Amsterdam University of Applied Sciences

BIOMECHANICS 3

EUROPEAN SCHOOL OF PHYSIOTHERAPY

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THE OLYPMIC SNATCH – A BIOMECHANICAL ANALYSIS

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CREATING TOMORROW

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Introduction

Description of the movement

As the name implies, the Olympic Snatch is an Olympic discipline in the sport of weightlifting. Essentially, the athlete tries to propel a barbell from the ground to an overhead position in a single motion.

Before starting with the analysis one should look at the Olympic snatch and how it is performed. Watch this video.

Click here to access a slow-motion video dividing the snatch into several phases, which will be picked up in later sections of the assignment.

General

For the movement to be analyzed the authors have chosen the sagittal plane.

Furthermore, the displacement of the gravitational center of mass (GCM) is described in the section “Kinematics”. In addition, an external analysis is conducted due to the sake of completeness and to give the lecturer an insight into the knowledge gained during the course Biomechanics 3 at the European School of Physiotherapy (ESP).

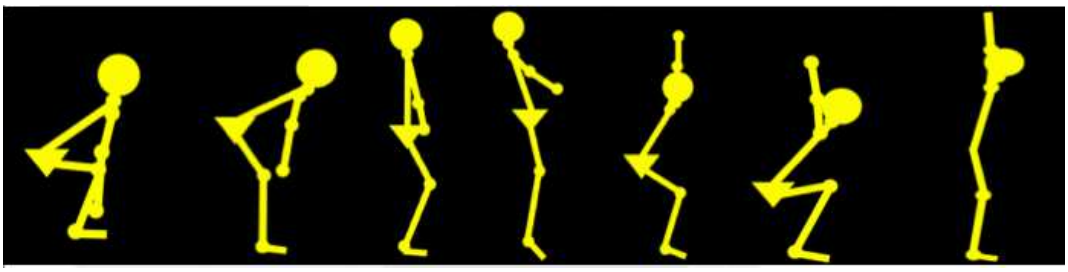
Both, the kinematics as well as the external analysis, are not of importance for the main question to be answered, which is: “Which internal forces are acting at the hip, knee and ankle joint in order to reach maximal vertical displacement of the weight?”

Phases

The phases of the Olympic snatch are:

1. **The preparation phase:** The preparation phase is characterized as a static position where the athlete positions himself optimally over the bar to facilitate maximal force production. The athlete grabs the bar in a wide grip of roughly double shoulder width with the arms extended.
2. **The first pull:** During the first pull, the athlete lifts the bar off the ground almost exclusively through knee extension until the bar reaches slightly above knee level.
3. **The scoop:** To allow for more vertical translation of the bar and to better position himself in relation to the bar, the athlete extends the hips. The scoop is a transition phase between the first and second pull and ends with the bar slightly below the hips.
4. **The second pull:** With the bar at the mid to top thigh, the athlete performs the so-called “triple extension”, which is characterized by explosive extension of the hip, knee and ankle. The bar reaches its highest velocity in this phase.
5. **The third pull:** After the triple extension, the athlete essentially pulls himself under the bar through shoulder abduction and external rotation plus simultaneous concentric hip and knee flexion. In some athletes, the concentric hip and knee flexion might give the illusion that the athlete is jumping.
6. **The catch:** In the catch, the athlete accepts and tries to control the bar overhead in a deep squat position.
7. **The overhead squat:** The athlete must stand up from the deep squat position whilst maintaining control of the bar over his head.

