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Guidebook to teaching the parallel squat

Ray William McCormick

GUIDEBOOK TO TEACHING

THE PARALLEL SQUAT

A Project

Presented to the

Faculty of

California State University

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Education:

Kinesiology

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ABSTRACT

The parallel squat is one of the main lifts taught within the high school weight room. Many coaches and teachers in physical education teach the squat as one of the core lifts for a weight training program. Many instructors are not formally trained in weight training or have little weight room experience and thus pay little attention to the initial move. This first move, placement of the feet, width of the stance, and the location of the bar across the back should be key areas of concern. Without proper guidance in the teaching of these techniques, athletes can perform many lifts without getting the true benefits associated with the squat. Many instructors' believe a good squat is simply going down then coming back up.

There are many videos and instruction books that teach an instructor through the technique of the squat. But, many of these instructions do not emphasize the first move, which can be pivotal in performing the squat technique correctly. The purpose of this project is to put together a handbook helping educators through simple written and illustrated step by step instructions. Technique variations

dealing with bar placement, stance width and foot placement will be covered along with reviews from testing done on each different technique and their effect on muscle development. By using the information provided within this project the instructor will be able help their student athletes perform the squat with more efficiency.

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CHAPTER ONE

INTRODUCTION

The squat lift is a basic unit of training for strength and conditioning coaches at various levels of athletics. The squat is performed by starting in an upright position and descending down through flexion in the hips and the knees. When reaching the desired depth continue with an ascent back up to the starting position. Due to its multi joint nature, the squat is considered as the "pillar of strength" exercise for the lower extremity (McCaw & Melrose, 1998). This multi joint exercise develops the largest and most powerful muscles of the body and has biomechanical and neuromuscular similarities to many athletic movements, such as running and jumping (Escamilla, Fleisig, Zheng, Lander, Barrentine, Andrews, Bergemann, Moorman, 2000).

Purpose of this Study

A problem seen with many high school athletes is the improper teaching of the squat. Within the high school weight room, a problem that occurs is the lack of attention given by the instructor. A common problem is bar placement,

with many beginning lifters placing the bar to high on their neck. This placement can create a high degree of stress on the cervical spine region, leading to a possible injury. A second problem is instructors who insist on a particular foot angle or stance width claiming it will increase muscle activation. McCaw and Melrose found no effect on any particular muscle due to foot or stance variation (1998). Another problem is the first move when squatting which is crucial to performing the squat. It is often not emphasized as a key element toward good squat technique. Therefore, it is a basis for the development of a faulty squatting technique.

Scope

The information covered in this project is intended to give the physical educator and coach an easy to follow manual with illustrations to guide them through basic instructions of the parallel squat. This project will include biomechanic principles of the squat exercise. There are two commonly recognized depths when performing the squat. The first depth of those two squats is the parallel squat. During the decent phase, the lifter simultaneously flexes at the hip and knee joints and dorsiflexes the ankle

joint to the body until the posterior surface of the thighs are parallel to the floor (McCaw & Melrose, 1998). The second depth when squatting is going beyond the parallel squat into what is called a deep squat. When performing the squat, the load on the knees increased significantly with increasing squatting depth (Wrentenberg, Feng, Arborelius, 1994). Therefore, the deep squat should not be considered appropriate for the high school athlete. This study will be working with the parallel squat solely. With proper technique training, injuries can be avoided and gains can be made to help the developing athlete.

Assumptions

Assumptions that are being made within this project include that the educators recognize basic muscle anatomy, and that they understand the meaning of the terms repetition, bar load and one rep max. It is also expected that they understand the meaning of ascending and descending while performing the squat and have some basic weight room experience.

Technique Variations

The squatting exercise can be performed using different techniques by each individual lifter. The

exercise can very with the amount of weight lifted, the location of the bar across the back, the width of stance, foot angle, and depth of the squat are all individualized.

The areas covered in this project are bar placement across the back/shoulders, along with the angle of foot and stance width in relation to the shoulders. These areas are being emphasized to find a comfortable placement for the lifter to perform the squat.

