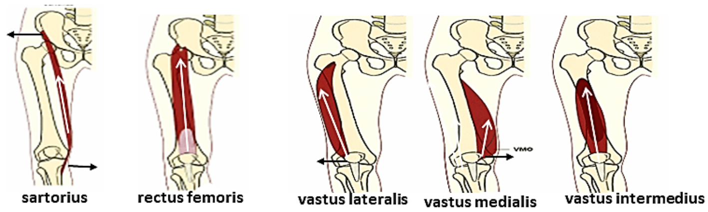
Descriptions and kinetics of a squat using The DB Method during the descent from the initial start position, at mid squat and at deep squat and at the ascent



MUSCLE	DESCENDING SQUAT MUSCLE ACTION	ASCENDING SQUAT MUSCLE ACTION
gluteus maximus	Eccentric contraction controls hip flexion; ER helps to stabilize hip rotation	Concentric (shortening) contraction extends hip; ER helps to stabilize hip rotation
gluteus medius	Eccentric contraction of posterior part controls hip flexion; anterior and posterior parts Abd and IR hip; stabilize hip in Abd in frontal plane; IR stabilize hip rotation in transverse plane	Concentric contraction of anterior and posterior parts stabilize hip in frontal plane; IR stabilize hip rotation in transverse plane
gluteus minimus	Concentric contraction Abd and IR hip; stabilize hip in Abd in the frontal plane; IR stabilize hip rotation in transverse plane	Concentric contraction stabilize hip in Abd in the frontal plane; IR stabilize hip rotation in transverse plane

ER = External rotation; IR = Internal rotation; Abd = Abduction; Add = Adduction; Arrows estimate muscle line of action

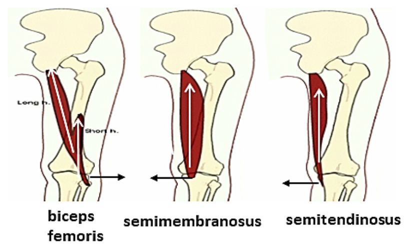
Figure 2. Gluteal muscles actions during the squat.



MUSCLE	DESCENDING SQUAT MUSCLE ACTION	ASCENDING SQUAT MUSLCE ACTION
sartorius	Hip flexion slackens muscle so little to no action at he hip and only slight IR of tibia at end of squat to stabilize tibial rotation at knee.	As the hip extends, concentric IR at the hip to stabilize hip rotation; concentric ER of tibia to stabilize tibial rotation at knee.
rectus femoris	Hip flexion slackens muscle so little to no action at he hip and only slight eccentric control of knee flexion at end of squat	Concentric extension of knee as hip extends; some eccentric control of hip extension near full active hip extension
vastus lateralis	Eccentric contraction to control of knee flexion and ER at tibia to stabilize knee rotation in the transverse plane; lateral pull to control patellofemoral alignment	Concentric extension of the knee and ER at tibia to stabilize knee rotation in the transverse plane; lateral pull to control patellofemoral alignment
vastus medialis	Eccentric contraction to control of knee flexion and IR at tibia to stabilize knee rotation in the transverse plane; lateral pull to control patellofemoral alignment	Concentric extension of the knee and IR at tibia to stabilize knee rotation in the transverse plane; medial pull to control patellofemoral alignment
vastus intermedius	Eccentric contraction to control of knee flexion; vertical downward pull on the patella to control patellofemoral alignment	Concentric extension of the knee; vertical upward pull of the patella to control patellofemoral alignment

ER = External rotation, IR = Internal rotation, Abd = Abduction, Add = Adduction, Arrows indicate muscle line of action

Figure 3. Sartorius and quadriceps muscle actions during the squat.



MUSCLE	DESCENDING SQUAT MUSCLE ACTION	ASCENDING SQUAT MUSLCE ACTION
biceps femoris	Posterior pelvic tilt and knee flexion slacken the muscle resulting in weak eccentric control of hip flexion; ER rotation at knee helps stabilize tibial torsion and with the medial hamstrings controls anterior tibial motion.	Concentric contraction assist in hip extension and helps control quadriceps driven knee extension; ER rotation stabilizes tibial torsion
semimembranosus	Posterior pelvic tilt and knee flexion slacken the muscle resulting in weak eccentric control of hip flexion; IR rotation at knee helps stabilize tibial torsion and with the other hamstrings controls anterior tibial motion.	Concentric contraction assist in hip extension and helps control quadriceps driven knee extension; IR rotation stabilizes tibial torsion
semitendinosus	Posterior pelvic tilt and knee flexion slacken the muscle resulting in weak eccentric control of hip flexion; IR rotation at knee helps stabilize tibial torsion and with the other hamstrings controls anterior tibial motion.	Concentric contraction assist in hip extension and helps control quadriceps driven knee extension; IR rotation stabilizes tibial torsion

ER = External rotation; IR = Internal rotation; Abd = Abduction; Add = Adduction; Arrows estimate muscle line of action

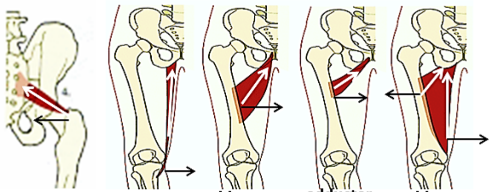
Figure 4. Hamstring muscle actions during the squat.

end of the squat are shown (**Figures 7-12**). Individual are instructed look forward, pull your shoulder back, lightly hold the handrails; place your heels in the center of the foot ramp, keep your knees slightly bent but straight forward; tighten your abdominal muscles; rotate the top of your pelvis back so your tailbone is tucked under you; and then tighten your gluteus maximus.

3.2.1. Description of Kinetics in Figure 7

1) **HIP MUSCLES AND MOVEMENTS**: Posterior pelvic tilt and the posterior position of the hip joint to the line of gravity and the ground reaction force produce an external flexion moment. As the body moves down, the amount of

hip flexion needs to be controlled to avoid falling. This control is produced mainly by eccentric (or lengthening) contractions of the gluteus maximus and posterior part of the gluteus medius muscles. While the hamstrings are also extensors of the hip, the posterior tilt of the pelvis slackens the hamstrings, producing only a small hip flexion controlling force compared to the gluteal muscles.



MUSCLE	DESCENDING SQUAT MUSCLE ACTION	ASCENDING SQUAT MUSCLE ACTION
piriformis	Concentric contraction Abd and IR hip; stabilize hip in Abd in the frontal plane; IR stabilize hip rotation in transverse plane	Concentric contraction stabilize hip in Abd in the frontal plane; IR stabilize hip rotation in transverse plane
gracilis	Muscle on slack; little, if any, action	Concentric contraction Add hip and IR tibia; stabilizes hip in frontal plane and tibial rotation in transverse plane
adductor longus	Concentric Add stabilizes hip in the frontal and IR stabilizes hip in the transverse planes	Concentric contraction Add hip and IR hip; stabilizes hip in frontal and transverse planes
adductor brevis	Concentric Add stabilizes hip in the frontal and IR stabilizes hip in the transverse planes	Concentric contraction Add hip and IR hip; stabilizes hip in frontal and transverse planes
adductor magnus	Adductor part: Add to stabilize the hip in the frontal plane; ER to stabilize the hip in the transverse plane; Hamstring part: Eccentrically helps control hip flexion and IR to stabilize hip rotation in transverse plane	Adductor part: Add to stabilize the hip in the frontal plane and ER to stabilize the hip in the transverse plane; Hamstring part: concentrically extends hip; IR to stabilize hip rotation in transverse plane

ER = External rotation; IR = Internal rotation; Abd = Abduction; Abd = Abduction; Arrows estimate muscle line of action

Figure 5. Hips rotators, abductors, and adductors muscles actions during the squat.