The following chart shows stick figures depicting the end position of each phase:

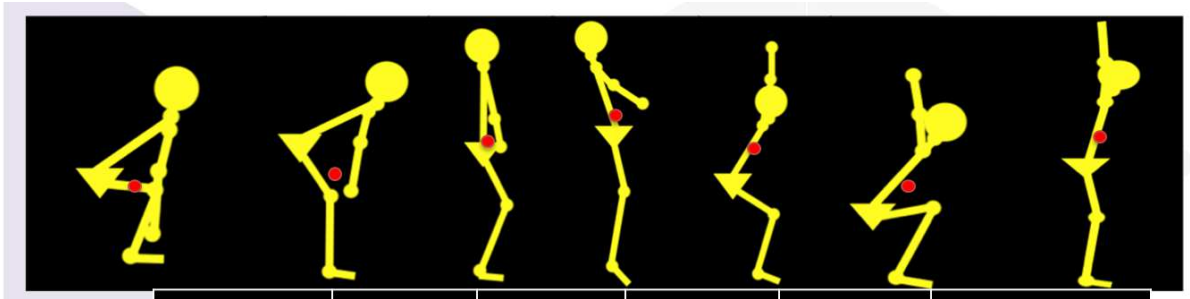


Preparation	1st Pull	Scoop	2nd Pull	3rd Pull	Catch	Overhead Squat

Kinematics

During the whole movement, the GCM of the body is displaced in a translational movement. The location of the GCM in the following drawings is estimated for an athlete of 80kg body weight snatching a total barbell weight of 40 kg.

The velocity shows how fast the GCM is moving and in which direction, while the last row of the table explains if the GCM is accelerating or decelerating.



Phase	1st Pull	Scoop	2nd Pull	3rd Pull	Catch	Overhead Squat
Velocity	0 ⬆	⬆	⬆ ⬆	⬆ 0	⬇ 0	⬆ 0
Acc/Dec	Acc	Dec	Acc Acc	Dec Dec	Acc Dec	Acc Dec

The reason for an acceleration of the GCM upwards is that the vertical component of the ground reaction force is bigger than the gravitational force that is acting on the body. The opposite is true for a deceleration of the GCM.

The GCM is accelerating downwards after the 3rd pull, as the gravitational force is bigger than the vertical component of the ground reaction force.

In order to further understand why the body is either accelerating or decelerating vertically, have a look at the external forces in the following section.