Bar placement on the back is the first area of emphasis. There are generally two locations where lifters place the bar across the back. The first one is just below the spinous process of the 7^{th} cervical vertebrae; this is known as a "high bar" placement. The other placement is down farther on the back resting across the spine of the scapula, otherwise known as a "low bar" placement (Wrentenberg, Feng, Arborelius, 1994). With the low bar placement a more pronounced forward lean of the upper torso is used to center the body under the weight of the bar. The differences between the two bar placements will be examined.

The second technique to be identified is foot placement, or angle of foot placement in front of the lifter. There are generally three foot placements. One is

with the foot pointing straight ahead with no lateral adbuction. The second position is with the foot being abducted 30 degrees from the midline of the body. The third method is with the toes pointing in towards the midline of the body.

The final technique variation when considering the squat is stance width. The more commonly used are wide stance, shoulder width stance and narrow stance. The wide stance is identified to be 140% of the lifters shoulder width stance or greater. The narrow stance is identified to be 75% of the lifters shoulder width stance or narrower as defined McCaw and Melrose in 1998. The third method of stance is the legs in line with your shoulders. Further indicating a lifter could choose any stance for which they feel comfortable with.

Definitions of Terms

1. Ascending- the motion of moving up from the parallel thigh position to starting position.
2. Bar load- amount of weight placed on bar.
3. Descending- the motion of moving down from the starting position to parallel thigh position.

4. Electromyography (EMG)- senses the activity of specific muscles by placing electrodes over intended site.
5. Lateral- motion away from the midline of body.
6. Medial- motion toward the midline of body.
7. One rep. max- the maximum weight an individual can lift for one repetition.
8. Repetition- the number of times a lifter performs the lifting sequence
9. Resistance - an opposing force.
10. Starting position- lifter positioned under weight, foot, stance positioned adjusted to comfort.

CHAPTER TWO

REVIEW OF LITERATURE

The research being reviewed examines the differences in squatting technique and the affect on muscle performance. The squat is a resistance training method used by many educators within the weight room setting. There are several squatting techniques used by weight lifters and the dispute is which technique enhances muscle development best. The articles test many of those different techniques to determine which method causes the greatest amount of muscle activation in relation to strength gain. Using the information from these articles, the goal is to dispel any theories about which technique is better and or which technique obtains more strength.

Resistance Training

The term resistance training is often used interchangeably with other terms such as "strength" training or "weight" training. Regardless of which term is used, it is a practice that is designed to enhance "one's ability to exert or resist force" (Bompa, 1993). Resistance training is when the designated muscles push or pull against a force. This force could be resistance from

weights or it could be a doing a pushup against gravitational forces. Strength training is a common component of physical fitness and sport programs for many adolescents. Getting stronger is one goal of resistance training, but strength training programs can also improve sport performance, rehabilitate injuries, prevent injuries and enhance long term health. Resistance training can stimulate the appropriate biological mechanisms that strengthen the supporting muscles, tendons, ligaments, and bones and enhance the ability of tissues to absorb more force prior to failure (tearing) and develop greater muscular balance about specific joints (Moreno, 2001). In a high school study comparing the incidence of injury among male and female adolescent athletes, the injury rate (26.2%) and recovery time (2.02 days) were significantly reduced for those who participated in a supervised strength training program when compared with a control group (72.4% and 4.82 days respectively) that did not follow a weight training protocol (Henja, Rosenberg, Buturusis, & Kreiger, 1982).

There has been some concern and disagreement whether weight training is something that should be done by the adolescent. Much of the concern has focused on the

occasional incidence of musculoskeletal injury (e.g. epiphyseal fractures, ruptured intervertebral disks, and low back bony disruptions); particularly during performance of the major multi-joint exercises such as the squat or dead lift (Nelson et al., 1990). There as been a limited number of case reports concerning epiphyseal injuries in the wrist and apophyseal injuries in the spine due to weightlifting by adolescents. Such injuries are uncommon and are believed to be largely preventable by avoiding improper lifting techniques, maximal lifts, and improperly supervised lifts (American Academy of Pediatrics, 2001). To help avoid injuries it has been recommended that specific training exercises should be learned initially with no load (resistance). Once the exercise skill has been mastered, incremental loads can be added (American Academy of Pediatrics, 2001). When working with adolescents in a strength program, it should address the major muscle groups and exercise through the complete range of motion.

