

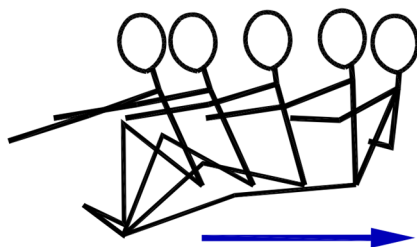
2.1 Drive

by Mike Purcer

The rowing stroke is generally divided into two main phases: the drive and recovery. This section aims to offer a detailed description of the athlete's body positions and movements during the drive phase. Many style variations exist regarding the extent of upper body (torso) swing and leg (knee joint) compression; however, the fundamental movements remain similar. Additionally, style variations within the stroke accommodate rowers of different body types. This section functions as a general guide to the drive phase of the stroke.

The drive phase starts when the athlete leaves the full reach position closest to the stern and ends when the athlete completes the release and reaches the finish position with the blade feathered. Figure 2.1a Drive Technique shows the athlete moving through the drive phase of the stroke.

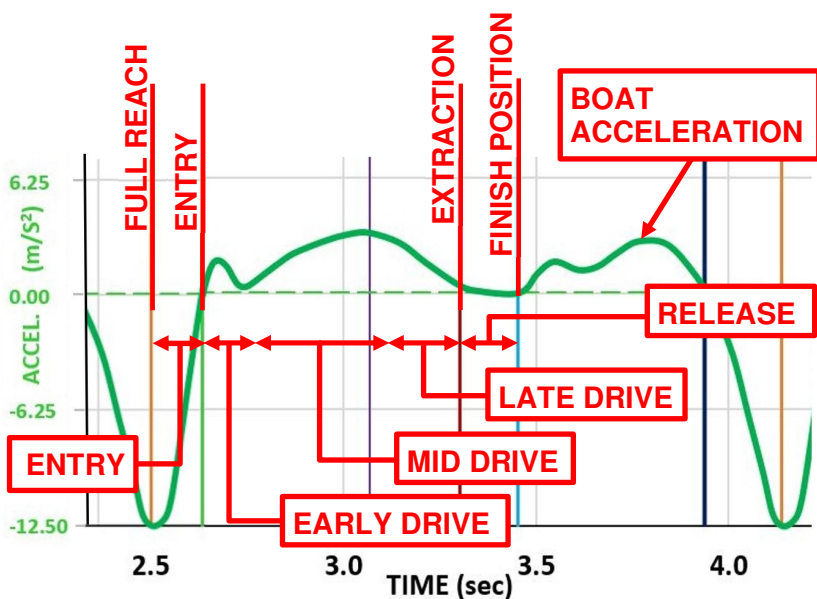
Figure 2.1a Drive Technique



The drive phase can be divided into the entry, power application, and release stages. The entry and release are transitional parts, with the blade entering and exiting the water, respectively. These stages are included in the drive phase section as they occur during the athlete's movement, pulling on the oar handle between the full reach and finish positions. Minimizing the time spent on the entry and release stages extends the power application stage, thereby increasing the crew's opportunity to accelerate the boat.

The power application (drive) stage begins when the blades are fully submerged at the entry. This phase ends with extraction when the blades are typically halfway out of the water and start to move with the boat. At this point, no force is applied to the oarlock to accelerate the boat. The power application stage can be further divided into early, mid, and late drive segments, as specific muscle groups engage to exert force. Figure 2.1b Drive Stages shows a boat acceleration curve that highlights the stages of the drive phase of the stroke.

Figure 2.1b Drive Stages



The drive starts with the legs pressing against the footstop, followed by the engagement of the torso, and finally, the arms complete the stroke. While these body movements begin sequentially, they overlap, creating a transition that extends to maximize muscle force application.

In the early drive, the legs move independently to initiate the boat's acceleration, while the torso holds the catch angle and arms hang onto the oar handle. During the mid-

drive, the hip joint engages, allowing the torso to pivot back and contributing to the power generated by the legs as they achieve full extension. In the late drive, the arms come into play, and the torso reaches the finish layback angle as the arms pull the oar handle towards the body, ensuring the blade remains submerged in the water for as long as possible. The synchronized, overlapping movements of the legs, torso, and arms provide continuous, effective power application throughout the drive. The following sections detail each stage of the stroke, including blade entry and release.

