

INDUSTRY EDUCATION

JONES MACHINE/MAXRACK VS. SMITH MACHINE: HISTORY, DEFINITIONS AND EFFICACY OVERVIEW

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ABSTRACT

Introduction: The Smith Machine has been a popular alternative to free bar exercises because of perceived safety advantages. With the advent of the Jones Machine/MaxRack, it is still a viable alternative to free weight training? Does the Jones Machine/MaxRack have a better combination of free weight results combined with enhanced safety?

History: The Smith Machine, with a fixed vertical motion, was pioneered in the late 1930s, and was adopted in response to increased interest in resistance training, while the Jones Machine/MaxRack were invented in combination to the path options of a free bar combined with safety consideration.

Bar Path Comparison: The bench press, deadlift and power clean are exercises that do not have a completely linear path. The squat, in performance, is ideally linear, yet not in learning the exercise. The Smith Machine does not allow the bar path used in major free weight exercises.

Strength Testing: Because of inherent friction and bar path limitations, the use of a Smith Machine in testing for free weight-based strength gains is not valid.

Conclusions: The Smith Machine does not match the free bar path of the major exercises, while the Jones Machine/MaxRack allow exercise specific and individual bar path variations and matching.

Key Words: Smith Machine; Jones Machine; MaxRack; Strength; Power; Testing; Free Weight; Squat; Bench Press.

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INTRODUCTION

Traditional barbell exercises are an effective and popular training methodology for both athletes and fitness enthusiasts. Because the barbell involves overcoming resistance and directing the movement, those exercises are often favored over machine versions.^{2, 10, 19, 20, 21, 26}

Not only does the athlete/participant gain strength, but they also gain some postural and kinaesthetic awareness from the addition of accessory muscles to guide the motion. Neurologically, a major adaptation to the prime movers in these exercises is increased ease of recruitment of additional, and more powerful motor units as well as the combined, synchronous innervation. However, barbell exercises and specifically those performed with an Olympic bar have a learning curve to do the movement correctly.^{20, 21, 26} It appears to be necessary for the participant to feel their way through the proper technique in the early stages of training for safety, the reinforcement of basic, then complex movement patterns and ultimately power/strength/endurance that can theoretically be transferred to sports activities.^{43, 45}

Without a spotter or assistance, the use of higher resistance loads can be a safety issue. In fact, research by the Nationwide Children's Hospital,³⁷ indicated that dropping the weight was responsible for 65% of weight lifting injuries. While this study showed the majority of injuries were from ages 14-24, the incidence of those injuries in age 40 plus are increasing dramatically. The study cited over 970,000 weight training-related injuries that were treated in U.S. hospital emergency departments between the period of 1990 and 2007, increasing nearly 50 percent during the 18-year study period. The commonality of these injuries is a likely reason for the early adoption of the Smith machine. Also, the increase in ACL injuries in female athletes and increased shoulder injuries has probably fueled the interest in the Smith machine. However, there was almost no evidence the adoption of the Smith machine was even a partial answer to reducing these injuries.

The Smith machine was invented and touted to be a safer means of barbell lifting as it took out path

variability and had greater safety compared to a barbell exercise. The Jones/MaxRack machine was invented to allow for safety yet have the bar move in user-defined paths of motion without restriction with added safety features. Is the Jones/MaxRack machine more effective and just as safe as the Smith machine? Is the Jones/MaxRack a relatively good substitute for a free weight bar yet with added safety?

HISTORY

Smith Machine History

The Smith machine was likely invented to add safety to the large muscle group exercises such as the squat.⁵⁴ The machine is purported to have been invented originally by American Jack LaLanne, who developed this as a sliding apparatus alternative to a free bar for squats. Lore notes that Rudy Smith, a manager of a bathhouse close to LaLanne observed the piece and then directed Paul Martin to fine-tune the design. The first commercial application of the



Figure 1 LifeFitness Smith machine. Used with permission by LifeFitness.

Smith machine appears to be Vic Tanny's gym in the Los Angeles area.

Sometime in the late 1950's, Rudy Smith became an executive in Tanny's gyms on the west coast of the United States, and the Smith machine was being manufactured and sold more widely. In the period from 1985 onward, almost all commercial exercise equipment companies produced their version of the Smith machine to appeal to those who were interested in free weight training but wanted an element of perceived safety without using a spotter or assistance.