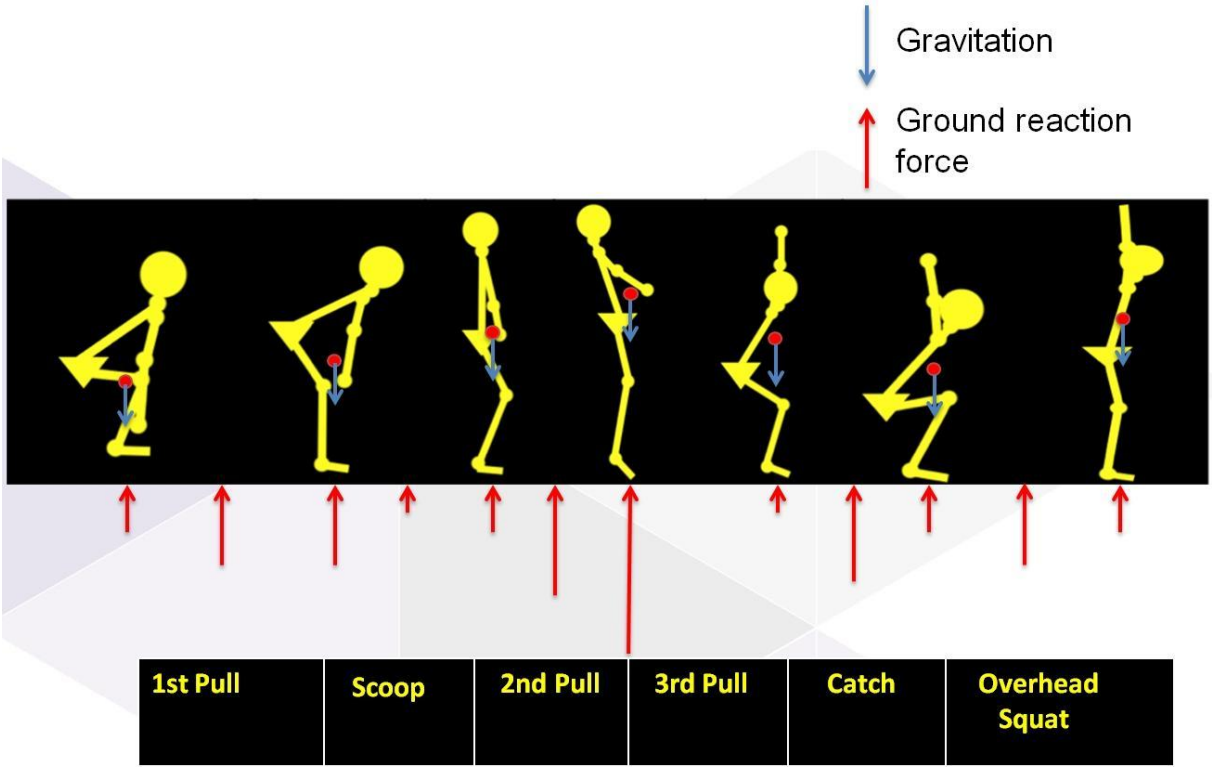
External analysis

With the help of the external analysis, it is possible to exactly determine if acceleration or a deceleration of the GCM is taking place.

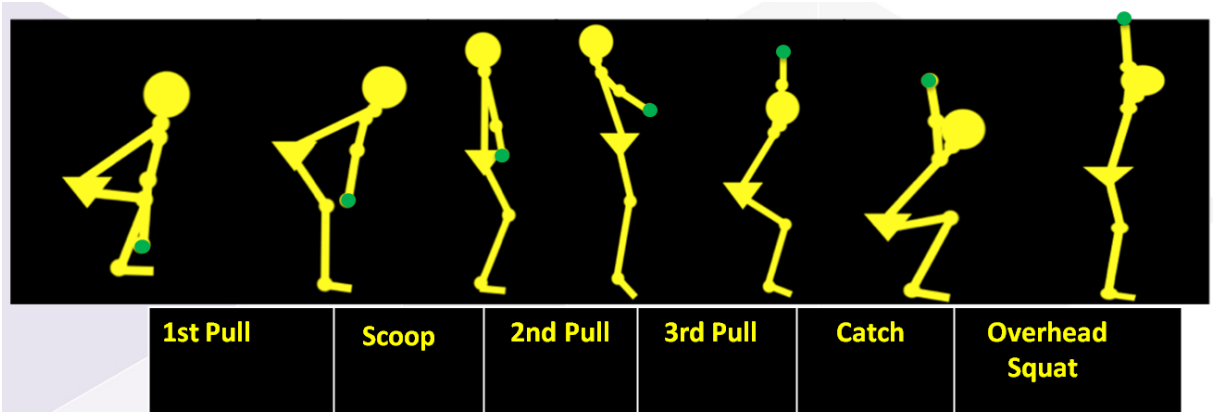
For the ground reaction force, only the vertical component is drawn.

After the 2nd pull there is no ground reaction force for a short moment as the athlete loses contact with the ground for a brief moment.

During the scoop phase, it is normal that the GCM decelerates and loses velocity.



Movement of the weight



The main goal of every athlete that is performing the snatch is to accelerate the weight as much as possible and to reach maximal velocity and thus maximal vertical displacement after the 2nd pull.

Ideally, the displacement of the weight describes a so-called “inversed candy cane” form throughout the whole movement and never travels out of the base of support.

According to (Bartonietz 1996) the speed of the bar reaches up to 2m/s for an athlete of the superheavyweight category.

Joint Analysis

In this section, the authors will analyze the Olympic snatch in the sagittal plane and concentrate on the hip, knee, and ankle joint, as they are the most interesting joints to evaluate in the chosen plane. The analysis for the joints will be separated amongst the authors and allocation is clearly stated.

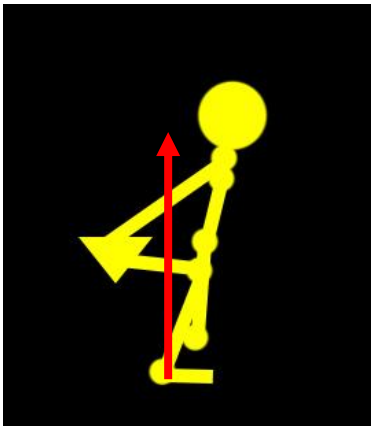
The gravitational force will not be drawn in the following frames as it is neglectable in comparison with the much higher ground reaction force.