MUSCLE	DESCENDING SQUAT MUSCLE ACTION	ASCENDING SQUAT MUSLCE ACTION
gastrocnemius	With the Center of Pressure (COP) at the heel, the GRF runs posterior to the ankle and places a mechanical plantar flexion moment on the ankle which press the foot against the angled foot ramp. The mechanical ankle position would need slight concentric contraction of the gastrocnemius and soleus muscles to hold and stabilize the foot in this position.	Slight concentric contraction of the gastrocnemius would help control the extended position of the knee and help stabilize rotation of the femur on the tibia to counteract tibial rotation by the hamstrings and quads.
soleus	Slight concentric contraction for stability of the posterior ankle, holding foot in slight plantar flexion on foot ramp.	Slight concentric contraction for stability of the posterior ankle, holding foot in slight plantar flexion on foot ramp
posterior tibialis	Slight concentric contraction for stability of the posterior ankle, holding the foot in slight plantar flexion on the foot ramp, stable ankle in neutral supination/pronation	Slight concentric contraction for stability of the posterior ankle, holding the foot in slight plantar flexion on the foot ramp, stable ankle in neutral supination/pronation
anterior tibialis	Slight concentric contraction for stability of the anterior ankle, holding foot in slight plantar flexion on the foot ramp, stable ankle in neutral supination/pronation	Slight concentric contraction for stability of the anterior ankle, holding foot in slight plantar flexion on the foot ramp, stable ankle in neutral supination/pronation
peroneus longus	Slight concentric contraction for stability of the ankle on the foot ramp in neutral supination/pronation	Slight concentric contraction for stability of the ankle on the foot ramp in neutral supination/pronation

Arrows estimate the line of action

Figure 6. Leg muscle actions during the squat.

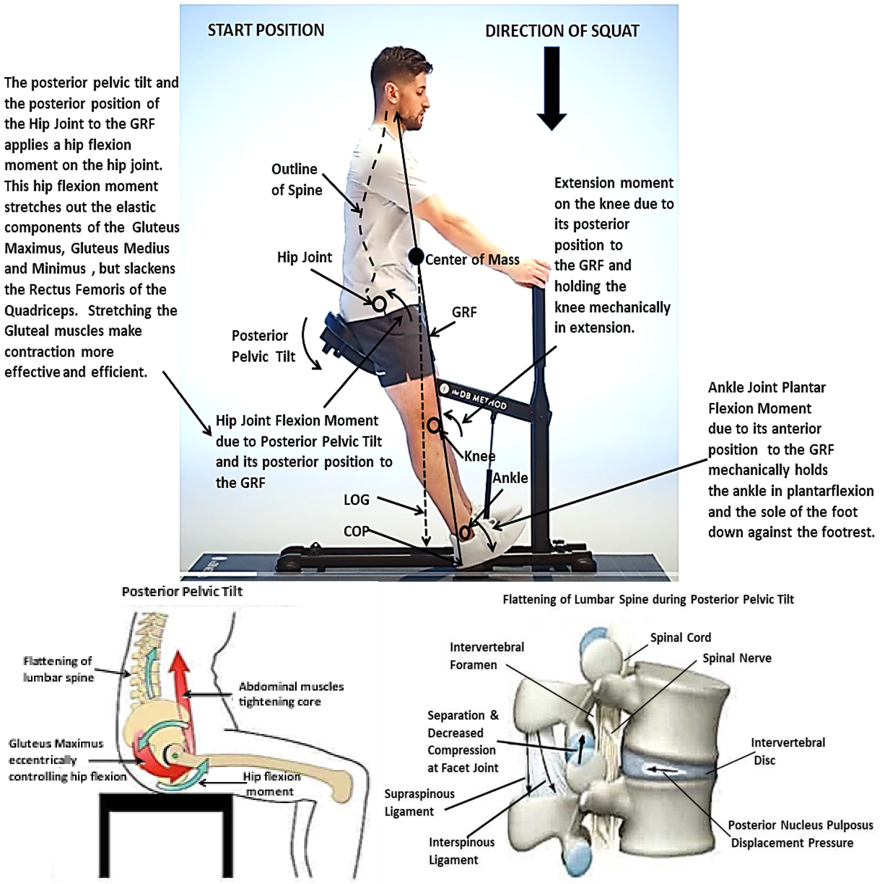


Figure 7. Lateral view at the start of the squat descent; COP = Center of Pressure, GRF = Ground Reaction force, LOG = Line of Gravity.

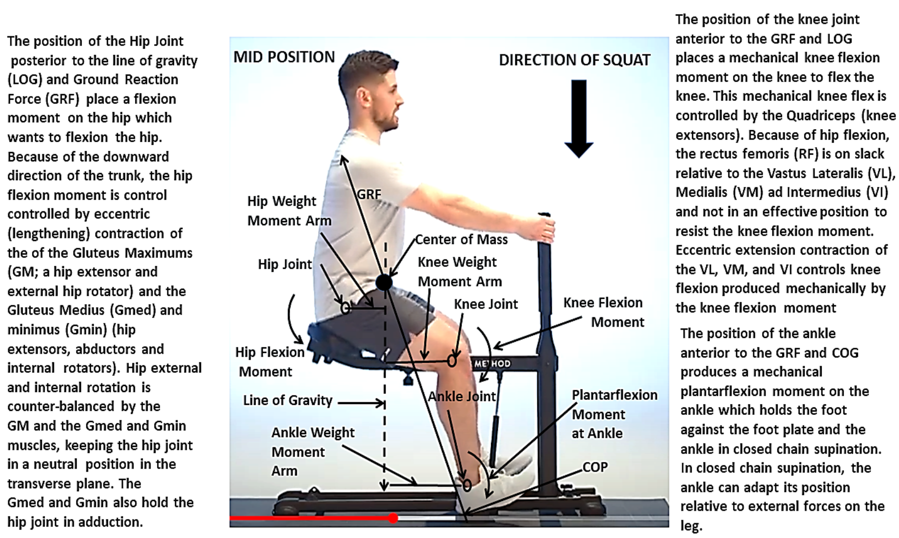


Figure 8. Lateral view at Mid Position during the squat descent.

The hip in this squat position is slightly abducted because of action of the gluteus medius and minimus, piriformis, and tensor fascia latae but the degree of hip abduction is stabilized by the hip adductors.

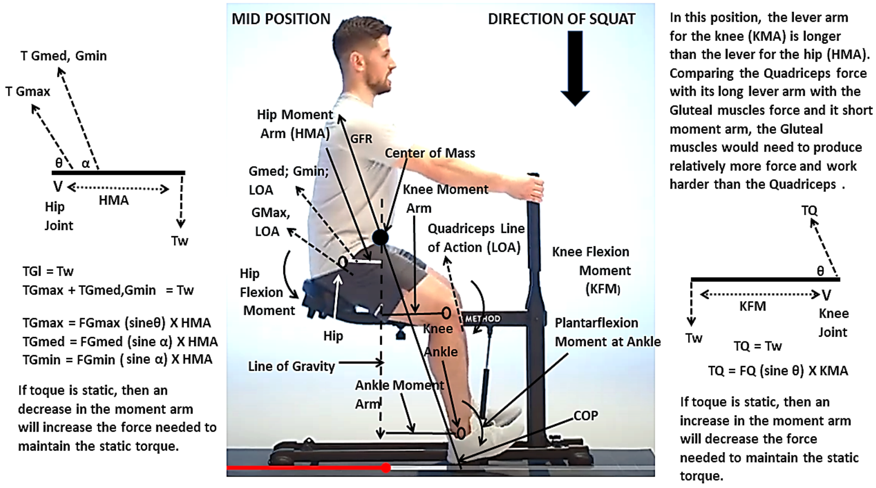


Figure 9. Lateral Mid Position during the squat descent.