Unlike a free bar exercise, there is a vertical post/guide that directs the motion on plane vertically up or down. Because of this feature, the bar on the Smith machine can only move vertically along the track; it cannot move forward, backward or sideways. Contrast this to the independent arm movement in a dumbbell where the right side can move at a different speed, a different path and even a different amount of travel than the left. This was initially seen as a safety advantage when combined with a safety-catch system.

Behind a vertical post (runner) is a series of slots on which the barbell/weight bar can be hooked or placed. Unlike an ordinary barbell, the Smith machine, depending upon specific design, can be re-secured at almost any point in the exercise, generally with a turn or the wrist to attach into the catches. The rationale was likely safety for those who lift without assistance, as the exercisers only need to twist the wrist in to lock the barbell in place when the weight becomes too great. Many variations incorporate blocks, pegs, or other devices/accessories that can be adjusted to stop the barbell at a specified minimum height.

While not formally advocated by any industry group, many feel that locking the bar forward and unlocking the bar backwards is preferable to the reverse. In addition, it is common for squats to be performed with the bar behind the user, while incline and military press motions seem to favor the bar in front of the user. If a Smith machine with an angle such as 5 or 7 degrees is used, it is more likely to be used for bench press motions with the bar moving from mid-chest to over the shoulders.



Figure 2 Matrix Smith machine. Used with permission by Matrix Fitness.

Unlike a free bar, the bar on a Smith machine only moves in one plane. Because lifting on a Smith machine requires less stabilisation by the lifter, some lifters can lift more weight on a Smith machine than on a free bar if the motion is purely a vertical motion or one that is matched kinaesiolegically with the mechanical path of travel.

It is important to remember that when Jack LaLanne and others pioneered the Smith machine, they used it as one component of a full strength and toning regime utilising free weights as well. These individuals likely never intended it to be used, particularly, to isolate and necessarily take the place of free bar activities that were the dominant resistance training methods.

Another factor is understanding of movement mechanics and kinaesiolegical analysis gained dramatically in the period from 1980-1998, where a vast amount of literature started the process of quantifying and describing the mechanical paths and benefits of major free weight exercises. Many "old time" training devices were part of the magic of that particular gym and expert before that, with little evidence of their efficacy except the possibility they

worked because they were different in the muscular stress placed upon the system. Many of the personalities who ran these gyms were both dedicated and genetically gifted to the point that specific training regimes and exercise principles were not as much of their success as their genetics combined with work ethic.^{19, 27, 28}

As free weight training became more popular, athletic/health clubs and school settings gravitated towards the Smith machines. The reason was simple; it appeared to be a free weight bar apparatus with a much-improved safety option.

While the Smith machine seems to reduce potential injury with the addition of the bar holding apparatus, it may be that it can do more harm than good when utilising it for exercises that do not match the pre-determined track, such as the bench press. Injuries while using the Smith Machine have been attributed to improper use of the apparatus as well as a lack of maintenance, supervision, and initial instruction. No data has been gathered to date about the long-term use of Smith machines in this regard.

Jones Machine/MaxRack History

Before there was the Jones machine, there was the MaxRack, invented in 1999 by Steve Skilken. These machines provide simultaneous horizontal and vertical exercise motion along a rail system with linear bearings. The design allowed the exercise bar to follow a front-to-back exercise motion but still eliminated the side-to-side balancing aspects of using a free bar. In essence, they allowed motion in the frontal plane, but not an independent motion on either side that would be found in a free bar exercise such as the bench press. The device provided a combination of the balance and coordination needed to perform free weight exercises and the single plane motion of a traditional Smith machine. This design also provided the ability to perform exercises such as lunges that require horizontal movement forward and backward.

Currently, the MaxRack has licensed the patent to two companies. It is manufactured and sold by StarTrac/Nautilus as the MaxRack. The MaxRack underwent further development by the American company, BodyCraft, by adding two functional



Figure 3 BodyCraft Jones machine. Used by permission of BodyCraft Fitness.

elements; the bar hooks and safety catches traveling in unison with the lifting bar as well as bar balance via tilting provided by the axial bearing system on the guide rods. Thus the Jones machine incorporates what can be considered a “natural” lift-off and re-rack at any point in the exercise and range of motion. The Jones machine will also lock the horizontal rails to essentially make a Smith machine.

These features are not available in free weight systems and Smith machines. It can be postulated that these abilities might lead to solo exercisers pushing to a particular limit when fatigue may be present because the floating bar can be secured at any point in the range of motion.

