The Back Squat

Stuart Yule, BSc (Physio), ASCC

Stuart Yule is the column editor for the 'Exercise of the Month' section.

Stuart is the current English Institute of Sport Strength and Conditioning coach for Judo. He is responsible for delivering National S&C services to world class funded players across the UK.
Stuart previously worked for the Scottish Institute of Sport, where he had the role of leading the S&C service to athletes in the West of Scotland as well as leading and coordinating S&C nationally for the Judo and Badminton programmes.
Stuart is a physiotherapy graduate and his sporting background lies in Olympic Weightlifting, where he represented Scotland at two Commonwealth Games.

In this, 'exercise of the month' article, the back squat will be discussed. It is a well established exercise in many athletes' training programmes and is an exercise that every strength and conditioning coach should have in their armoury.

The back squat is an exercise that can be used across sporting populations and can be manipulated extensively as a tool to produce your desired training response.

The back squat is commonly seen in gyms and its use amongst athletes is becoming more prevalent, however there is often debate as to the correct implementation of the technique. In this article the correct and safe technique will be described. Some issues and solutions to squatting problems will be highlighted and finally the practical application and positive benefits of successful back squatting will be discussed.

Overview

The back squat is a knee and hip extensor exercise.

The list below highlights the key muscles that are used in the correct execution of the back squat and the muscle action:

- Quadriceps-knee extension
- Gluteus maximus-hip extension
- Gluteus medius (posterior fibres) - hip extension and lateral hip rotation
- Hamstrings-hip extension
- Erector spinae-spinal and pelvic stabilization
- Latissimus dorsi-spinal and pelvic stabilization
- Adductors (magnus, longus, brevis, minimus)-assist with hip extension and stabilization
- Abdominals- spinal and pelvic stabilization

Technique

Technical issues

Table 1 and figures 1-7 highlight a correct and safe technique, which when performed with appropriate supervision can enhance performance and aid in an injury prevention strategy.

The two issues that have caused debate are the depth to which the squat should be performed and the extent to which the knees go beyond the toes. In the sporting environment it is important to provide an appropriate stimulus which will result in specific adaptations necessary to improve sporting performance. It is therefore important to consider the specificity of force and power characteristics as well as movement in the sport prior to prescribing a particular squatting technique.

In dynamic sporting activities hip extension is central to explosive movement. During a full range of motion back squat,

the gluteus maximus, a powerful hip extensor, becomes increasingly more active, the deeper the squat is performed (Caterisna et al 2002). This highlights the importance of performing the movement, through its full range, if specific force and power characteristics are desired.

Coaches will often prescribe partial squats, the rational being that the knee angle is specific to that which occurs during running. However the force and power characteristics are often neglected and the load that is required in the partial squat position to overload sprinting or jumping is substantial. Prescribing partial squats should always be carefully considered, through analysis of athlete's training history, their ability to load through their spine and the power and force characteristics of the event/sport. These considerations will establish an understanding of the partial squat load, which is required to give an appropriate training overload, for a particular event and also the athlete's ability to perform the exercise effectively, to have a positive transfer of training effect and avoid injury.

Knee and hip/lumbar spine torque are central to the second issue. It is very common to see individuals from the health and fitness industry squatting and not allowing their knees to go beyond their toes; however is this appropriate and safe within a sports performance context?

Firstly, if we merely consider the action of taking our knees past our toes. Does it happen in sport? It depends on the sport and the techniques involved, however from judo to curling, the knee is stressed in a position beyond the toes. The fact that it happens raises the question- should we train it?

Forward motion of the knees beyond the toes is dependant on squatting depth and anterior trunk inclination. Research does suggest that increasing knee extension does decrease patellofemoral and tibiofemoral compressive forces (Escamilla, 2001) and therefore by increasing the forward motion of the knees during the squat, will increase the shearing forces through the knees. If stress through the knees is to be minimized, there must be a re-distribution of the force and this occurs around the hip and lumbar spine. Due to the anterior trunk inclination, to minimize knee stress forces, excessive forces are potentially transferred through the hips and lumbar spine (Fry et al 2003), thus increasing injury potential to the lower back. With an injury free athlete, it is important therefore to apply correct technique and allow the forces to be distributed evenly through the hips and knees safely to avoid injury by allowing some anterior trunk inclination and allowing the knees to move forward in front of the toes.