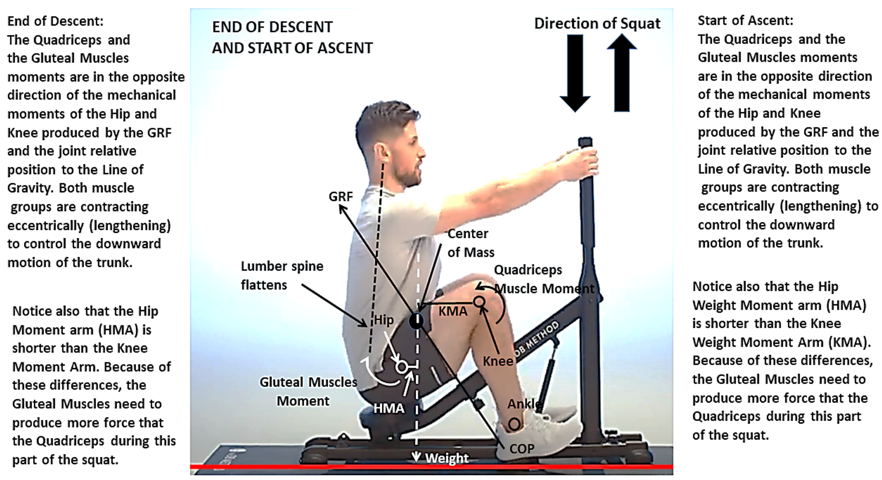


Figure 10. Lateral view at the End Descent and the start of ascent.

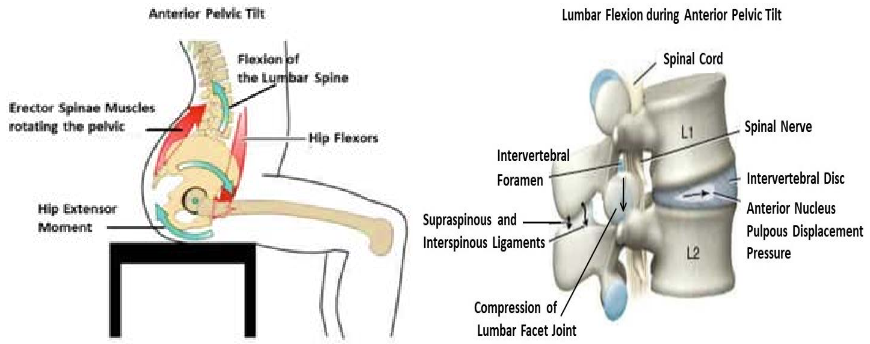


Figure 11. Lateral view at the End Ascent.

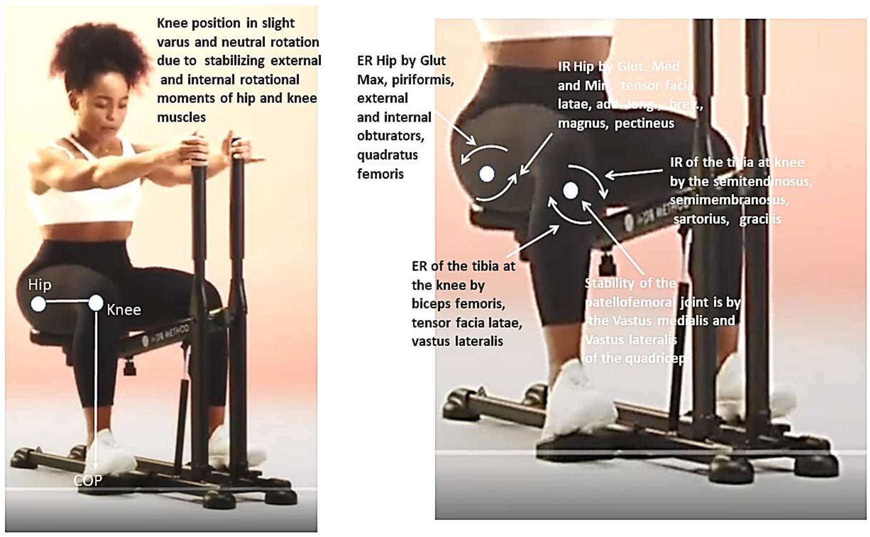


Figure 12. Frontal view at mid position (ER = External rotation; IR = Internal Rotation): The hip is stabilized by the contraction of the ER and IR muscles of the hip. The knee is stabilized by the ER and IR of the tibial and the patellofemoral joint vastus lateralis and vastus medialis of the quadriceps.

Rotation of the hip is near neutral and stable at this squat starting position if the feet are properly aligned in a straightforward position with the knee and hip. Internal rotation is produced by the gluteus medias and minimus, the piriformis and tensor fascia latae and hip adductors and this internal rotation moment is counterbalanced by an external rotation moment produced by the gluteus maximus, quadratus femoris, obturator internus and internus, and sartorius. If the feet are pointed outwardly, then the hip external rotators are acting with more force than the hip internal rotators. If the feet are pointed inwardly, then the hip internal rotators are more active than the hip external rotators.

2) KNEE MUSCLES AND MOVEMENTS: Hip flexion slackens the rectus femoris muscle so little to no action occurs at the hip and only slight eccentric control of knee flexion at early in the squat. The knee is held in extension because the GRF lies anterior to the knee joint. No quadricep activity is needed to maintain knee extension, but contraction from the vastus lateralis and medialis may stabilize knee rotation and the knee flexes. Contraction of the hamstrings are initially assisting the gluteus maximus in controlling hip flexion and are counterbalancing the extension moment by the GRF at the knee and the vastus lateralis and medialis to stabilize tibial rotation.

3) ANKLE MUSCLES AND MOVEMENTS: With the Center of Pressure (COP) at the heel, the GRF runs posterior to the ankle and places a mechanical plantar flexion moment on the ankle which presses the foot against the angled foot plate. The mechanical ankle position does not need concentric contraction of the gastrocnemius and soleus muscles to produce and hold this position. Slight contraction of the gastrocnemius would help control the extended position of the knee and help stabilize rotation of the femur on the tibia to counteract tibial rotation by the hamstrings and quads.

3.2.2. Description of Kinetics in Figure 8, Figure 9 and Figure 12

1) HIP MUSCLES and MOVEMENTS: At the 90˚ squat, there is still a posterior pelvic tilt which flattens the lumbar spine, opening the intervertebral foramen and decreasing the compression force on the intervertebral or facet joints. The erector spinae muscles are active eccentrically at this time to stabilize the spine. The hip remains in an external flexion moment and the gluteus maximus and the posterior gluteus medius muscles are still eccentrically active, controlling the degree of hip flexion. The weight and force moment arms of the gluteus maximus at a 90˚ squat is about the same as those at the start of the squat. As the gluteus maximus is near its optimal fiber length at 90˚ of flexion and in an area on the length-tension curve that shows the greatest number of cross bridges and highest tension, the force of the gluteus maximus remains high and relatively the same from the start of the squat to a 90˚ squatting position.

The hip is stabilized in abduction by action of the hip abductors (gluteus medius and minimus, piriformis, tensor fascia latae) and concurrent action of the hip adductors (gracilis, adductor longus and brevis and the large adductor magnus). Hip rotation is stabilized by the actions of the internal rotators and the hip external rotators. The degree of hip abduction and rotation varies depending on foot placement and the type of squat.

2) KNEE MUSCLES AND MOVEMENTS: Because the knee is flexed, and the pelvis is in a posterior tilt, the hamstrings are slack. This position results in weak hamstring activity that is primarily associated with stabilizing tibial torsion and in controlling anterior motion of the tibia as the femoral condyles rotate anteriorly (Posterior roll of the femur) and glide anteriorly from 25 - 145 degrees of closed chain knee flexion. If anterior translation of the tibia is not controlled, then the anterior tibial movement would increase tension on the ACL during closed chain knee flexion and may damage the ACL.

The quads are eccentrically contracting to control knee flexion occurring because the GRF lies posterior to the knee producing a mechanical knee flexion moment. The vastus lateralis and medialis stabilize femoral rotation as the hamstrings stabilize tibial rotation. As the knee flexes, compression at the patellofemoral joint increases but so does the areas of force distribution also increase which lessens the unit compression force as knee flexion reaches and passes 90˚ of flexion. (The highest joint reaction forces for non-weight bearing knee flexion are reported from 30 to 70 degrees of flexion, peaking at 45 - 60 degrees and at 90 degrees for weight bearing knee.)