The squat, as stated by Escamilla, begins with the individual in the upright position with the knees and hips fully extended. The individual then squats down in a continuous motion until a desired squat depth is obtained and then in a continuous motion ascends back to the upright

position (2001). There are two more recognized depths when performing the squat the first being parallel and the second being deep. During the parallel squats decent phase, the lifter simultaneously flexes at the hip and knee joints and dorsiflexes the ankle joints until the posterior surface of the thighs are parallel to the floor (McCaw & Melrose, 1998). The second depth, when squatting, is going beyond the parallel squat into what is called a deep squat. For the purpose of this project, the focus will remain on the parallel squat.

The areas of focus will be the placement of the bar across the back, the stance width and the position of the feet. The muscle recruitment patterns while performing specific techniques will be examined throughout the review.

Bar Placement

The first technique for review is the placement of the bar across the back. The two recognized placements are known as the high bar and the low bar placement. The high bar placement is the bar resting across the neck at the height of the seventh cervical vertebrae. The Wrentenberg et al.(1993) study was to determine the effect bar placement had on the knee load and thigh muscle activity.

This study included eight weight lifters and six power lifters were used all of Swedish national class for their age and body weight. Wrentenberg et al. study had the weight lifters performing the high bar squat, the bar placed across the seventh cervical vertebrae. The power lifters performed the low bar squat which places the bar across the spine of the scapula. The weight lifters using the high bar placement performed the parallel squat and determined their repetition weight as 65 percent of their one repetition max. Electromyographic (EMG) analysis was placed on the vastus lateralis, rectus femoris and the long head of the biceps femoris to identify muscle activity. The results from Wrentenbergs' study showed the activity in the biceps fermoris muscle is slightly higher for the low bar squat when compared with the high bar squat. The vastus lateralis and rectus fermoris showed no significant change between low bar placement and the high bar placement. The most significant change in activity was shown with the change in the load. In all the tests, when load changed muscle activity increased. Another result showed that high bar placement produced forces distributed equally between the knee and the hip. With the low bar placement the force measured in Newton meters was almost twice as much from the

hip to the knee. When using the "low bar" technique, there is more emphasis on hip flexion. The "high bar" placement is performed more upright and the joint movement of force is more equally distributed between hip and knee joints (Wrentenberg, Feng, Arborelius, 1994).

Stance Width

When discussing variation in squat technique, the stance width whether wide, shoulder width or narrow should be a consideration. The shoulder width stance is defined as the legs placed in a vertical line with the shoulders. The wide stance is identified to be 140% of the lifters shoulder width stance. The narrow stance is identified to be 75% of the lifters shoulder width stance. These stance variations were defined by McCaw and Melrose in their study in 1998. The purpose of the McCaw and Melrose work was to compare activity in six muscles crossing the hip and knee joints when performing the parallel squat.

The squat concentrates on several muscles of the lower extremities. The first of which is the quadriceps, which consists of the rectus femoris, vastus lateralis, vastus medialis, and the vastus intermedius. Secondly, the back of legs or hamstrings muscles: which consist of the biceps

femoris, semitendinosus and the semimembranosus. The gluteus maximus and the gastrocnemius also play a roll in performing the squat.