Application

As has been described, the back squat is multi joint hip and knee strengthening exercise. Its use across sports and the qualities it is aiming to develop are unique to the sport and individual. Outlined below are some examples of variations that may be applied, the physical benefits at different stages of a periodised sporting plan and an example of the sports that may benefit. At all stages of training it must be emphasized that correct technique and the athletes well being is paramount.

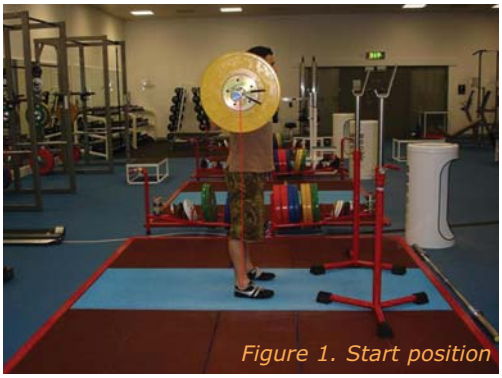
Figure 1. Start position

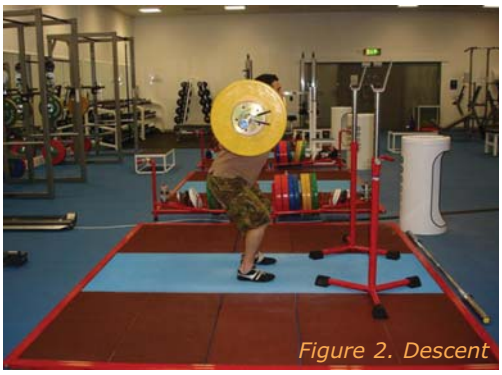
Figure 2. Descent

Figure 3. Descent approaching parallel position


Figure 4. Descent- maintaining posture

Figure 5. Descent/Ascent-loss of spinal posture

Table 1. Outline of back squat technique.

POSITION	DESCRIPTION	PROBLEMS	VARIATIONS/SOLUTIONS
Start position *(Figure 1)*	Hands evenly spaced shoulder width apart on bar	Unable to have shoulder width grip due to poor shoulder external rotation	Widen grip until comfortable
	Bar positioned just below C7 across upper trapezius and rear deltoids-high bar	Pain across neck where bar is positioned	Ensure bar is below 7th cervical vertebrae Low bar-positioned below rear deltoids and upper trapezius
	Athlete stands extended through spine, hips and knees-bracing spinal musculature	Unable to hold extended position	Ensure athlete has no spinal pathology that limits ability to extend thoracic and lumbar spine. Has ability to hold correct posture without bar or load
	Feet are positioned just outside shoulder width with toes pointing slightly outwards	Potential depth problems	Allow athlete to experiment with stance width to find a comfortable position that allows a full range of motion
Descent *(Figures 2-5)*	Athlete takes a breath in at start		
	Unlocks hips and begins to flex at knees with a slight anterior lean with trunk		
	Hips go behind heels and knees and hips flexed until femur is parallel with floor	Unable to reach parallel	Widen stance, point toes out slightly
	Feet remain flat throughout	Heels come off floor	Check ankle range of motion. Widen stance, turn feet out slightly. Raise heel of shoe (weightlifting shoe)
	Knees go beyond toes in the sagittal plane and maintain alignment over toes in the coronal plane		
	Athlete maintains anterior trunk lean throughout motion maintaining lumbar lordosis and thoracic rigidity	1. Athlete leans too far forward 2. Athlete allows lumbar spine to flex 3. Allows thoracic spine to flex	1. Widen stance, adjust load, encourage athlete to drive and extend hip 2. Ensure that athlete can posteriorly and anteriorly tilt pelvis in an unloaded situation. Adjust load and practice correct movement patterns 3. Encourage athlete to keep chest up and to keep their elbows under bar and not extend behind their body
Ascent *(Figures 5-7)*	Feet forcefully driven into floor		
	Knees and hips extend		
	Knees maintain position over toes in coronal plane	Knees deviate inwards and hips internally rotate	Possible weakness in hip abductors. Increased foot pronation. Load too heavy? Single leg exercises may need to be considered in conjunction with reinforcement of squatting movement pattern
	Hips raise at the same tempo as bar	Hips raise at a higher tempo than bar	Athlete has relative weakness in hip extensors. Load is too heavy? Encourage athlete to extend at hip forcefully through sticking point
	Spinal curvature is maintained (rigid extended thoracic and lumbar lordosis)	Lumbar and thoracic flexion	Load too heavy? Weakness in spinal extensors Encourage athlete to drive chest up.
	Breath out through mid range of movement (sticking point)		