It can also be theorised that those exercisers who are taught proper bar path, and are kinaesthetically aware of path deviations can stop the exercise at that point to ensure correct bar path and training results.^{2, 6, 13, 14, 20, 38} Is this less likely to occur with a free bar version or a Smith machine?

As few individuals are entirely symmetrical from right to left regarding strength and accessory



Figure 4 Front lunge performed on Jones machine. Used with permission by BodyCraft Fitness.

muscular usage, this potentially forces the user to balance the bar during the exercise in this plane of motion. For example, if the exerciser were performing a bench press with a slight curve to the lifting motion going from approximately the sternum to over the shoulder capsule, the bar would move with the path of motion determined by the user and the user would have to ensure the bar moves evenly in all three possible motions or planes with control. The same is theoretically true with exercises like lunges and squats.

As noted, the Jones Machine is different from the MaxRack in this balance bar feature and the ability to have safety catches move with the bar anywhere in the plane of travel. From a practical perspective, the Jones machine appears to function as a free bar with

safety stops and catches that travel with the user at any point in the exercise, unlike most Smith machines. The MaxRack systems require the user to re-rack the bar on either the front or back of the cage.

At the same time that the Smith machine was becoming more available from various manufacturers, the concept of Closed Kinetic Chain exercise was widely discussed and interpreted in sports medicine and sports science circles. This likely added to the rationale for using a Smith machine, especially in the 1990's.^{4, 24, 54}

In actuality, the Smith machine as well as the Jones/MaxRack machines are closed chain exercise apparatus. Closed Kinetic Chain exercises or closed chain exercises have been defined as physical exercises performed where the hand (upper body) or foot (lower body) is fixed in space and cannot move. Closed chain exercises often use compound movements that incur compressive forces, like the squat or the deadlift. Another factor in the initial definition CKC activities was that the external resistance was "considerable" forcing of the recruitment of multiple muscle groups to overcome the resistance.

The foot or hand remains in constant contact with the immobile surface, usually the ground or the base of a machine. Open Kinetic Chain exercises are where the foot or hand moves a lever arm that is not fixed to the ground or the apparatus. A common example is the leg extension movement and many functional exercises. It has been felt by many that open-chain exercises, often isolation movements, promote more shearing forces.

Closed Kinetic Chain exercises involve multiple muscle groups and joints simultaneously rather than concentrating solely on one, as many OKC exercises do (single-joint movements), lending the CKC to more multiple strength gains and likely more improvement of athletic activities.

So, by early and accepted definitions, the common exercises of squat, deadlift and bench press are CKC exercise as either the feet or back are fixed in the exercise, and the bar remains fixed to the extremity. In contrast, OKC exercises have a rotary component, isolate the joint motion, and stress a single muscle

Table 1: Comparison of Some Common Smith Machines, MaxRack, and Jones Machines.

Sample Smith Machine/Jones/MaxRack Specifications		
Smith Machines		
Manufacturer	Weight of starting/Bar	Angle
Life Fitness	45	0, 7 degrees forward
Cybox	15, counter balanced	0 degrees
Matrix	15, counter balanced	0, 7 degrees forward
Body Solid	13/45	0 or 7 degrees
Tuff Stuff	10/45	0 or 7 degrees
Inspire	45	0 degrees
3D Machines		
Manufacturer	Weight of starting/Bar/Movements/Notes	
StarTrac/Nautilus	45 Movement: Frontal, Sagittal Plane Catches/Safety Rack: One on the bottom to set maximum depth which cannot be performed while in the machine, bar must be racked/stopped by moving bar to the front or back of the machine.	
BodyCraft Jones	45 Movement: Frontal, Sagittal & unequal Frontal with right and left sides on a U-joint bearing system that promotes the user balancing the bar by allowing the right and left side of the bar to move independently in a vertical/tilting motion. Catches/Safety Rack: Bar depth is set with a spring-loaded bumper that can be set anywhere along the rail height, and can be set while the user is in the machine. Bar can be racked at any point in the range of motion or by re-catching the bar-catch on the safety hooks, travels with the user and the exercise. Additional: Floating guides on the bottom railing can be locked, essentially creating a standard Smith machine if desired.	

group with little contribution regarding co-contraction. A prime exercise is the leg extension.