3) ANKLE MUSCLES AND MOVEMENTS: With the COP maintained posterior to the ankle, The GRF continues to apply a mechanical plantarflexion moment on the ankle but with the knee flexed, no activity would be expected from the gastrocnemius and only slight activity form the solus to adjust the position of the heel.

3.2.3. Description of Kinetics in Figure 10 and Figure 11

1) HIP MUSCLES AND MOVEMENTS: At full squat, the hip reached about 125˚ of flexion, and the fiber length has increased resulting in fewer cross bridges and less force production. Further, the weight moment arm in shorter than at 90˚ which also produces a reduction in the magnitude of gluteus maximus force needed to provide an equilibrium state. This reduction in gluteus maximus eccentric force may be a protective mechanism to minimum damage to the muscle or tendon. The hip remains abducted but stable because of the interactions of the hip abductors and adductors. Hip rotation is also stabilized because of the opposing actions of the hip internal and external rotators. But the degree of hip abduction and rotation varies again depending on foot placement and the type of squat.

At the end of full squat, the stretched elastic components of the gluteus maximus and posterior gluteus medius act as a stretched spring and recoil extending the hip, concurrent with concentric (shortening) contraction of the gluteal muscle. This produces an external extension moment at the hip and the ascent stage of the squat begins. The lumbar spine remains flattened but the pelvic begins an anterior tilt. The anterior tilt stretches the hamstrings and concentric activity of the hamstrings produced hip extension, assisting the gluteus maximus.

2) KNEE MUSCLES AND MOVEMENTS: With the knee flexed beyond 90˚, eccentric contraction of the quads increases but patellofemoral unit compression force decreases. At the end of full squat, the stretched elastic components of the quadriceps act as a stretch spring and recoil extending the knee, concurrent with concentric contraction of the quadriceps muscle. This produces an external extension moment at the knee and the ascent stage of the squat begins.

The vastus lateralis and medialis concentrically contract to extend the knee and stabilize femoral rotation and movement of the patella at the patellofemoral joint in the frontal plane. The rectus femoris and vastus intermedius main contribute to knee extension and upward vertical movement of the patella and the patellofemoral joint.

The hamstrings are slack in this position but may provide some weak concentric action to stabilize tibial rotation at the full squat. As the knee extends during the ascent, the hamstrings are stretched, and this passive elastic component will begin move the tibia posteriorly which initially help extend the knee. As the knee further extends and the elastic component of the hamstrings becomes tight, concentric action of the hamstrings will move the tibia future posteriorly helping to extend the knee as well helping to extend the hip which is extending at the same time. The hamstrings will also stabilize rotation at the knee by controlling tibial torsion and counterbalancing the femoral rotation produced by the vastus lateralis and medialis.

3) ANKLE MUSCLES AND MOVEMENTS: With the COP maintained posterior to the ankle, the GRF continues to apply a mechanical plantarflexion moment on the ankle but with the knee flexed, no activity would be expected from the gastrocnemius and only slight activity from the soleus to adjust the position of the heel.

During the ascent, the COP should remain posterior to the ankle and maintain the plantarflexion moment to the end of the ascent. As the trunk rises and the knee and hip extend, the GRF will move closer to the knee which will decrease the mechanical knee flexion moment and assist knee extension until the end of ascent when the GRF now lies anterior to the knee applying mechanical knee extension moment and decrease the need for quadricep muscle concentric contraction. At the hip, the GRF will move more anterior to the hip increasing the mechanical hip flexion moment. This increased moment would place increased resistance to hip extension causing the extensors to produce more force to actively extend the hip. The gluteus maximus and hamstrings would have to work harder to extend the hip, producing a resistive concentric exercise.

3.3. Description of the Pelvic Floor Muscles and Ligaments

Descriptions of the anatomy and functions of the pelvic floor muscles (PFM) are abundant and show complex interconnections among viscera, muscle and supporting fascial elements [24] [31] [46] [49] [54] [82]-[99]. This anatomical complexity and anatomical variations explain some of the difficulties associated with the interpretations, causation, understanding and treatment of pelvic pain and dysfunction [2] [11] [17] [46] [67] [70] [73] [79] [80] [82] [84] [89] [99]-[104].

When bladder, pelvic and abdominal forces are high, urinary continence is maintained by the ligaments of the pelvic floor and viscera, and the muscles of the pelvic diaphragm acting as a unit to hold the bladder, urethra and vagina in an upward and forward position [31] [46] [52] [54] [67] [71] [72] [73] [74] [81] [82] [85] [86] [88] [89] [91] [92] [96] [99] [100] [102] [103] [105]. The levator ani, coccygeus, piriformis and obturator internus muscles form the pelvic floor muscles (**Figure 13**, **Table 3**). The levator ani consists of the pubococcygeus, iliococcygeus, and puborectalis muscles. The pubococcygeus is divided into the levator prostatae in males, and pubovaginalis in females. The levator ani and coccygeus form the pelvic diaphragm. The pelvic diaphragm is a thin, flat, membrane-like muscle [4] [11] [17] [29] [69] [84] [88] [90] [93] [94] [97] [98] [100] that is split in the middle by the urethra, vagina, and rectum and attaches laterally to the mobile thin fibrous tendinous arch of the levator ani and medially to the viscera by another tendinous arch of the pelvic fascia. Its only stable bony attachment is to the pubic bone by the pubococcygeus muscle and a fibrous attachment to the mobile coccyx. In union with the muscles of the pelvic floor, the actions of the surrounding and interconnecting connective tissue elements are needed to support the pelvic viscera and maintain continence.

Table 3. Attachments and actions of the pelvic floor muscles.

Names	Attachment (origin)	Attachment (insertion)	Actions
Pubococcygeus	Anterior: superior pubic ramus and tendinous arch of pelvic fascia	Posterior: coccyx; anococcygeal ligament	Elevates pelvic floor; supports pelvic organs; moves rectum, vagina/prostate, urethra forward
Pubovaginalis	Anterior: medial fibers of pubo-coccygeus	Posterior: sides and back of vagina; perineal body	Supports vagina; pulls vagina forward; vaginal sphincter
Levator Prostate	Anterior: medial fibers of pubo-coccygeus	Posterior: sides and back of prostate; perineal body	Support prostate, pulls prostate up and forward
Puborectalis	Anterior: thick medial band of fibers of pubo-coccygeus	Posterior: forms muscular sling with opposite side puborectalis at posterior anorectal junction	Elevates anorectal junction and holds junction anteriorly; sphincter action on rectum
Iliococcygeus	Lateral: tendinous arch of the levator ani from upper obturator internus fascia; ischial spine	Medial and posterior: blends with fibers of the middle and posterior pubococcygeus; anococcygeal ligament; coccyx	Elevates pelvic floor; supports pelvic organs; moves vagina, prostate, urethra forward
Coccygeus	Lateral: ischial spine; sacrospinous ligament	Medial: lower sacral and upper coccyx segments	Stabilizes coccyx; supports levator ani
Compressor Urethrae	Female & Male: inferior pubic ramus	Female & Male: covers external urethral sphincter	Female & Male: urethral closure
Urethral Vaginal Sphincter	Vagina	Covers urethra anteriorly	Urethral and vaginal closure
External Anal Sphincter	Female & Male: Anterior: Perineal body	Female & Male: Posterior: anococcygeal ligament (raphe)	Female & Male: voluntary closure of the anus
Obturator Internus	Pelvic side of obturator foramen	Medial greater trochanter	Fascia forms the tendinous arch of the levator ani; supports pelvic diaphragm; external rotation of the femur
Piriformis	Ventral sacrum, sacrotuberous ligament	Superior aspect of the greater trochanter of the femur	Moves sacrum forward; external rotation of the femur with hip extended; internal rotation of the femur with the hip flexed greater than 90 degrees