The techniques examined by Escamilla et al. were with experienced lifters performing the squat and high foot placement leg press, and low foot placement leg press employing a wide stance, narrow stance and two foot angle positions (feet facing straight forward and feet turned out 30 degree). Each subject performed four repetitions for each variation of the lift. Data collection was initiated at the end of the first repetition and continued throughout the final three repetitions. The subjects determined their own descent and ascent pace with the exception of the one-second pause between repetitions to clearly define the start of a new repetition. An EMG (electromyography) was used to quantify muscle activity and help with internal muscle forces. The EMG found no significant differences in muscle activity between the different foot angles or stance variations. The Escamilla et al. study did find more muscle activity of the quadriceps and hamstrings when performing the squat as compared with the leg press.

In the second study by McCaw and Melrose, the subjects completed five consecutive repetitions of the squat using

shoulder width stance, narrow stance (75% of shoulder width) and wide stance (140% of shoulder width) with low and high loads of weight which included 60% and 75% of one repetition maximum. A surface EMG system recorded the activity of six muscles: rectus femoris, vastus medialis, vastus lateralis, adductor longus, biceps femoris and gluteus maximus. The subjects performed five squat trials for each of the load and stance conditions, for a total of 30 repetitions. There was also a rest period of at least three minutes between each set. To control the speed of the descent and ascent, a tape recording of cadence for three and two tenths seconds was played. The descent phase took one and seven tenths seconds and the ascent phase took one and five tenths second. During the performance of the testing, no belts or knee wraps were worn by any of the lifters. Vastus lateralis, rectus femoris and vastus medius showed more activity from load effect. Variation in stance and load had an effect on the adductor longus. Also shown was that the biceps femoris had its highest activity during the ascent phase. Mccaw and Melrose found significant load and phase main effects were identified for different muscles, no main effect for stance was identified for any

muscles. These testing methods have many similarities to that of a workout within a weight room setting.

Foot Placement

The following studies examined the angle of the foot in relation to muscle activation. The first study by Boydon et al.(2000) tested six college male students 23 $\pm$ 4.1 years of age. All the subjects were experienced in performing the parallel squat. The purpose of the study was to investigate the EMG activity of quadriceps fermoris muscles. These muscles were the vastus lateralis, vastus medialis and rectus femoris. The muscle activity was recorded during four different foot positions, which were twenty percent lateral rotation, ten percent lateral rotation, neutral position and a ten percent medial rotation. Each lifter performed three repetitions of each foot position while lifting 65% and 75% of their one repetition maximum load. The out come was eight sets of three squats with three to four minutes rest between sets. The individual sets were done in random order. The results of the study showed greater overall mean values for the 75% 1RM than for the 65% 1RM. Each of the muscles examined showed no significant activation differences existed

(p=0.05) (Boyden et al. 2000). Analysis of variance indicated that the differences in levels of activity between the four foot positions were not statistically significant (p> 235) even when considering the extreme (-10 degree to 20 degree) positions (Boyden et al. 2000).

In the study performed by Signorile et al. (1995), ten men performed three parallel squats with added resistance equal to their weight. There were five foot positions tested in this study: dorsal flexion and plantar flexion of the ankle, inversion and eversion of the subtalar joint, and a neutral position (Signorile 1995). The subjects were tested at 65% to 80% of their one repetition maximum. Once the weight to be used was selected, it was used for all test performed. EMG was placed on the vastus lateralis, vastus medialis, and the rectus femoris of the dominant leg only. Each lifter began the session with a minimal weight warm up of ten repetitions followed by a two minute rest. After the initial warm up set and before moving into any further foot positions, the lifters were given a five minute rest period. The foot position order was randomly assigned to complete the test. In regards to the parallel squat, no significant difference was found in the electrical activity of any muscles tested. Signorile et al.

also tested the same subjects using a knee extension machine, varying the foot positions to the same degree as the parallel squat. From this test they did find that lateral rotation of the tibia did show greater activity for the lateral and medial heads of the rectus femoris. But, there was no significant difference for varying foot position and muscle activation. The Signorile et al. study in 1995 showed no significant differences in muscle activation between the various techniques of foot placement.

CHAPTER THREE

METHODOLOGY

The journals reviewed where chosen in relation to the parallel squat exercise and muscle activation. Several other journals reviewed were chosen for their input on training methods with adolescents. The articles were located through a subject query through an internet data base. Secondary articles were located through reference sources on the primary articles.