To fully understand the drive phase of the stroke, it is essential to recognize the athlete's movement within the shell and its influence on boat movement. During the stroke, both the athlete and the boat move in the same direction. At the full reach and finish positions, they both travel at the same speed. Throughout the drive and recovery phases, the athlete continues to move in the same direction as the boat but at different speeds as they move back and forth within the shell. The athlete's movement within the shell contributes to significant variations in the boat's hull speed as they push or pull on their foostops during the drive and recovery phases.

Figure 2.1c, Power Application Stage, shows an example of a woman's single, including the boat and the athlete's centre of mass (COM) distance movements.

Figure 2.1c Power Application Stage

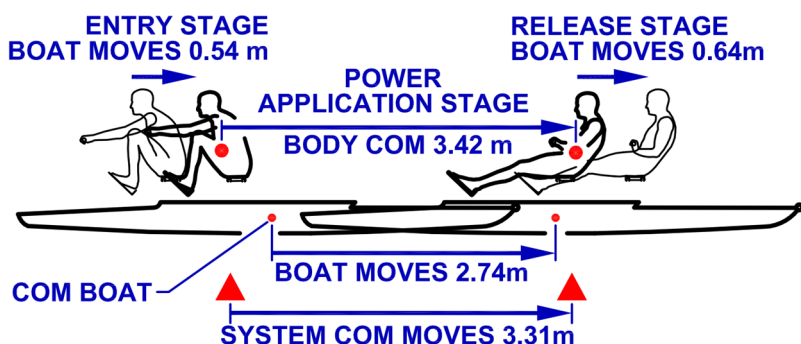


Figure 2.1c Power Application Stage shows that during this phase, the boat moved 2.74 metres while the athlete's COM moved 3.42 metres. The athlete's weight and the movement of the COM are key factors limiting the boat's acceleration during the drive phase. In the example from Figure 2.1c, the athlete weighs 72 kg and the boat weighs 14 kg. The combined weight of the boat-athlete system is 86 kg, and their combined COM moves 3.31 metres during the power application stage, represented by the red triangles in Figure 2.1c: Power Application Stage. This stage, from entry to extraction, takes 0.68 seconds, resulting in an average system speed (d/t) of 4.87 m/s, while the average boat speed was 4.03 m/s.

Figure 2.1d Athlete COM Movement

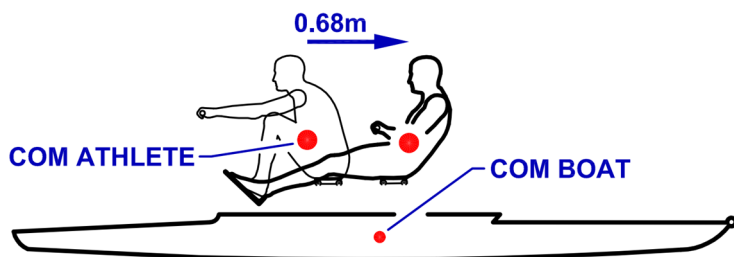


Figure 2.1d Athlete COM Movement highlights the athlete's movement within the boat during the power application phase. The force exerted by the athlete at this stage is primarily used to accelerate their body mass, which typically ranges from 4 to 8 times the weight of the boat. The resistance force caused by drag on the hull is relatively minor in comparison. During the drive, the athlete pushes against the footstops, shifting their centre of mass (COM) toward the bow of the boat. This movement limits the boat's acceleration; however, it also shifts the athlete's mass toward the bow, which can then be leveraged during

recovery to accelerate the boat as the athlete transitions from the finish back to full reach.

Measuring the boat's acceleration as a performance factor does not take into account the momentum gained during the drive due to the athlete's COM being repositioned toward the bow. Section 2.9 Objective Analysis provides a thorough examination of the technique factors used to evaluate rowing technique. Sections 2.9.1 to 2.9.4 outline the technique factors specific to the drive phase of the stroke.