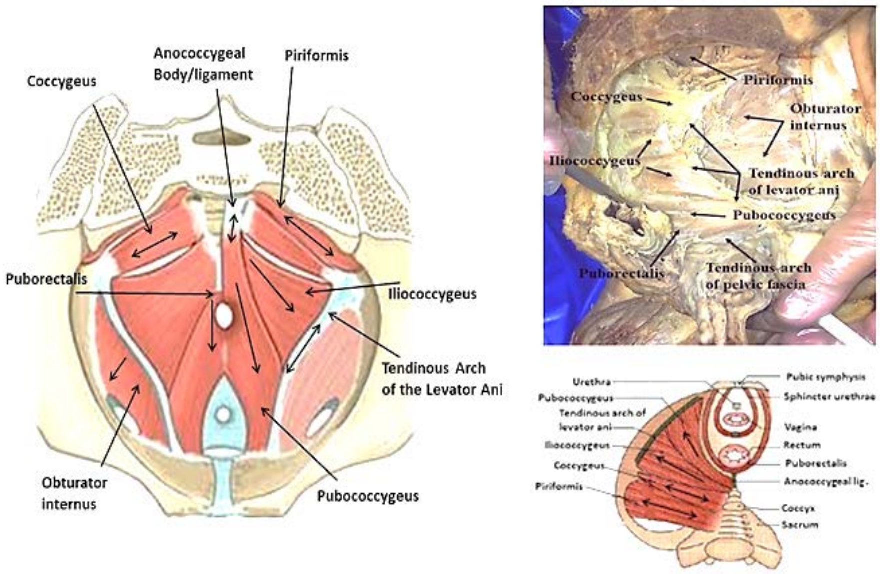


Figure 13. (Left) Drawing of the pelvic floor muscles showing their main action (arrows) during a squat. (Right Top) Dissection of the pelvic floor. (Right Bottom) Diagram showing the internal left side of the pelvic floor and the main actions (arrows) during a squat.

Contractions of the pubococcygeus and iliococcygeus lift the pelvic floor and tenses the connective tissue network, resulting in stiffening of the pelvic floor and elevation and forward displacement of the pelvic organs [11] [29] [73] [75] [81] [82] [85] [86] [88] [94] [97] [104]. The iliococcygeus may also be important in controlling side to side movement of the pelvic organs that occur during physical activities. Bilateral contraction of the coccygeus closes off the posterior part of the inferior pelvic opening and applies tension to the coccyx to stabilize it. The pubococcygeus and iliococcygeus attach to the coccyx (**Table 3**). Coccygeal stability allows the levator ani muscles to produce a tight and stiff muscular sheet to support the viscera and resist depression of the pelvic floor with increased abdominal pressure.

The pelvic floor muscles control and delay emptying of the bladder and rectum until it is convenient. Contraction of the pelvic floor muscles lifts the pelvic organs and tightens the openings of the vagina, anus and urethra. Relaxation of the levator ani results in downward movement of the pelvic floor associated with urination and defecation. The levator ani muscle and the pelvic fascia interact to maintain continence and pelvic organ support [11] [17] [31] [46] [51] [52] [69] [74] [81] [82] [86] [89] [96] [99] [102] [104] [106] [107]. The upward displacement of the urogenital organs by the pelvic diaphragm is relatively small. Because maintaining an upward and forward position of these organs for urinary continence is important and because upward displacement of these organs by the pelvic diaphragm is small, the resting position of the urogenital organs is near the elevated holding level needed for urinary continence. This resting position is maintained by several pelvic ligaments (**Figure 14**, **Table 4**).

Table 4. Fascial and ligaments support structures.

NAME	DESCRIPTION	FUNCTIONS
Tendinous Arch of Levator Ani (TALA)	This bilateral structure attaches to superior body of the pubic bone lateral to the symphysis and superior lateral to the Tendinous Arch of Pelvic Fascia and the pubococcygeus muscle. Runs laterally as the thick band across the central aspect of the Obturator Internus muscle fascia to attach posteriorly on the ischial spine.	Provides attachment for the anterior part of the pubococcygeus and the entire iliococcygeus muscles of the levator ani.
Tendinous Arch of Pelvic Fascia (TAPF)	This arch is bilateral and attaches to superior body of the pubic bone lateral to the symphysis and inferior medial to the Tendinous Arch of the Levator Ani and superior to the puboccocygeus muscle. This fibrous bands runs posteriorly along the edge of the urogenital hiatus and connects medially to visceral structures in the hiatus. The band ends posteriorly at the ischial spine with the TALA.	Provides support for the visceral structure lying in the urogenital hiatus and closes areas between the viscera in this region and the medial edge of the hiatus. Restricts hypermobile movements in all directions of the bladder neck, urethra, and vagina in female and the prostate and membranous urethra in males.
Pubovesical	This short strong bilateral ligament attaches lateral to the pubic symphysis on the inferior aspect of the pubic body and inferior to the TAPF. It has two and maybe 3 bands. A superior band runs horizontally and an inferior band vertically. These two bands may be connected by a thin third band. In females, the superior band attaches to the sides of the bladder neck and TAPF while the inferior band attaches to the urethra and vagina complex. It is also referred to as the paraurethral and pubourethral ligaments in females. In males, the pubovesical ligament is commonly called the puboprostatic ligament. See below for description and function.	In females, this ligament holds the bladder, urethra and vagina upward and anteriorly. Because of the attachment of the urethra and vagina and because this ligament connects to the TAPF, it will restrict hypermobile posterior, inferior, sideward and rotational movements of these structures.
Sacrogenital	This bilateral thick, fibromuscular ligament connects the sides of the lower uterus, cervix and upper vagina in the female and the sides of the prostate in the male to the S1-S4 segments of the sacrum and the sacrospinous ligament.	Holds the lower uterus, cervix, upper vagina, prostate posteriorly while restricting hypermobile anterior, upward, downward, sideward and rotational movements.
Lateral ligament of bladder	This bilateral endopelvic fascial fold lies deep to the overlying peritoneum. It attaches to the posterior lateral aspect of the bladder and lateral wall of the pelvis. These bilateral fibrous bands run lateral and posteriorly towards the sacrum to join the sacrogenital ligament.	Holds the body of the bladder posteriorly, restricting hypermobile anterior, upward, downward, sideward and rotational movements.
Urachus	This fibromuscular cord attaches to the apex of the urinary bladder and runs superiorly along the anterior abdominal wall to the umbilicus under the peritoneum. It forms the middle umbilical ligament.	Holds the anterior most part of the bladder in a upward and forward position. It would resist downward and posterior movement of the bladder but not sideward or rotational movements.
Anococcygeal ligament	A short, strong, elongated central ligament in median part of the anal triangle of the perineum that connects the posterior aspect of the external anal sphincter to the coccyx bone.	Provides support for the anus and holds it posteriorly, restricting anterior movement of the anus and anal canal. Provides a secure attachment for contraction of the external anal sphincter to voluntarily close the anal opening.

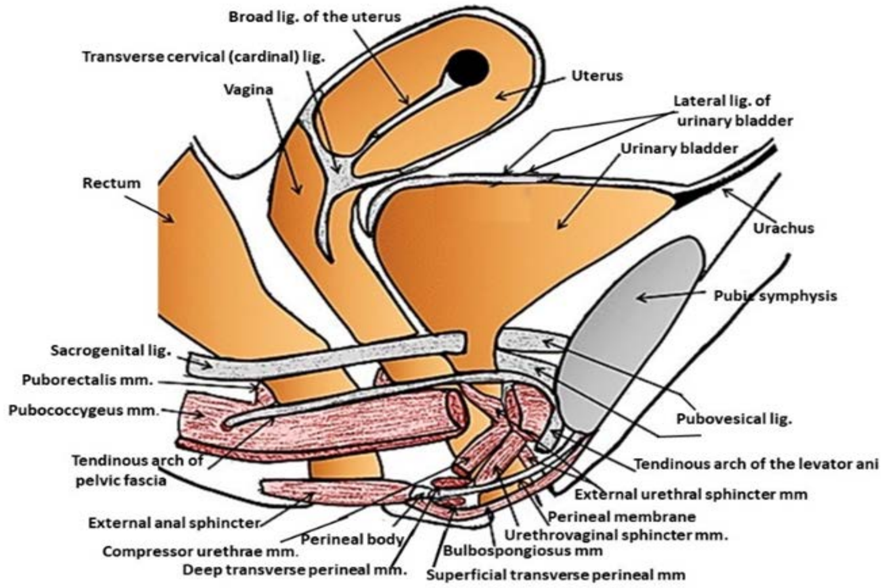


Figure 14. Diagram of a sagittal view of the female pelvis with ligaments (by GG from J Women's Physical Therapy 36: 2015).