The main focus for the articles used was to identify which muscles show the greatest activity due to technique adjustments in the squat. The author chose articles which defined muscle pattern recruitment while performing the squat. The articles had tested the squat in various forms measuring individual muscle activity. These articles were used to support the theory that technique adjustments do not affect specific muscle activity.

The remaining journal reviews covered the topic of adolescent weight training and its significance to body development. The positives and negatives of resistance training were inquired about for the developing of a

student's body in relation to injury. Finally, reviews looked at the teaching of lifting exercises to adolescents.

CHAPTER FOUR

SUMMARY, CONCLUSION, RECOMMENDATIONS

Summary

Within the literature review, different aspects of the squat were analyzed. Position of the bar, placement of the feet and width of stance were examined in various studies. Through all the research, reviewed there were no significant differences encountered regarding a particular technique being better than another. The main cause of muscle activation was increasing the load and not modifying the technique. With this understanding, educators working with young, beginning lifters should let the lifter decide which stance, bar placement and foot position is most comfortable for them. Upon determining this comfort, the instructor should start to teach the mechanics of the parallel squat.

Conclusions

The high school weight room is filled with many new lifters that have never worked with weights. Many lifters learn the lifts from their peers who themselves are not taught the correct form. The squat is a lift that is considered by many as a core lift and is worked on

throughout all weight rooms. The purpose of this review was to inform educators within the weight room setting about technical variations of the squat. It also demonstrates that different techniques will not necessarily enhance specific muscles. Finally, this review is showing the educator the various teaching points, positions and teaching cues through pictures and checklists.

Recommendations

In teaching the squat to a beginner, it is important that the beginner learns to perform the technique properly before increasing the load. The beginner should learn the skill patterns without the use of weight in order to develop the motor training for the muscles. The muscles will learn a movement better when it is under less fatigue, therefore creating the highest level of performance practice (Barnett, M.L. Ross, D. Schmidt & Todd, B.). Muscle fatigue is the transient decrease in performance capacity of muscles, usually evidenced by a failure to maintain or develop a certain expected force or power (Asmussen, 1979).

Emphasis on the teaching of the first move of the squat when descending needs attention. Many beginning

lifters start their decent with pushing out their knees. Lifters with the greatest forward knee motion had the greatest shear force across the knee as found by Escamilla (2001). The motion of pushing the knees forward can also create a loss of center of gravity. Therefore, forcing work with non essential muscles to regain center of gravity, taking time and energy away from the muscles to be emphasized. Starting the squat by pushing the gluteus maximus back and down is a much more practical technique. By leading with the glutes the knees will follow with a natural bend. The patella of the knee will not be extended beyond the toes and will keep the lifter balanced. At the start of the exercise when the knee is fully extended, instruct the trainee to push the buttocks backward by a slight flexion of the hip joint while maintaining an upright or near upright torso (Barnes et al. 1989).

The lifter should maintain a slow steady descent to maintain proper form until reaching a parallel thigh. When the thigh is parallel the ascent should be done rapidly and controlled to maintain muscle stimulation. Bouncing at the bottom to get a start up is not recommended; this may cause loss of balance and loss of key muscle stimulation.

These tips will help an educator teach the squat and potentially eliminate wasted motion. The more the lifter performs the lift incorrectly the harder it is to break the lifter of these habits.

The information covered in this project should allow the educator to work with any beginning lifter. The use of the pictures will be a visual aid the educator can use as a teaching tool to show proper motion and technique.

APPENDIX A

TEACHING THE PARALLEL SQUAT

The following guidebook is designed to help physical educators teach the parallel squat to a beginning lifter with the aid of pictures and teaching points. The book is broken down into easy instructions with few commands in order to keep the lift simple. There are key elements to technique variations that an educator can use when working with a new lifter to help them get comfortable with the lift. The author of this project has included some lifting points, both good and bad seen within a high school weightroom. Also included within the book is a check list developed by authors in the National Strength and Conditioning Association Journal.