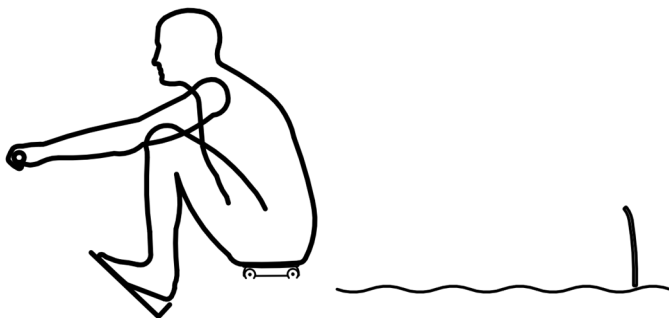
2.1.1 Full Reach Position

The full reach position marks the transition point, representing both the end of the recovery phase and the beginning of the drive. In this position, the body is at maximum reach, which is crucial for extending the length of the stroke. The athlete reaches forward on the balls of their feet, with shins perpendicular and the knee joint compressed. The torso touches the thighs, maintaining a straight lower back and a neutral spine, while the upper back and shoulders extend forward. The arms are straight, reaching out, and the oar handle is held firmly in the fingers.

Sweep rowers will turn their shoulders toward the oar handle by pivoting from the lower back to extend their reach. The sweep oar handle is held firmly in the fingers of the outside hand under the second knuckle and beneath the palm of the inside hand. The difference in hand positions is necessary to allow both arms to be fully extended at the full reach position.

Figure 2.1.1a Full Reach shows the athlete in the full reach position. Below the figure is a description of both the body and the oar positions.

Figure 2.1.1a Full Reach Position (0%)



Legs

- legs compressed at the knee joint with the connection to the footstops on the ball of the feet
- the seat is in its sternmost position, transitioning instantaneously from sternward on recovery to bowward movement during the entry

Torso

- the torso is reaching forward with the lower back straight with a neutral spine
- upper back and shoulders reaching forward to maximum extension
- in sweep rowing; the shoulders are turned towards the oar handle

Arms

- arms are straight. In sculling, the hands are spread wide
- wrists are flat
- oar handles are held firmly in the fingers

Oar

- the oar is at the catch angle, with the blade square just above the water

2.1.2 Entry

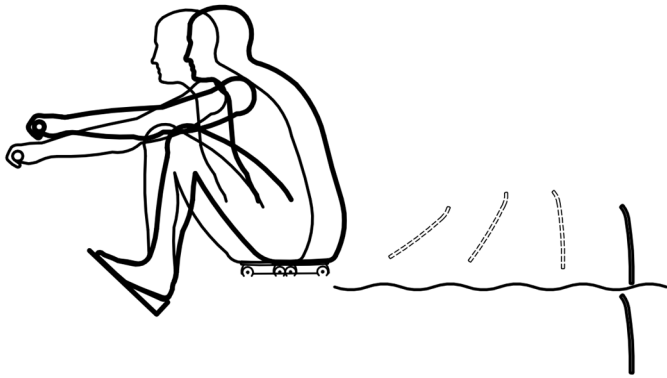
The entry phase of the stroke, also known as the catch, is the movement from the full reach position to when the blade is fully submerged. During the entry, the athlete presses the balls of their feet against the footboards, opening the knee joint while lifting their hands and arms from their shoulders. The torso remains forward at the catch angle, and their arms stay straight. Typically, the entry takes less than two-tenths of a second, with top performers approaching one-tenth of a second. The speed of the movement and the accuracy of the blade entry directly impact performance.

The effectiveness of the entry is highly dependent on the athlete's body and blade preparation during the final part of the recovery. In the last few inches of the athlete's seat moving sternward, their torso and arms are in the full reach position as they lower the squared blade down to the water's surface. This preparation is essential and cannot be overstated in its role to reduce the entry time.

Figure 2.1.2a Entry shows the knee joint opening as the arms lift to bury the blade in the water. The torso stays at the forward angle, and the arms remain straight. The oar handle is pulled to allow the blade to match the speed of the water passing the boat as it moves vertically, burying the blade with minimal splash. It is crucial to apply pressure on the blade face as quickly as possible.