The tendinous arch of the levator ani and the tendinous arch of the pelvic fascia form a thin, dense connective band on each side of the urogenital hiatus. Tension on this fascia and pelvic ligaments make up a support system that elevates the pelvic organs while slack in this system results in depression of these organs. In females, these ligaments are the urachus, pubovesical, broad ligament of the uterus and the transverse cardinal ligament of the cervix and in males these are the pubovesical, puboprostate and urachus [11] [89] [91] [99] [106]. Stretching of these ligaments during pregnancy, expansion of the abdominal due to weight gains, weakness of the abdominal muscles and surgery or trauma involving the anterior abdominal wall may result in the downward and posterior movement of the bladder. If these ligaments are stretched, increased abdominal pressure may move the bladder into a downward position favorable for urination. The coccyx, anococcygeal raphe (ligament) and sacrococcygeal joint are needed for proper action of the puborectalis at the anorectal junction to control anal continence.

3.4. Kinetics of the Pelvic Floor during Squatting

The kinetic actions of the pelvic floor and the interconnecting connective tissue structures are described and shown in **Figures 15-18**.

4. Discussion

The survey used in this article was a simple descriptive survey intended to give indications of who, why, and for what reasons The DB Method is being used. The developer of The DB Method could not do traditional squats because of injury and so designed this apparatus that would enable individuals to access the benefits of a squatting, especially those who have difficulty performing traditional squats. This survey was to provide a verification that met the designer's goals. The results of the survey (Table 2) show that of those using The DB Method, 56% reported being able to perform tradition squats, but 44% could not do so. Thus, the goal to enable those who could not perform and benefit from squatting exercises seems appropriate. The goal of increasing gluteal (85%) and core muscle strength (75%) also seems to have been met. In addition, over 70% described an increase in lower limb strength (84%); pelvic floor strength (70%); an increase in activity level (82%) and an increase in energy (71%). Overall, it was not surprising that 99% of the respondents recommended The DB Method.

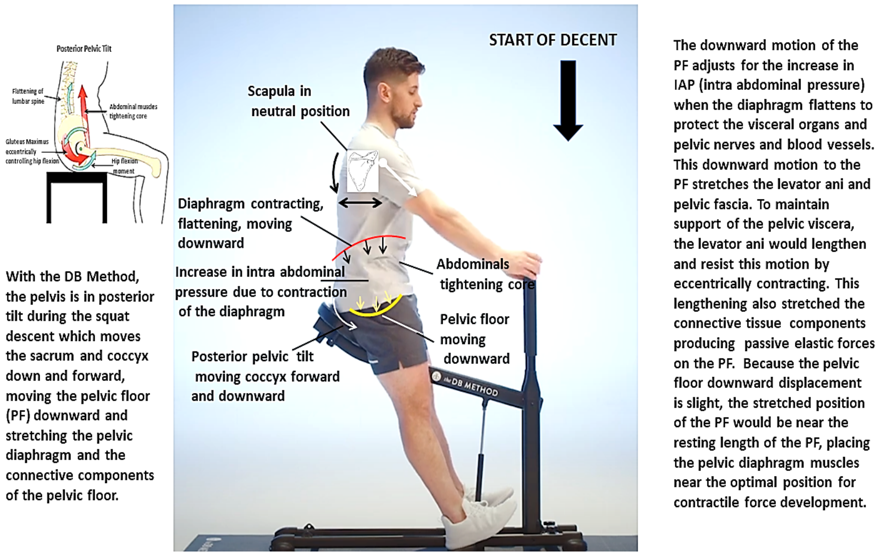


Figure 15. Diagram showing the kinetics at the start of the squat descent on the pelvic floor.

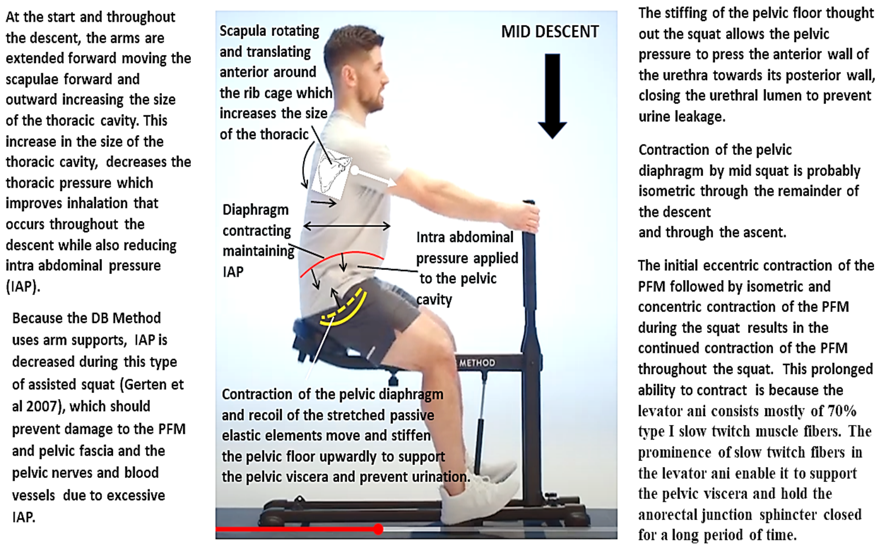


Figure 16. Diagram showing the kinetics at the mid position of the squat descent on the pelvic floor.

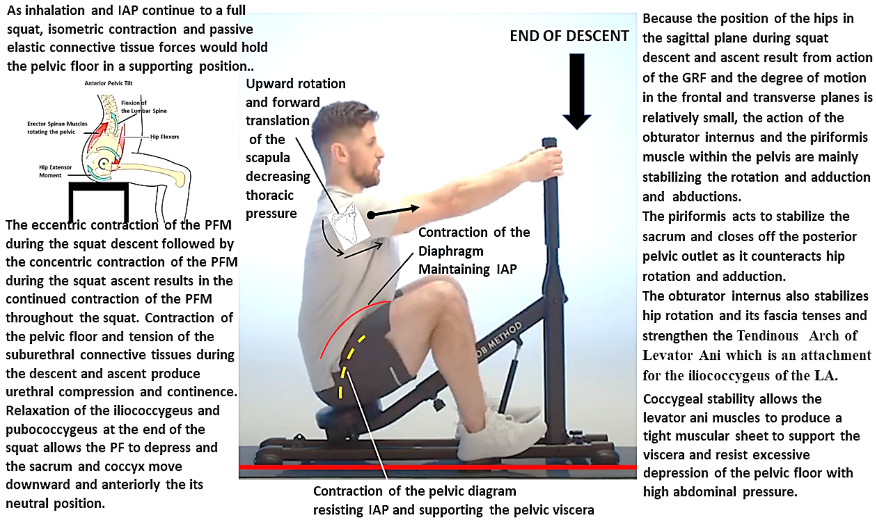


Figure 17. Diagram showing the kinetics at the end position (deep squat) of the squat descent on the pelvic floor.