Path Comparison: Bench Press & Squat

There has been some consensus about how to perform the bench press. Analysis of power lifters and those with exceptionally high maximal lifts compared to body weight strongly suggest that the bar follows a somewhat curved path for maximal contractile power and efficiency.^{2, 14, 34, 35}

In this school of technique, the bar starts at approximately the sternum, and as the individual presses upward, the bar begins a slight path backward and ends directly over the shoulders. In this fashion,

the larger muscles of the chest start the motion, and the motion is finished by the shoulder area at a point of mechanical advantage at the end point. The exact muscles used are a function of the path, grip orientation, grip width, bench angle and direction to the bar.

In comparative evaluations, specifically with the bench press motion, the free bar did invoke higher levels of muscular activation than the Smith machine.^{8, 33, 44, 50} One study used Electromyography (EMG) data to compare anterior deltoid, medial deltoid, and pectoralis major at different repetition maximum levels. The conclusion of the study showed greater activation of the medial deltoid when performing the

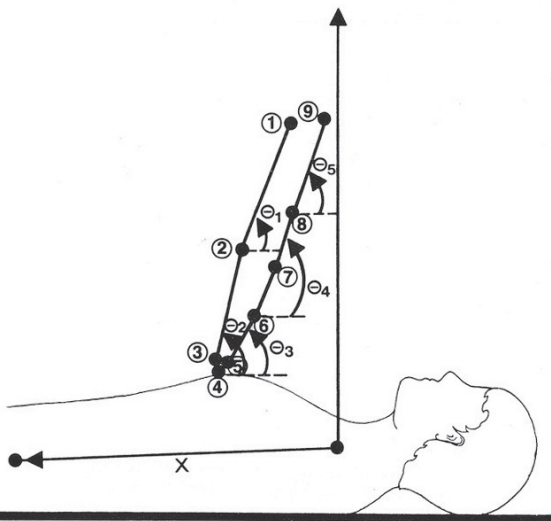


Figure 5. Bar path of elite powerlifters in the bench press, McLaughlin, *Bench press techniques of elite heavyweight powerlifters*, 1984. Used with permission by the National Strength & Conditioning Association.

free weight bench press independently of the load and experience that each subject had with the exercise. The higher activation of the medial deltoids was due to the instability when using free weight. The anterior deltoid and pectoralis major muscles did not show any differences in activation. According to the study, using the free weight bench press is more applicable to athletes because the instability will

challenge the glenohumeral joint more and more muscles will be used.

In a comparison of true one repetition maximums, the weight lifted on a Smith machine was less than a free bar exercise in those with moderate lifting/training experience. It could be postulated that a Jones machine with the 3rd motion, that of independence of right to left motion would invoke a similar EMG response, similar to dumbbells or a free bar.³

Another investigation noted that testing on the Smith machine with a counter balance to measure the abilities in explosive movements such as a bench