An effective entry reduces the time between full reach and blade bury. The shorter time achieves two goals. First, it reduces the boat's deceleration by accelerating sooner through an earlier connection. Second, by burying the blade quicker in the water, the crew or sculler increase their effective stroke length. Although the quickness is emphasized, it is the timing and placement that matter most. Coaches aiming to enhance boat speed would be wise to focus on improving the entry.

Figure 2.1.2a

Entry**Legs**

- entry begins with the athlete pushing on the balls of their feet, engaging the calf muscle.
- legs compressed in the full reach position begin the drive with a quick movement opening at the knee joint.
- the legs alone drive the seat while the torso and arms connect to transfer the leg force to the oar handle.

Torso

- the torso holds the catch angle, with the lower back straight in the neutral spine position.
- upper back and shoulders reaching forward to hang onto the position
- sweep rowing, the shoulders are turned towards the oar handle

Arms

- arms remain straight and lift the oar handle quickly from the shoulders at the beginning of the entry
- oar handles are held firmly in the fingers

Oar

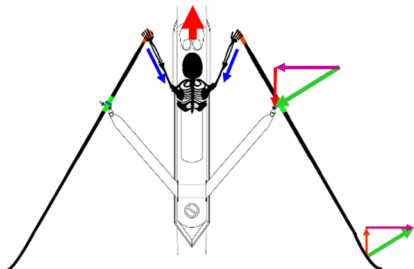
- the oar begins at the catch angle with the blade just above the water
- the blade is quickly buried from full reach with minimum splash as it enters the water.

2.1.3 Early Drive

Following the entry, when the blade becomes fully submerged, the power application stage of the stroke begins. The early drive stage generates force on the oar handle by engaging the legs and using the quadriceps to straighten the knee joint. The torso maintains the forward catch position, and the arms stay straight, moving the oar handle with the seat. The early drive stage is marked by movement from the legs only, in both sculling and sweep rowing, and continues until the knee joint passes through ninety degrees. Figure 2.1.3b Early Drive illustrates the body's movement with a bullet-point description below. During this stage, athletes apply power by pushing on the footstops and pulling on the oar handle to exert pressure on the blade surface, transferring force to the oarlock and accelerating the boat. Some sculling coaches prefer slightly less pressure during the early drive, allowing athletes to build force throughout the stroke—a technique known as back-end-loaded power application. This method can be effective in sculling, as the oar catch angle is significant and provides only partial force in the vector direction that accelerates the boat, as shown in Figure 2.1.3a Early Drive Forces.

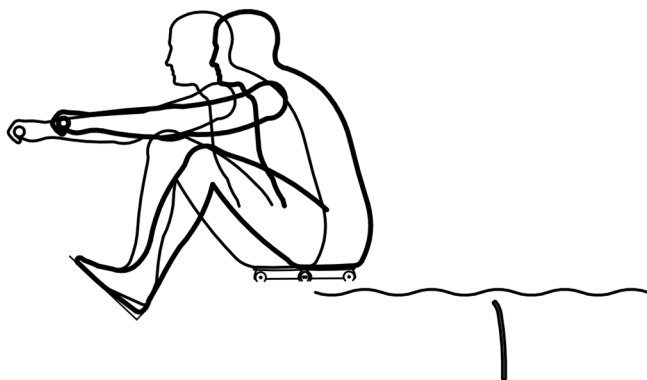
Figure 2.1.3a Early Drive Forces

Some of the force not used to accelerate the boat is absorbed into the shaft of the oar, causing it to bend. This force can be utilized at the end of the drive when the force on the oar handle decreases, allowing the oar shaft to spring back straight.



The early drive effectiveness is characterized by leg-only power application, horizontal pull, and consistent blade depth.

Figure 2.1.3b

Early Drive**Legs**

- legs push from the balls of the feet as the knee joint opens. The knee joint extends through a ninety-degree angle in the early drive stage
- the legs are the only muscle group actively extending to generate force between the foot stops and the oar handle which moves with the seat

Torso

- the torso holds the forward catch angle as the legs push the slide from the footstops.
- lower back straight with the spine in a neutral position
- upper back and shoulders holding on may appear to stretch linking the hips to the arms to the oar handle

Arms

- arms are straight and hanging, linking the torso movement with the oar handle
- hands are moving the oar handle horizontally

Oar

- the oar blade is fully buried and maintains consistent depth
- the oar handle moves with the seat
- the shaft of the oar bends storing force not used to accelerate the boat.