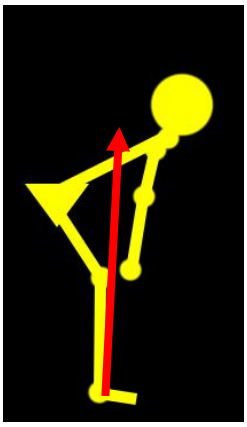
The direction and magnitude of the ground reaction force are estimated.

Minor muscle groups that don't play a role, as the primary movers for a movement are not mentioned for reasons of simplicity.

Author Kai Sigel will describe the first 3 phases (frames 1-4), while Andreas Heck explains the last 3 phases (frame 4-7).

Frame 1 – Frame 2: First Pull





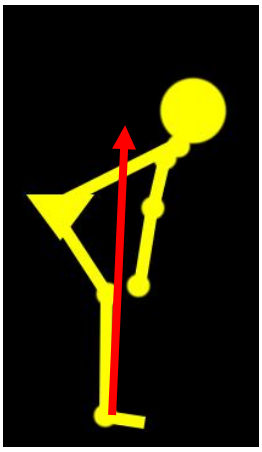
Joint	°start	°end	Move-ment	Moment Gravity	Moment GRF	Muscle Moment	Mono-articular	Bi-articular
Hip	140°	92°	Extension	Flexion	Flexion	Extension	Gluteus maximus concentric	Rectus femoris isometric Hamstrings isometric
Knee	76°	38°	Extension	Extension	Flexion/ Extension	Extension	Vasti concentric	Rectus femoris isometric Hamstrings isometric Gastroc-nemius isometric
Ankle	20°df	0°pf	Plantar-flexion	Dorsiflexion	Dorsiflexion	Plantar-flexion	Soleus concentric	Gastroc-nemius isometric

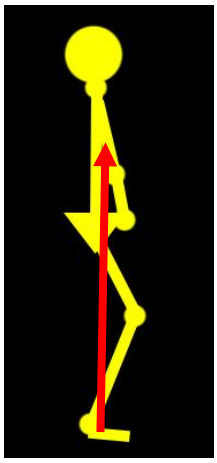
Explanation:

The movement is initiated by concentrically contracting vasti that transfer energy to the hip over isometrically contracting hamstrings and rectus femoris that act as a rope (according to the theory of and herewith assist the gluteus maximus, which is concentrically active to perform extension of the hip (Van Ingen 1989).

The isometrically contracting gastrocnemius is acting as a rope as well and assists the soleus in its concentric plantar flexion.

Frame 2 – Frame 3: Scoop





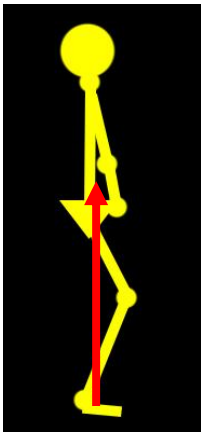
Joint	°start	°end	Movement	Moment Gravity	Moment GRF	Muscle Moment	Mono-articular	Bi-articular
Hip	92°fl	28°fl	Extension	Flexion	Flexion	Extension	Gluteus maximus concentric	Rectus femoris eccentric Hamstrings concentric
Knee	38°fl	49°fl	Flexion	Flexion	Extension/ Flexion	Extension	Vasti eccentric	Rectus femoris eccentric Hamstrings Concentric Gastrocnemius isometric
Ankle	0°pf	20°df	Dorsi-flexion	Dorsi-flexion	Dorsi-flexion	Plantar-flexion	Soleus eccentric	Gastrocnemius isometric

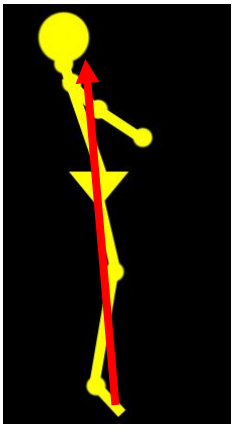
Explanation:

The movement is initiated by concentrically contracting gluteus maximus and hamstrings in order to bring the upper body in an almost upright position with the barbell close to the pelvis. At the same time, the knee is slightly flexed by the ground reaction force and gravity and eccentrically controlled by the quadriceps muscles.