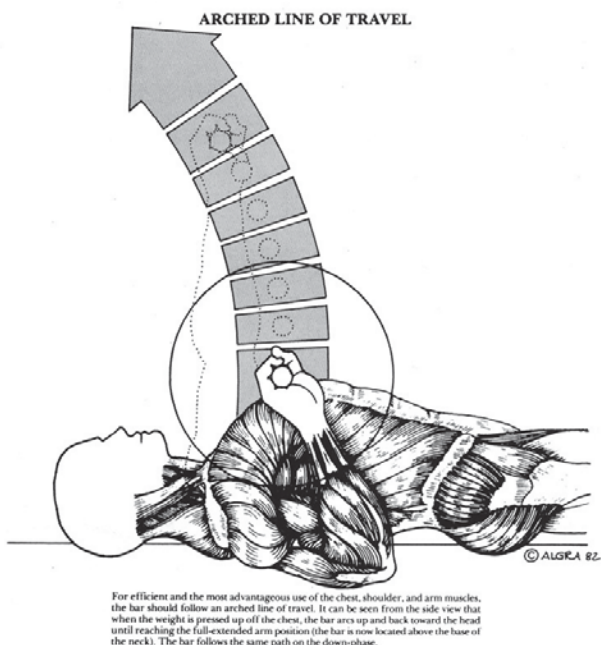
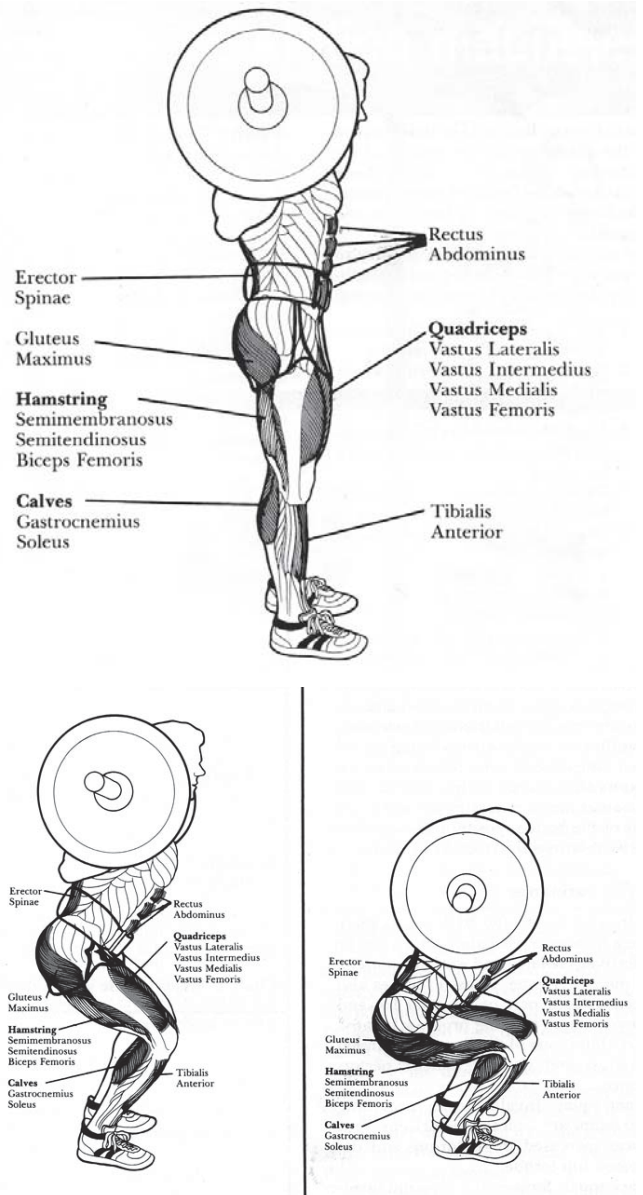


Figure 6, Bench press motion illustration, Algra, *An In-Depth Analysis of the Bench Press*, 1982. Used with permission by the NSCA.



Figures 7/8, Squat motion and major muscle usage, O'Shea, *The Parallel squat*, 1985. Used with permission by the NSCA.

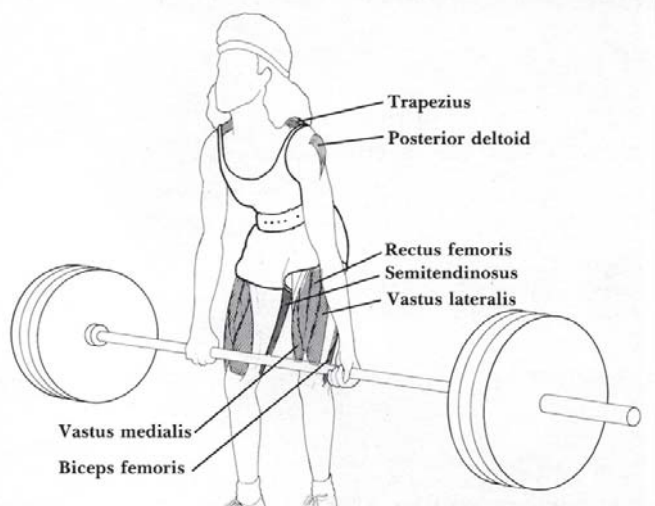
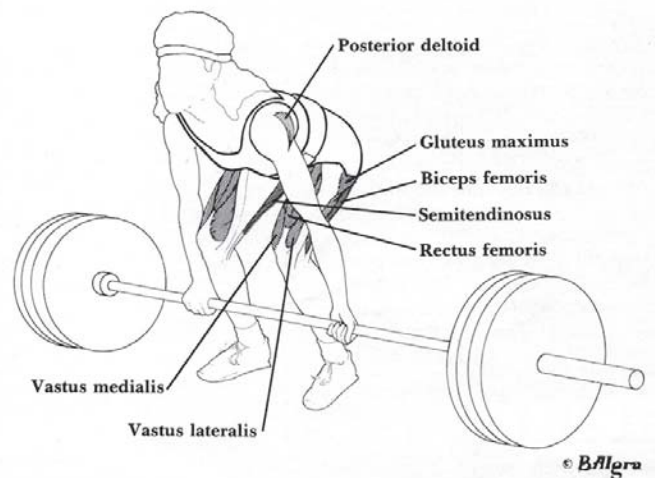
press underestimates actual weight lifted and power measures by 17-21%.⁵ For testing of explosive movements, the use of a counterbalance system likely increases in the net external load during the concentric phase. Therefore, a counterbalance system, a feature of many Smith machines, should not be used for explosive movement performance testing according to this study.