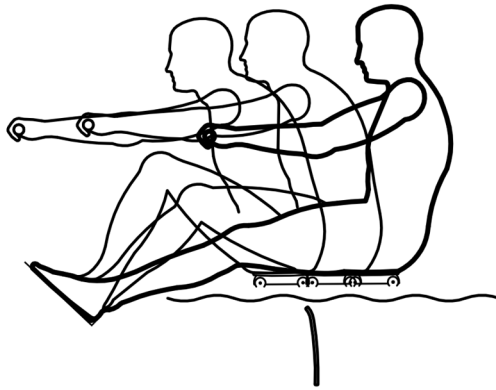
2.1.4 Mid Drive

The mid drive begins after the knee joint opens past ninety degrees and represents most of the power application stage, see Figure 2.1b Drive Stages. The legs maintain their powerful extension, accounting for the majority of the oar handle movement during the first half of the mid drive. In this stage, the hip joint engages, starting the torso opening, slowly at first, but increasing force and speed as the legs approach full extension. The hip joint accounts for the majority of the force applied to the oar handle through the latter half of the mid drive. As the oar shaft approaches perpendicular, the legs are almost fully extended, and the hip joint aggressively opens the torso to maximize the force on the oar handle and peak boat acceleration. Near the end of the mid drive, as the legs fully extend and the torso passes through vertical, the upper back (lats) and arms actively contribute to the applied force. The mid drive stage features the synchronized, orderly engagement of the legs, torso (hip joint), and arms, which start independently but overlap to maintain and optimize power application.

Throughout this stage, the horizontal pull on the oar handle is vital to maintaining the constant depth of the blade in the water. The uniform blade depth maximizes the blade connection, which allows the transfer of force to the oarlock. The force exerted on the oarlock peaks as the oar shaft approaches perpendicular, providing peak boat acceleration. Bladework and the horizontal movement must be emphasized throughout the mid drive stage.

Figure 2.1.4a Mid Drive illustrates body movements during this stage of the stroke. Below the figure, bulleted descriptions detail the movements of the legs, torso, arms, and oar.

Figure 2.1.4a

Mid Drive**Legs**

- the legs continue to drive the seat back aggressively through the mid drive stage
- heels connect on the footplate to support the hamstring muscles and the hip joint opening

Torso

- the torso (hip joint) initiates and starts opening slowly in the first half of the mid drive
- the hip joint takes on the major movement of the oar handle as the oar shaft approaches perpendicular
- upper back (lats), and shoulders engage as the torso nears perpendicular
- shoulders pull back when lats engage the upper arms

Arms

- arms are straight through most of the mid drive, hanging on between the shoulders and the oar handle
- arms engage as the legs near full extension
- arms and hands pulling horizontally on the oar handle

Oar

- the oar blade remains at a consistent depth throughout the mid drive

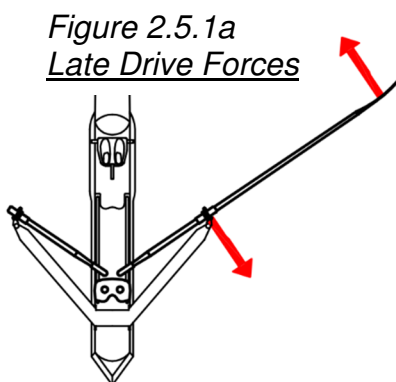
2.1.5 Late Drive

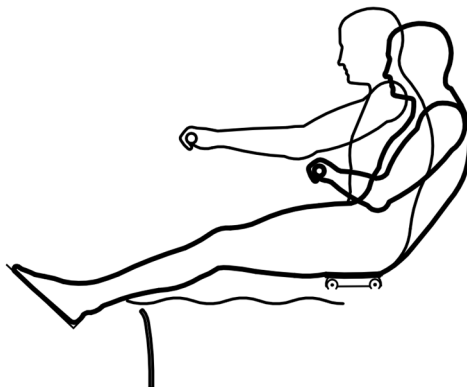
The late drive is the final part of the power application stage, involving the torso (hip joint) and arms to apply force on the oarlock. It is often called the finish, as it is the last opportunity to accelerate the boat/athlete system, but it does not include the release. The blade is fully submerged at the start of this stage and maintains depth for as long as possible before beginning to exit vertically. This stage ends at the blade extraction point, when it is about halfway out of the water with no force on the oarlock.