General preparation:

- Leg and hip hypertrophy (sprinting, rugby, throwing..)
- Leg and hip strengthening (judo, team field sports, track and field, racket sports curling…)
- Rehabilitation/prehabilitation (all sports, female athletes prone to ACL/ligament ruptures)
- Specific trunk strengthening (rugby-front row forwards, contact sport…)

Specific preparation:

- Leg and hip strengthening (track and field, rugby….)
- Partial squats-overload certain weak positions specific to event/sport (throws, sprints..)
- Speed squats-leg and hip power (badminton, explosive anaerobic sports…)

Competition:

- Strength maintenance (team/seasonal sports….)
- Jump squats – power development

Table 2 (below) is an example of how the back squat could be progressed in a power sport and the volume load and intensity manipulated over a mesocycle.

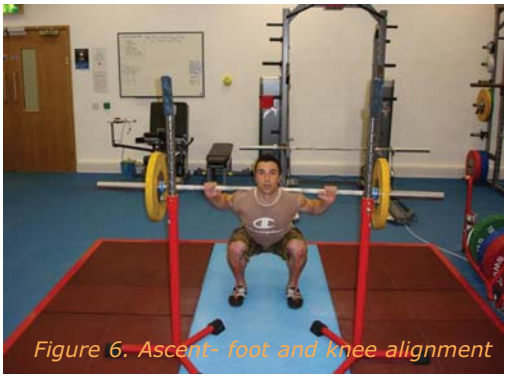

Figure 6. Ascent- foot and knee alignment

Figure 7. Ascent- incorrect knee alignment (internal rotation)

General preparation				Specific preparation 1				Specific preparation 2				Competition			
B SL	BS SL	BS SL	BS SL	BS	BS	BS	BS	BS	BS PS	JS PS	JS PS	BS JS	JS	JS	

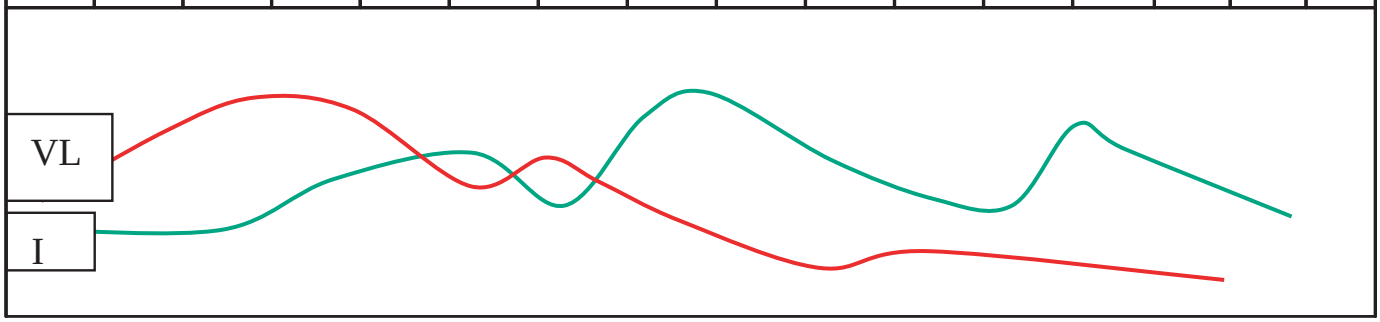

Table 2. Example of back squat volume load and intensity over a mesocycle

Key: VL- back squat volume load, I-back squat intensity, BS- back squat, PS- explosive partial squat, JS-jump squat, SL- single leg squat.

Acknowledgements

Thank you to photographer Tommy Yule and demonstrator James Karageorgiou.

References

Fry AC, Smith JC and Schilling BK. Effect of knee position on hip and knee torques during the barbell squat. Journal of Strength and Conditioning Research. 17(4): 629-33, 2003.

Escamilla, RF. Knee biomechanics of the dynamic squat exercise. Medicine and Science in Sport and Exercise. 33 (1): 127-141, 2001.

Caterisano A, Moss RF, Pellinger TK, woodruff K, Lewis VC, Booth W, Khadra T. The effect of back squat depth on the EMG activity of 4 superficial hip and thigh muscles. Journal of Strength and Conditioning Research 16(3):428-32, 2002.