The dorsiflexion movement at the ankle is eccentrically controlled by the m. soleus while the gastrocnemius is isometrically assisting this movement as it is shortening at the knee and lengthening at the ankle.

Frame 3 – Frame 4: Second pull





Joint	°start	°end	Movement	Moment Gravity	Moment GRF	Muscle Moment	Mono-articular	Bi-articular
Hip	28°fl	10°fl	Extension	Flexion	Flexion/ Extension	Extension	Gluteus maximus concentric	Rectus femoris isomentric Hamstrings isometric
Knee	49°fl	20°fl	Extension	Flexion	Flexion	Extension	Vasti concentric	Rectus femoris isomentric Hamstrings isometric Gastrocnemius isometric
Ankle	20°pf	50°pf	Plantar-flexion	Dorsi-flexion	Dorsi-flexion	Extension	Soleus concentric	Gastrocnemius isometric

Explanation:

For the goal of maximal acceleration of the barbell, the hip, knee and ankle are all in a slightly flexed position (ankle dorsiflexed) at the start of the phase.

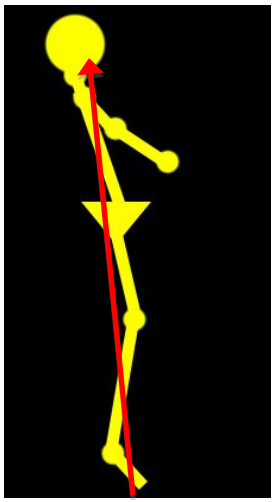
The movement is initiated by an explosively concentrically contracting gluteus maximus that transfers energy to the knee joint over isometrically contracting rectus femoris and hamstrings.

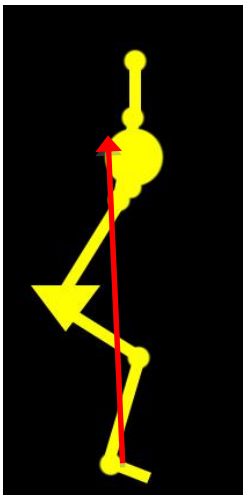
The velocity of the barbell is further increased by the concentrically contracting vasti that becomes active a brief moment after the gluteus maximus.

At last, energy is transferred from the knee to the ankle via an isometrically contracting gastrocnemius that is acting as a rope.

The maximum velocity of the barbell is achieved by a concentrically contracting soleus a few milliseconds after the vasti are contracting.

Frame 4 – Frame 5: Third pull



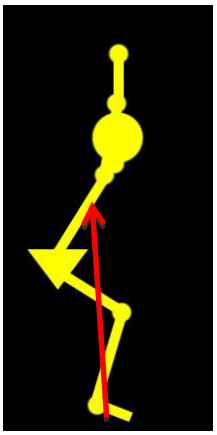


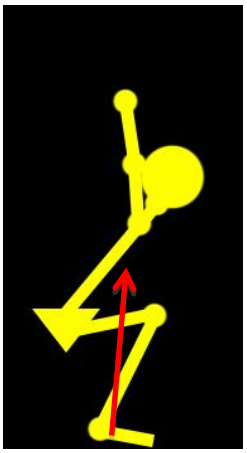
Joint	°start	°end	Movement	Moment Gravity	Moment GRF	Muscle Moment	Mono-articular	Bi-articular
Hip	10°fl	60°fl	Flexion	Flexion	Extension /Flexion	Flexion	Iliopsoas concentric	Hamstrings isometric Rectus femoris isometric
Knee	20°fl	70°fl	Flexion	Flexion	Flexion	Flexion	Biceps femoris short head concentric	Hamstrings isometric Rectus femoris Isometric Gastrochnemius isometric
Ankle	50°df	10°df	Dorsi-flexion	Dorsi-flexion	Dorsi-flexion	Dorsi-flexion	Tibialis anterior concentric	Gastrocnemius isometric