Pre-lift Conditions

1. Lifter should be wearing proper clothing.
    a. shorts that stretch
    b. shirt
    c. shoes with good support
    d. weight belt (optional)
2. There should be a minimum of two spotters, three would be preferred. One on each side of lifter, a third behind lifter.
3. The weight load must be secured with bar collars.

4. The floor area within the weight rack should be free of any obstacles.

Lift Condition

1. Lifter positioned in comfortable placement.
    a. Feet positioned for comfort.
    b. Stance width for comfort.
    c. Bar placement for comfort.
2. Open chest to prevent rounding of back.
3. Eyes looking straight ahead or slightly up to a fixed spot to help maintain balance.
4. Spotters are in place.

Lift Motion

1. First move should be the buttocks being push back and downward.
2. Weight centered over feet as descent continues.
3. Descent should be slow and controlled.
4. Eyes continue forward glare.
5. When parallel, stop descent for split second then ascend to the starting position.
6. Ascent should be quick and controlled.
7. Additional repetitions repeat 1-6
8. When set is done, return bar to rack with aid of spotters.

Bad Squat Habits

1. Spotters not located in proper positions.
2. Weights not secured
3. Upper torso is to vertical
4. Back rounded
5. Eyes wondering around room.
6. First motion for lift is pushing the knees forward to begin descent.
7. Bouncing at bottom of lift to start ascent.
8. Weight overloaded
9. Bar rack is not set to proper height for lifter.