During this phase, the legs remain extended, supporting the torso (hip joint) as it completes its final opening movement. The shoulders (lats) and arms pull the oar handle horizontally as close to the torso as possible before moving downward to start the blade extraction. Figure 2.1.5b Late Drive illustrates the torso and arm movements with descriptive bullet points below.

The effectiveness of the late drive is shown by applying steady force on the oar handle and keeping the blade fully submerged for as long as possible. Extending the time the blade stays underwater increases the effective stroke length and allows the flex of the oar shaft, which has stored elastic energy earlier in the drive, to rebound and contribute to boat acceleration. The quick and clean vertical movement that starts the blade out of the water marks the end of the late drive and the beginning of the release.

In the late drive, as the oar rotates toward the finish angle, it results in a less efficient position. Figure 2.5.1a Late Drive Forces illustrates the force vectors on the blade and oarlock and highlights the inefficiency of applying additional power in this stage.



*Figure 2.1.5b**Late Drive***Legs**

- legs are fully extended at the start of the late drive, supporting the hip joint

Torso

- hip joint extends as the final movement (extension) of the torso and reaches the full layback position
- lower back straight in strong neutral spine position
- upper back and shoulders rotate back to maintain power and support the arms pulling the oar handle horizontally to the body

Arms

- arms engage, contracting at the elbow
- hands drawing the oar handle to the torso horizontally as long as possible until moving down with the forearm to start the blade extraction
- oar handles are held firmly in the fingers, and the wrists remain flat

Oar

- the oar blade remains at a constant depth until the final movement, when the blade starts the vertical release from the water

2.1.6 Release

The release marks the final part of the drive phase as the athlete extracts the blade from the water and rotates it to the feather position. The release is considered part of the drive because the oar handle is still moving toward the bow, and the athlete has not yet reached the finish position, with their hands close to the body.

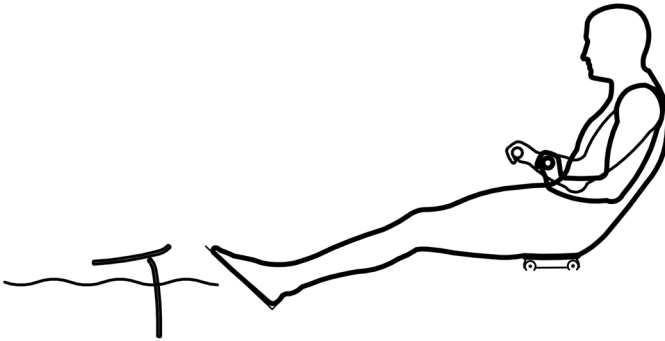
The release begins when the blade is about halfway out of the water and the force on the oarlock drops to zero. The blade is no longer stationary in the water and starts to move with the boat as the oar rotates to the finish oar angle. The blade usually reaches full feather as the athlete reaches the finish position, completing the release stage.

During the release, the legs stay relaxed, and the arms pull the oar handle both horizontally and vertically as they move toward the body. In sweep rowing, only the inside wrist rotates the oar handle to feather the blade, while the outside wrist remains flat as the forearm presses down to move the blade vertically. The focus is on using the athlete's torso (mass) as the stable point for pulling the arms. Figure 2.1.6a Release illustrates the arm and wrist movements with descriptive bullet points below.

A variation in release style used by some scullers involves starting the pivot of the torso forward (sternward) as the blade is being feathered. Moving the torso forward allows athletes to pull on the footstops and initiate hull acceleration as the blade is being feathered. This combined release and recovery movement is not currently popular. However, it is used by a number of athletes, and the author considers it worth noting as a variation of the release movement.

An effective release is characterized by a clean blade extraction that is quickly feathered. Section 2.9 Objective Analysis includes data on release time (2.9.4) and suggests that minimizing this time could be a performance factor.