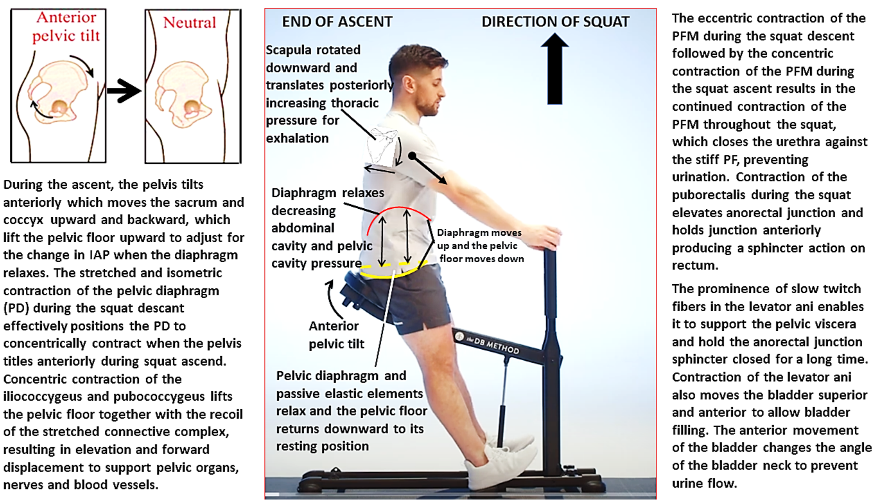


Figure 18. Diagram showing the kinetics at the end position at the end of the squat ascent on the pelvic floor.

Table 5 shows a comparison of traditional squats and the DB Method.

There are several structural elements in the design of the DB Method that are important. The handrails and the seat provide the user stability which can overcome balance problems and fear of falling from the apparatus while in use especially by the elderly and those with lower limb weakness because of neurological problems and disuse. The handrails also extend the arms forward moving the scapulae forward and outward which increases the size of the thoracic cavity. This increase in the thoracic cavity decreases the thoracic pressure which improves inhalation that occurs throughout the descent while also reducing intra-abdominal pressure (IAP). This decreases the forces on the pelvic floor [107] [108], making movement and exercising of the pelvic muscles easier and reducing the energy requirements for muscle contraction and motion. This decrease may also prevent damage to the pelvic floor muscles (PFM) and pelvic fascia and the pelvic nerves and blood vessels due to excessive or repetitive increases in IAP.

Table 5. Comparison between traditional squat and the db method.

STANDARD WEIGHTBEARING SQUAT	DB METHOD SQUAT
Head looking forward and straight arm forward help maintain a straight and flat spine during the descent and ascent of the squat.	Head looking forward and straight arm forward help maintain a straight and flat spine during the descent and ascent of the squat.
No grip handles require the need to rely on erector spinae and abdominal muscles to stabilize the trunk and shift in trunk balancing motions. If the erector spine and abdominal muscles are weak then the trunk would be unstable during the descent and ascent which could result in musculoskeletal damage and pain.	The Straight arm forward position holding on to grip handles provides stability, support and balance for the trunk during the descent and ascent, and guards against any unexpected and sudden body motions.
Anterior pelvic tilt during the descent decreases the mechanical hip flexion moment and shifts the line of action of the gluteus maximus so that the gluteus maximus and hamstring are contracting concentrically. As the descent continues and these muscles shorten, they lose force (length-tension) and the advantaged of eccentric muscle contraction. At full squat, concentric contraction forces of these muscles are reduced, and the muscles have lost their spring reaction effect. These muscles remain concentrically action throughout descent and ascent. An anterior pelvic tilt also flexes the lumbar spine which closes down the intervertebral foramen the surrounds the spinal nerve.	Posterior pelvic tilt passively produces hip flexion and requires the gluteus maximus to contract eccentrically to control hip flexion throughout the descent and benefit from eccentric muscle training. At full squat, a reversal to an anterior pelvic tilt results in the gluteus maximus and hamstrings recoiling their passive elastic component and forcefully contracting concentrically as per the length -tension relationship, making the transition from descent to ascent efficient and energy conserving.
With the knee anterior to ankle and foot contact area, a mechanical dorsiflexion moment occurs at the ankle. In this position, the GFR lies anterior to the ankle, producing a mechanical dorsiflexion moment, and posterior to the knee producing a mechanical flexion knee moment. The dorsiflexion ankle moment places the ankle in a closed packet position which permits very little motion in the frontal or transverse planes and damage ankle ligaments if an unexpected movement occurs. The mechanical knee flexion movement minimizes action from the hamstrings during the descent.	Heel contact position on foot base plate places the GRF posterior to ankle joint, anterior to the knee at the start of the descending squat and posterior to the knee at 90˚ position and at full squat. The GRF anterior to the knee helps holds the knee in extension early in the descent allowing the quadriceps to stretch their elastic components before eccentrically contracting to control knee flexion. Late in the ascent, the GRF produced extension moment helps the quadriceps to extend the knee in full extension when the quads at a low mechanical advantage.
The anterior position of the flexed knee relative to the ankle and the resulting dorsiflexion moment at the ankle, placed the gastrocnemius on slack during most of the descent. Because of this slackened position, gastrocnemius activity is minimal for knee extension and ankle plantarflexion. At the start of the ascent, this position places the gastrocnemius in a poor and ineffective condition for actively producing forces to plantarflex the ankle, extend the knee and stabilize rotation of the femoral condyles. By mid ascent, the increase in knee extension will stretch the passive elastic components of the gastrocnemius so concentric contraction can	Heel contact places the GRF posterior to the ankle hold the ankle in a plantarflexed moment and knee in flexion requiring little concentric activity of the gastrocnemius and soleus during descent. At the start of the ascent, the gastrocnemius begins to stretch as the knee extends and the ankle is held by the GRF by the mechanical plantarflexion moment. This action stretches the elastic components of the gastrocnemius allowing it to effectively and rapidly produce concentric contraction during the ascent.

Another important element of The DB Method is the bilateral foot ramp which positions the feet in front of the knee, places the ankle in a plantarflexion moment, and the COP at the heel of the foot. This position of the foot and the use of the seat and handrail change the kinetics for the squat by shifting the line of gravity away from the ground reaction forces. The design of The DB Method facilitates the GRF to mechanical position the hip, knee and ankle, rather than muscle action, which would decrease muscle energy requirements during the squat.

Posterior pelvic tilt and the posterior position of the hip joint relative to the line of gravity and the GRF produce a mechanical flexion external moment at the hip. As the body moves down, the amount of hip flexion needs to be controlled to avoid falling. This control is produced mainly by eccentric (or lengthening) contraction of the gluteus maximus and tension on the muscle's passive elastic components. While the hamstrings are also extensors of the hip, the posterior tilt of the pelvis and knee flexion slackens the hamstrings, producing only a small hip flexion controlling force compared to the gluteal muscles.

The posterior pelvic tilt and flattening of the lumbar spine is not a passive event but requires muscle action. The rectus abdominis, external and internal obliques, transverse abdominis, gluteus maximus and hamstrings all have to fire to establish this position. The contractions of the abdominal muscles facilitate core activation at the start of the squat, containing IAP. The flattening of the spine as a result of the posterior pelvic tilt during the squat 1) increases the size of the intervertebral foramen which decreases compression forces on the spinal nerve, 2) separates the facet joint decreasing compression on the joint, and 3) tightens the posterior longitudinal ligament increasing the vertebral canal and providing a barrier for posterior disc motion.

During the squat descent, the GRF lies anterior to the knee joint and provides an extension external moment at the knee. Because the weight of the body is applying a flexion moment at the knee, quadriceps is active eccentrically to control knee flexion. Contraction from the vastus lateralis and medialis stabilizes sagittal plane knee rotation and the position of the patella as the knee flexes. Contraction of the hamstrings is stabilizing anterior translation and medial and lateral transverse rotation of the tibial.

With the Center of Pressure (COP) at the heel, the GRF runs posterior to the ankle and places a mechanical plantar flexion moment on the ankle which presses the foot against the angled foot plate. The mechanical ankle position does not need concentric contraction of the gastrocnemius and soleus muscles to produce and hold this position. With the COP maintained posterior to the ankle, the GRF applies a mechanical plantarflexion moment on the ankle. With the knee flexed, no activity would be expected from the gastrocnemius and only slight activity from the soleus to stabilize the tibia.