APPENDIX B

FOOT POSITIONS

Foot Position Toes
Pointing In

Foot Position Toes
Pointing Out

Foot Position Toes
Straight Ahead

APPENDIX C

STANCE WIDTH

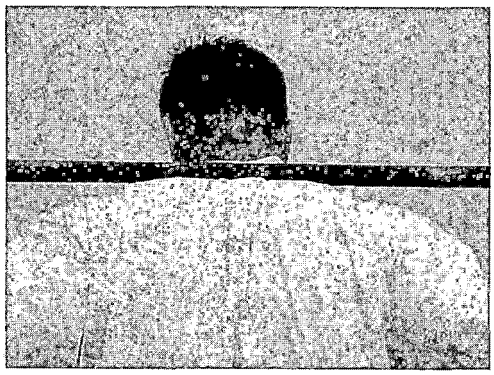
Stance Width
Narrow

Stance Width
Shoulder

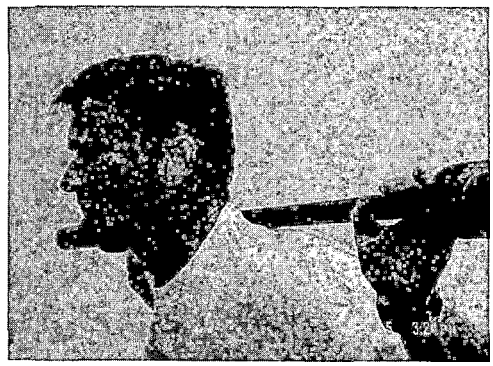
Stance Width
Wide

APPENDIX D

HIGH BAR PLACEMENT



High Bar Placement
Back View

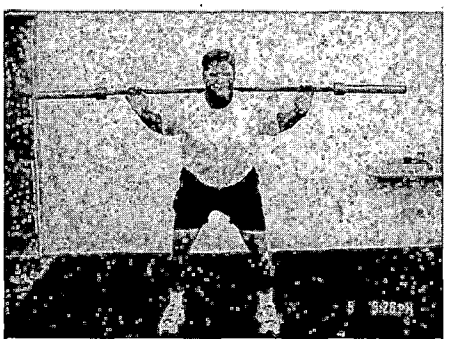


High Bar Placement
Front View

High Bar Placement
Lateral View

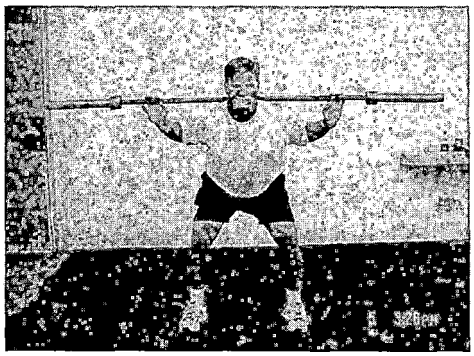
APPENDIX E

HIGH BAR PLACEMENT DECENT



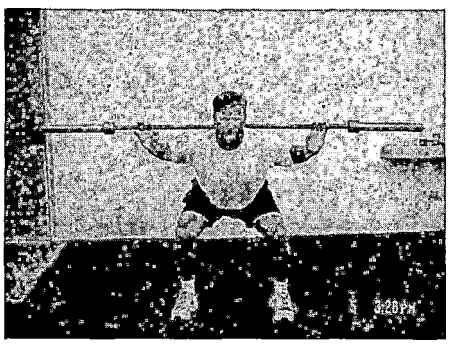
First move pushing the buttocks back and down