Figure 2.1.6a

Release**Legs**

- legs remain relaxed, transitioning to pulling on the footstops

Torso

- torso remains at the layback position as the oar handle is pulled towards the body, see note below.
- the torso is supported by the core muscles, getting ready to pivot forward

Arms

- arms pull the oar handle towards the body, as the forearm pushes the oar handle downward
- wrists rotate the oar handles to feather the blade
- in sweep rowing, only the inside wrist rotates the oar handle, and the outside wrist remains flat as the forearm pushes down to raise the blade over the water

Oar

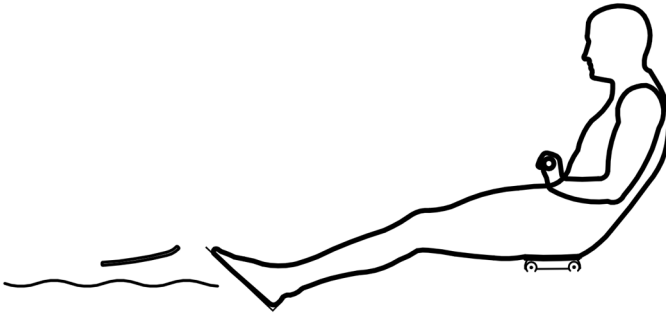
- the oar blade is typically half out of the water as it starts to rotate towards the feather position.
- blade becomes fully feathered above water or wave crest

NOTE: The author recognizes that some athletes combine the release with the beginning of the recovery by starting to pivot their torso forward during the blade release.

2.1.7 Finish Position

The finish position indicates both the end of the drive phase and the beginning of the recovery, and it is crucial for maintaining balance. The drive ends when the athlete reaches the finish position closest to the bow of the boat. Reviewing the finish position can help ensure the athlete is properly aligned as they complete the drive phase. Figure 2.1.7a, Finish Position, shows the athlete in the finish position after completing the drive, with a point-form description of the body positions provided below.

The finish position is often used as a pause drill, allowing coaches to observe and assess the athlete's placement of their arms, shoulders, head, and torso. The finish position pause can be held for up to two or three seconds, known as pause one. Alternatively, the pause can be very brief, such as a tenth of a second, called a micro-pause. The micro-pause provides athletes with a physical break between the drive and recovery and may enhance the crew's timing. Besides analyzing the athlete's physical position, the pause exercises enable the coach to compare and evaluate the positions of all athletes in the crew, ensuring they share similar finish positions.

*Figure 2.1.7a**Finish Position***Leg**

- legs are relaxed, fully extended
- legs have transitioned to pulling on footstops

Torso

- lower back is straight
- torso in the layback position,
- core muscles contracted, ready to pivot the torso
- shoulders are down and back, having just completed the release
- head up, eyesight forward and level on the horizon

Arms

- arms are relaxed
- upper arms back with elbows at or behind the torso
- lower arms level with the water surface
- hands holding the oar handle at the body
- hands are spaced at an equal distance from the centerline of the body
- sculling wrists down or sweep inside wrist only is down, holding the blade(s) in the feather position.

Oar

- the blade is above the water on the feather

2.1.8 Power Application

The body uses chemical energy and converts it into movement through muscle contraction. Power results from the work done (force x distance) and the time (quickness) of the muscle contraction. The extended drive phase (full reach to finish position), which includes the entry and release of the stroke, typically lasts between 0.75 and 0.95 seconds, and coaches focus on the power applied during this phase.

Power application, especially in sculling, has become a popular focus. Some coaches believe that maximum power should be applied at blade entry and maintained throughout the stroke. This is referred to as front-end loaded. Others believe the power should be slightly less at the entry, with increased force applied throughout the drive. This is known as back-end loaded.

Not much has changed in the last thirty years, and we refer to a nearly universal rowing technique in the Modern Orthodox Style. Slight variations in how far the athlete reaches forward with the upper body, how straight the spine is held, how much the legs compress at the catch, or how far the athlete lies back at the finish are a few of the stylistic variations currently seen.

2.1.9 Practice v. Racing

Rowing technique modifications made in practices must enhance movements required in racing that support increased boat speed. The **specificity of training principles** should guide coaching, and the biomechanics required in racing must be emphasized in practice.