Explanation:

After the “triple extension” during the scoop, which resulted in vertical displacement of the bar, the athlete quickly flexes the hips through concentric activation of the mm. iliopsoas. The energy is transferred over the isometrically contracting Hamstrings and rectus femoris, which in turn induces knee flexion. Knee flexion is assisted by a concentric contraction of the short head of the biceps femoris. The ankle is dorsiflexed by the tibialis anterior, which contracts concentrically.

Frame 5 – Frame 6: Catch





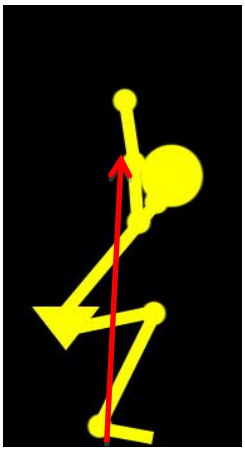
Joint	°start	°end	Movement	Moment Gravity	Moment GRF	Muscle Moment	Mono-articular	Bi-articular
Hip	60°fl	100°fl	Flexion	Flexion	Flexion	Extension	Gluteus maximus eccentric	Hamstrings isometric Rectus femoris isometric
Knee	70°fl	126°fl	Flexion	Flexion	Flexion	Extension	Vasti eccentric	Rectus femoris isometric Hamstrings Isometric Gastrocnemius isometric
Ankle	10°pf	18°df	Dorsi-flexion	Dorsi-flexion	Dorsi-flexion	Plantar-flexion	Soleus Eccentric	Gastrocnemius isometric

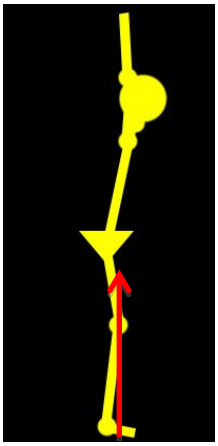
Explanation:

After the athlete pulled himself under the bar, the goal is to slow down and stabilize the barbell overhead whilst moving into a deep squatting position.

The eccentrically contracting gluteus maximus allows for controlled hip flexion whilst moving downward. Isometrically contracting hamstrings and rectus femoris act as a stabilizer. The vasti contract eccentrically as well to gradually let the knee adopt increased flexion position. At the ankle, the soleus contracts eccentrically to slow down the forward moving tibia.

Frame 6 – Frame 7: Overhead squat





Joint	°start	°end	Movement	Moment Gravity	Moment GRF	Muscle Moment	Mono-articular	Bi-articular
Hip	100°fl	10°fl	Extension	Flexion	Flexion	Extension	Gluteus Maximus concentric	Rectus femoris isometric Hamstrings isometric
Knee	126°fl	14°fl	Extension	Flexion	Flexion / neutral	Extension	Vasti concentric	Rectus femoris isometric Hamstrings Isometric Gastrocnemius isometric
Ankle	18°df	4°pf	Plantar-flexion	Dorsi-flexion	Dorsi-flexion	Plantar-flexion	Soleus concentric	Gastrocnemius isometric

Explanation:

During this last phase, the athlete has to stand upright from the deep squatting position.

The Gluteus maximus contracts concentrically and energy is transferred over the isometrically contracting hamstrings to induce knee extension.

The vasti contract concentrically to extend the knee joint.

The extension at the knee joint is coupled to ankle plantar flexion through the isometrically active gastrocnemius acting as a rope and the movement is assisted by a concentrically contracting soleus (Van Ingen 1989).

References

Bartonietz KE. Biomechanics of the Snatch: Toward a Higher Training Efficiency. Strength & Conditioning Journal 1996;18(3):24-31.

Van Ingen, GJ. On the action of bi-articular muscles, a review. Neth.J.Zool. 1989;40(3):521-543.

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