During the ascent, the COP should remain posterior to the ankle and maintain the plantarflexion moment to the end of squat ascent. As the trunk rises and the knee and hip extend, the GRF will move closer to the knee which will decrease the mechanical knee flexion moment and assist knee extension until the end of ascent when the GRF now lies anterior to the knee where the GRF applies a mechanical knee extension moment which decreases the need for quadricep muscle concentric contraction. At the hip, the GRF will move more anterior to the hip increasing the mechanical hip flexion moment. This increase moment would place increased resistance to hip extension causing the extensors to produce more force to actively extend the hip. The gluteus maximus and hamstrings would have to apply increased muscle tension work to extend the hip, producing a resistive concentric exercise.

Strength of the gluteus maximus and quadriceps is necessary to perform many activities of daily living safely. An anterior pelvic tilt that occurs during the traditional squat makes contraction of the gluteus maximus muscles less efficient and less able to increase muscle size and strengthen. Starting in a posterior pelvic tilt, eccentric contraction of the gluteus maximus during the descent followed by concentric during the ascent of the squat acts to strengthen the gluteus maximus throughout the squat. Eccentric exercises are more effective at increasing muscle mass than concentric exercises [13] [61] [109] [110] [111] and higher forces are developed during eccentric contraction than concentric contraction. Total force production is greatest for eccentric contraction than for isometric contraction and both types are greater than concentric contraction [109]. The lengthening of muscle fibers during eccentric contraction produces more force because both the active and passive elastic elements of the muscle are involved. In concentric contractions, only the active element is involved. A single muscle can produce about 50% more force during lengthening than during shortening. It is reported that we are 25% - 30% stronger when lowering a weight than when lifting it. Eccentric contraction is more energy efficient than concentric contraction. Eccentric contraction of the gluteus maximus, quadriceps, and pelvic diaphragm produce tension and stretch the elastic components of the muscle during the squat. Eccentric muscle tension stretches the elastic components during eccentric contraction to store potential energy, which is used when the elastic elements recoil, like a spring, when eccentric contraction is followed by a concentric contraction. This example occurs when eccentric contraction of the gluteus maximus transitions to concentric contraction at the end of the descent phase of a squat to the ascending phase. This sequence optimizes the effects of the passive elastic components of eccentric contraction and directly prepares the muscle to contract concentrically at the bottom of the squat to ascend the body. It also optimizes the gluteus maximus contraction during both the eccentric descent and concentric ascent and strengthens the gluteus maximus from the start to the end of the squat. The functional significance of the muscular elastic components is often overlooked in kinetic analyses.

At the end of squat descent, the gluteus maximus continues to lengthen which increases sarcomere length but decreases muscle contraction force. However, muscle tension is maintained by the stretched passive elastic component producing a spring-like tension and high potential energy. At the start of the ascent, the weaker concentric contraction of the gluteus maximus and the quadriceps is aided by the recoil of the muscle elastic component.

During a squat, abdominal pressure changes which moves the pelvic diaphragm upward anteriorly and downward posteriorly. The tension of the pelvic fascia would stimulate fibroblast activity to increase collagen fiber production and with time assist in strengthening the fascia when IAP is high as during coughing, Valsalva maneuvers, jumping, lifting and carrying 30 lbs (13.6 kg) [80] [108]. This response to tension at the fascial attachment sites of the gluteus maximus and quadriceps muscles and would increase the strength of the series and parallel elastic components of the muscle. As muscle tension is a factor of active and passive tensions, an increase in passive tension by the elastic component would increase total muscle tension [13] [109].

The obturator internus muscle stabilizes hip rotation during a squat and its fascia attaches to the Tendinous Arch of Levator Ani (TALA). This Arch is a primary attachment site for the iliococcygeus and pubococcygeus muscles of the pelvic diaphragm. Tension of the obturator internus fascia to the Tendinous Arch of Levator Ani strengthens and secures the attachment site of the levator ani, allowing the pelvic diaphragm function eccentrically and concentrically to move the pelvic floor. This tendinous and connective tissue complex forms the passive elastic forces of the PF which stretches during eccentric contraction of the LA and recoils during concentric contraction of the LA.

The abdominal pressure acts transversely across the urethra, altering the stresses in the wall of the urethra so that its anterior wall is deformed toward its posterior wall, thereby helping to close the urethral lumen and prevent leakage caused by the increase in intravesical pressure.

Prolonged and repetitive elevated abdominal and pelvic forces, associated with pregnancy, abdominal weight gains, coughing, sneezing, heavy laughing, strenuous lifting and other activities, can stretch the ligaments supporting the pelvic organs and the pelvic diaphragm. This stretching can move the resting position of the urinary bladder caudally towards a position of urination. The repetition requires greater displacement and force production by the pelvic diaphragm to reach the continence position. To counter this stretching action, the pelvic diaphragm needs to be strengthened to produce increased force to lift the pelvic viscera and withstand increases in abdominal and pelvic captivity forces.

5. Practical Applications

The requirements of balance, spatial awareness, proprioception and coordination are major barriers to exercise for large segments of the population. A lack of physical support and guidance coupled with a lack of personal supervision (*i.e.*, training or coaching) makes squatting all but impossible to perform for many people. Simply introducing a place to hold on for balance and a seat support during the squat is a major improvement in accessibility of the squat as an exercise.

The DB Method for squatting described here seems to strengthen the gluteus maximus, quadriceps, abdominal core and the pelvic diaphragm. As exercise is an important part of maintaining good cardiopulmonary, musculoskeletal and psychological health, an apparatus that allows more people to exercise is beneficial to many but especially to the elderly and home bound. Individuals with unilateral low limb weakness as from a CVA or peripheral nerve damage may be able to perform squats to increase strength, lower limb coordination, and generally improve their health and way of life.

Pelvic floor exercise by squatting can be beneficial and should be available to any individual that experiences a disruption of continuity of the pelvic fascia, or when the pelvic diaphragm is damaged, as during childbirth, hysterectomies, prostatectomies, prolapses, and trauma [11] [42] [43] [45] [48] [50] [52] [54] [62] [92] [112]. Both fascial and muscle damages produce less stiffness of the supportive layer under the urethra and provides less resistance to deformation during increases in abdominal pressure. Thus, closure of the urethral lumen is not ensured, raising the possibility of stress incontinence. Pelvic diaphragm damage may also increase the connective tissue composition of the muscle and reduce its contractibility so that it is less effective in lifting and holding the pelvic organs to maintain urinary and anal continence [11] [73] [74] [79] [100] [104] [106] [107].

Because the pelvic viscera move with changes in posture and with activities [72] [81] [82] [86] [106], a strong contractile mechanism that produces bilateral contractile forces and controls excessive lateral movements of the pelvic organs is needed. Guided and balanced sagittal plane squatting exercises that can uniformly and bilaterally activate the pelvic diaphragm will provide strong and highly repetitive resistance to abdominal forces that move the pelvic organs laterally. Unilateral movement of the pelvic organs and unilateral tension of the pelvic fascia and diaphragm may compress the neurovascular bundles lying in the fascia, interfere with blood flow and produce pain and possible organ dysfunctions [11] [81] [82] [83] [90]. Because the iliococcygeus is composed mainly of type I muscle fibers, this muscle can act bilaterally for a long period of time as a postural muscle to control the central position of the pelvic organs. Using a squatting method to control and guide repetitive contraction of the pelvic diaphragm would minimize unilateral stretch of the pelvic fascia and compression of the neurovascular structures.

Decreased forces production by the pelvic diaphragm may be of particular concern with a nonactive aged person and a person on prolonged bed rest [1] [2] [3] [4] [46] [88] [98] [100] [104] [109] [110]. Because slow twitch fibers atrophy with disuse [3] [4] [90] [94] [100] [109], the predominance of slow twitch fibers in the pelvic diaphragm would produce a decrease in contractile strength, suggesting that with aging and reduced activity the ability of the pelvic diaphragm to resist increases in abdominal pressure may result in urinary stress incontinence. A repetitive routine of squat exercise would benefit the maintenance pelvic floor muscle strength.

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Statement

I am an independent analyst. I am not an employee of The DB Method®™, nor do I or many members of my family have a financial investment or shares in the company that manufactures, sells or owns The DB Method®™.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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