Open chest, Keeping back from rounding



Continue sitting in a chair

Notice knees not extending beyond toes

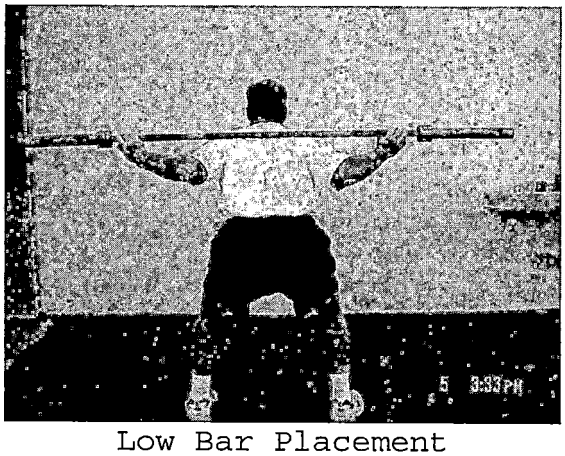


Continue descent until Thighs are parallel to floor

When parallel return to starting position

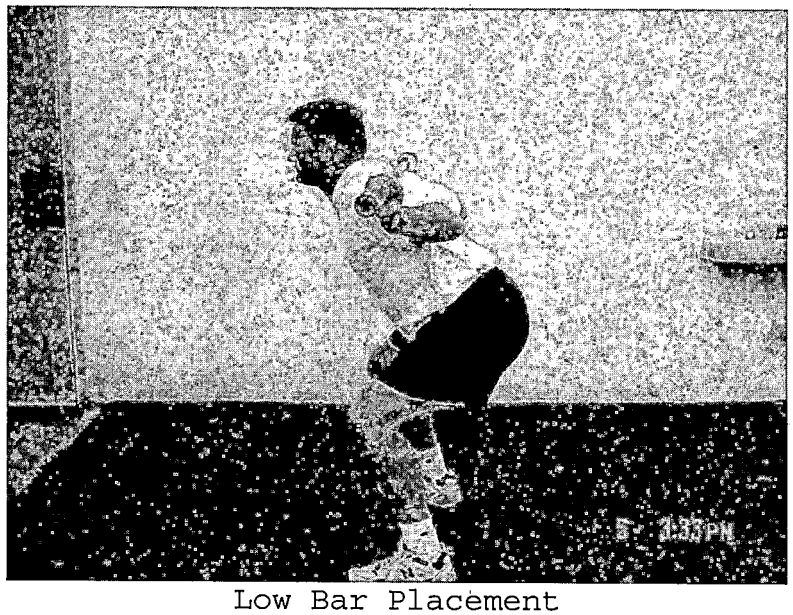
APPENDIX F

LOW BAR PLACEMENT



Low Bar Placement
Back View

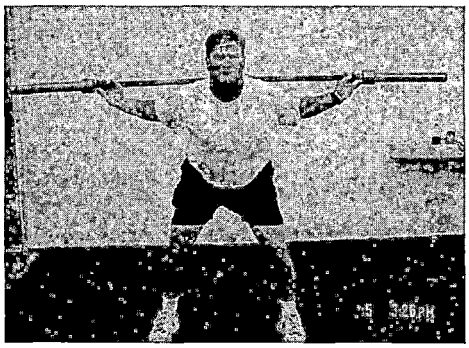
Low Bar Placement
Front View



Low Bar Placement
Lateral View

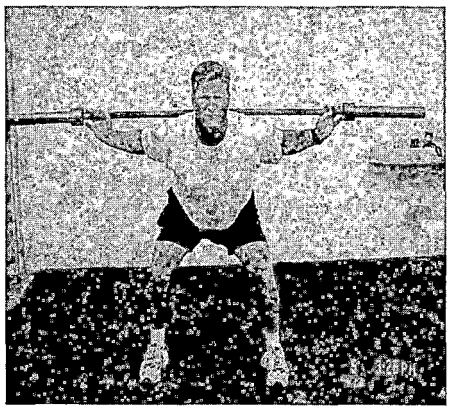
APPENDIX G

LOW BAR PLACEMENT DECENT



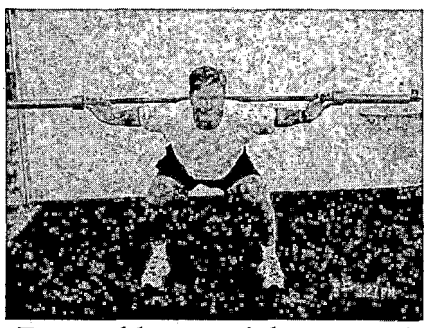
Low bar placement causes more forward lean

First move pushing buttocks back and down.



Continue descent, body weight over feet

Spread chest,
Keeping back from rounding



Forward lean, weight centered over feet

Stop at parallel position
Return to staring position

APPENDIX H

COACHES CHECK LIST

The following check list was developed by National Strength and Conditioning Association. It was included in an article NSCA Journal in April/May of 1989. It is being included here to give further guidance while teaching the squat.

The Start

- ✓ The bar is evenly loaded with collars
- ✓ Height of the bar on the rack is approximately at mid-chest
- ✓ Hands are placed evenly on the bar using a slightly wider than shoulder width grip with thumbs around the bar
- ✓ Step under the bar with both feet
- ✓ Place upper back in center of the bar, bar rests across posterior deltoids and the middle of trapezius
- ✓ Chest is held out and up, shoulder blades are pulled together
- ✓ Straighten both legs to lift bar off the rack: take one step back

- ✓ Position feet approximately shoulder width apart with toes pointed slightly out
- ✓ Feet remain flat on floor throughout the motion
- ✓ Head faces straight forward throughout the motion
- ✓ Torso is held straight and rigid throughout the exercise

The Descent

- ✓ Start descent by slightly bending forward at the hips, then bending the knees
- ✓ Weight is over the middle of the foot or the heels, not over the toes
- ✓ As knees bend they stay over ankles
- ✓ Descend slowly (45 degrees/second)until tops of thighs are parallel to the floor
- ✓ Push the bar up to the starting position

The Ascent

- ✓ The ascent should be done rapidly but under control
- ✓ Keep hips under the bar as much as possible
- ✓ Do not shift knees toward one another
- ✓ Use a smooth motion; do not "jam" or accelerate the bar at the top of the motion

- ✓ Step back to the rack taking small steps with both feet after lift is completed

The Squat

- ✓ "Sit back" in the down phase (do not shift forward)
- ✓ Do not bounce at the bottom
- ✓ Inhale at the top before lowering the bar, hold your breath during the lowering phase, and slowly exhale while lifting the bar to the starting position

Avoid

- ✓ Hips to far forward- results in torso too upright
- ✓ Rounding of back
- ✓ Bouncing at bottom position
- ✓ Excessive forward lean at waist
- ✓ Pulling knees together

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