In contrast, the squat exercise, when performed with the bar on the back, has more of a linear or vertical motion.^{1, 7, 31}

As the participant lifts the bar off the starting catches, the lowering motion is ideally performed with the knees moving forward with the hips moving backward to essentially keep weight distribution in the middle or close to the midst of the foot. As the participant squats deeper, the larger muscles are more powerfully engaged in the hips and legs. Variations occur with stance, front or back position, foot placement, and even grip.^{1, 6, 7, 13, 16, 17, 18, 32, 39, 55, 56}

Squats on a free bar, in EMG measurement, were demonstrated to have higher activation in the gastrocnemius, biceps femoris, and vastus medialis muscles (34, 26 and 49 percent greater), when compared to the same movement (squats), performed on the Smith machine.⁴⁶ Since both the Jones machine and the MaxRack are more like a free bar than a Smith machine, it could be postulated EMG results would be similar when compared to the Smith machine for this movement. One study did note that women in the study had a higher one repetition maximum on the Smith machine than the free bar, yet possible rationale beyond the lessened need for balance and bar stabilisation was not elaborated.⁸ Also, the squat exercise on a free bar appears to have more potential for the range of motion and depth of movement versus a smith machine where the track is set by the bar.²²

It should be noted a limited amount of research concluded that the bar path changes with fatigue, especially early in technique acquisition, indicative that certain muscle groups are not able to withstand the load and contribute in a coordinated fashion.^{3, 7, 10, 13, 14, 20, 36, 45, 48} Thus a free bar or Jones/MaxRack machine may indicate the technique is diminishing via incorrect bar path, and the athlete should stop or



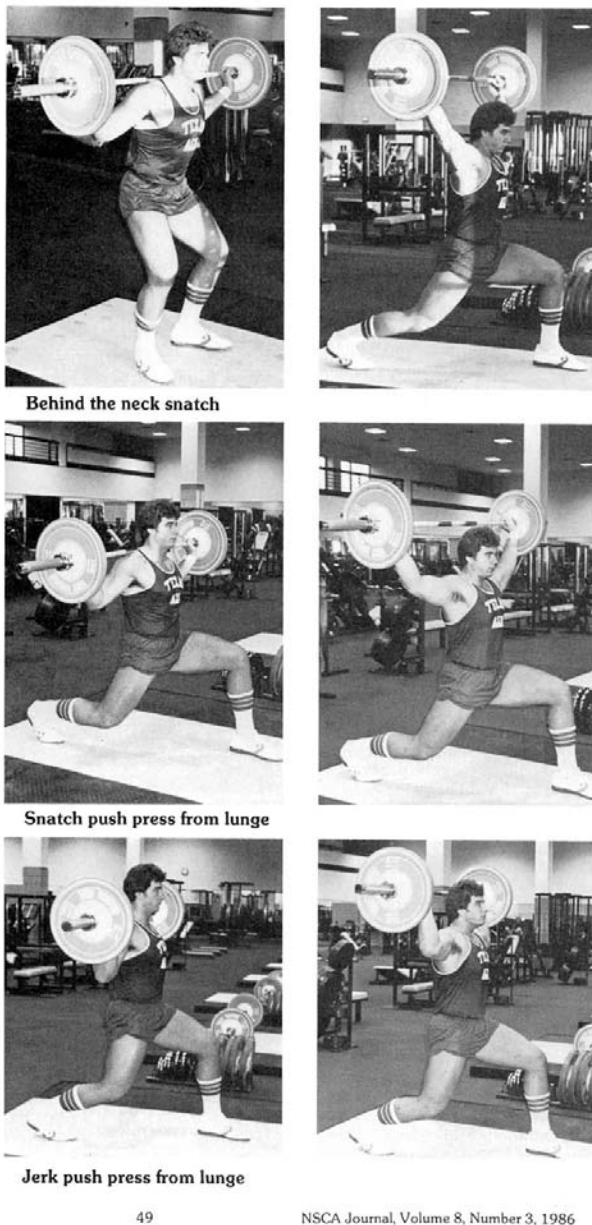
Figures 9/10, Bar path and major muscles of the deadlift, Gotschalk, *Analysis of the deadlift*, 1985. Used with permission by the NSCA.

limit the exercise.

While not compared in both modalities, the deadlift exercise does appear to have a slight movement of bar forward and backward as well as vertical to avoid the shins and for optimum motor unit recruitment.²¹

How does learning occur in free weight/bar exercises?

In most cases, instructors/trainers/coaches start with a light load and attempt to teach the correct motion to the individual. It is quite common during initial attempts for the bar to wander off the intended path due to a variety of factors. These include lack of stabilisation in accessory muscular groups, lack of flexibility in the joints stressed during



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Figure 11, Teaching exercise examples snatch and clean and jerk. Javorek, *Teaching of technique in the snatch and the clean and jerk*, 1986. Used by permission of NSCA.

the lift, the lack of coordination when performing a new activity and lack of specific contributing strength in the affected muscle groups.^{1, 2, 20, 38}

Because of these variables, it is common for those just learning these exercises to demonstrate gains in the resistance used because the individual has learned the motion and improved neurological coordination, and not necessarily impacted the larger muscles used in the motion. Also, the major lifts are often separated into smaller skills, most of which require the bar to follow a non-linear path.²⁷

In essence, many individuals gain performance in the exercise initially because of coordination gains, and once that general coordination and muscular recruitment is maxed, then further and substantial strength gains occur.¹³ Many strength and conditioning coaches favor free weight motions for the reason that the accessory and secondary muscular groups contribute, useful in generating more force and power in the application of sports movements.^{5, 21, 26, 33, 38, 43, 45}

In the limited studies performed on the squat, the Smith machine had far less muscular activity recorded with EMG than performing the same exercise with a free bar. This appears to demonstrate that for training, bars that allow a free range of motion in as many directions as possible simply have a higher activation of the same motor units and additional motor units. Additionally, because the bar is fixed, one study demonstrated the subjects changed foot position from a normal free bar version to try to accommodate force requirements by placing the feet farther away from the knee during the exercise.^{1, 6, 8, 47} One could postulate that free bar trained individuals would not perform at the same level on a Smith machine and visa versa.

Strength Testing/Applications of Smith Machine vs. Free Weight/Jones/MaxRack Machine

Some clubs and sports performance programs while using free weights for training, have used the Smith machine to quantify strength gains. If the results were consistent, this would appear to provide a safer means to test athletes than relying on bar exercises with multiple spotters in a group situation. The trend of these studies was simply that the Smith machine did not approximate the actual weight that could be lifted. This was likely due to the fact the bar did not move in the same mechanical path and had more inherent friction because of the fixed motion. Additionally, some Smith machines are counterbalanced, adding another source of inherent friction.

It should also be noted that the results of such studies need to be quantified and viewed considering the angle of the guide rods, as Smith machines have variations including vertical or 0 degrees, a 5-degree angle, and even a 7-degree angle. Thus a Smith

machine with a 7-degree angle could be postulated to give a better view of maximal capabilities in the bench press by matching somewhat the curved lifting pattern. However, in the squat, which is clearly more vertical, a machine with this angle would probably inhibit result accuracy, where a Smith machine at a 0-degree angle would likely show more similarity.

CONCLUSION

In the search for effective resistance training gains combined with the safety of the participant, the Smith machine initially appeared to be a viable answer to melding both goals, especially early on in the modern era of resistance training. However, as training theory and quantification advanced, it became apparent that the Smith machine did not fully replicate free bar training either in training results or testing situations.

The reason appears to be the bar in major exercises rarely follows a straight vertical line. The one exercise where a vertical line of travel is close to optimal is the squat. However, in an exercise such as a squat on a Smith machine, the lack of using the accessory muscles to balance and direct the motion likely has an adverse effect on both strength development and transfer to sports and athletic performance.

In both training and testing, the Smith machine does not appear to be a reasonable substitute when considering results compared to a free bar or a Jones/MaxRack machine.

Physical therapists, coaches and trainers should be aware of these distinctions. From a performance and results perspective, the free bar and Jones/MaxRack options are superior to a Smith machine in learning, performing and testing with the major free bar exercises used in modern training.

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