VALD

FORCEFRAME
STRENGTH TESTING SYSTEM

Test Guide

Understanding common testing applications on the ForceFrame.

Contents

1 Introduction

This document aims to provide practitioners with an understanding of common testing applications on the ForceFrame.

This document assumes the reader has a basic knowledge of how to use the ForceFrame Fold or ForceFrame Max, including setting up the hardware and software, managing profiles, running tests and accessing results. To get up to speed on these processes, refer to the VALD Support Site.

1.1 What does ForceFrame Measure?

The ForceFrame measures isometric strength and asymmetry.

What is isometric strength?

There are three types of muscle contractions that produce force:

- **Concentric** (muscle **shortens** whilst producing force)
- **Eccentric** (muscle **lengthens** whilst producing force)
- **Isometric** (**no change in length** whilst producing force)

During an isometric muscle contraction, the muscle produces force and tension however there is no change in muscle fibre length. Since the muscle doesn't lengthen or shorten, the joint remains in the same position.

What is asymmetry?

Asymmetry is sometimes referred to as imbalance, or a difference in performance levels between two sides.

The ForceFrame collects force output data that can be compared for both sides and analyses the difference between them to determine asymmetry.

Types of asymmetry include:

- Bilateral asymmetry: this is the difference between the left and right limb regarding the same contraction type (e.g., Left/Right Hip Adduction)

- Within limb asymmetry: this is the difference between opposing muscle groups within the same limb (e.g., Shoulder Internal/External Rotation)

ForceFrame results can help determine areas of asymmetry and the conditions in which they present.

What are the key metrics?

ForceFrame measures the following key metrics:

- **Force** – measured in Newtons (N)
- **Impulse** – measured in Newton-Seconds (Ns)

Force is measured directly from the ForceFrame sensor pads. Load cell sensors interpret how much force is being applied to each pad per test type.

Impulse is calculated by determining the "area under the force curve". Impulse is a factor of force and time, so the longer and/or more forceful a contraction is held, the larger the impulse results will be.

Impulse = Force x Time

1.2 Why use the ForceFrame?

The ForceFrame includes testing and training functionality, that provides a controlled method to safely measure and improve isometric strength and asymmetry.

Why measure force output?

The ability to measure force output is particularly important for:

- Monitoring athletic performance;
- Reducing the risk of injury;
- Collecting objective data to strengthen clinical reasoning; and
- Engaging individuals to take ownership of their own progress.

Why measure asymmetry?

Range of motion limitations, unilateral force production deficits, or learned neuromuscular patterning (e.g., post injury changes) can all affect symmetry.

By measuring asymmetry, practitioners can monitor the role an imbalance might be playing in the physical performance and/or rehabilitation of an individual. This information can then be used to prescribe an appropriate training or exercise response.

What are the benefits of isometric testing?

Isometric testing has several benefits when used in the appropriate context.

It can be used to determine maximum force output, to inform practitioners on an individual's performance and asymmetry levels:

- Without requiring fast, ballistic movements; and
- With minimal joint range of motion.

Explosive movements like a vertical jump or plyo push up require significant power output and force absorption ability. These tests may not be advised for post-operative cases, those in the early stages of rehabilitation, or seniors.

Isometric testing also requires minimal joint range of motion, typically only what is necessary to get in position for a given test.

Removing fast contraction speeds and substantial ranges of motions can preserve joints and/or muscle tissues that are not yet ready for large rates of force development.

Isometric testing is also self-limiting, making it a very safe alternative to dynamic testing and a great option for fatigue monitoring.

Injuries often occur when the demands placed on a joint/muscle exceed its capacity.

Since isometric testing is solely dependent on an individual's own maximum output rather than dynamic forces applied at speed, it is inherently much safer.

Testing is also used to monitor fatigue, as any combination of decreased neural activation, available muscle energy, and tissue trauma (soreness) will reduce maximum force output and will register as reductions in the expected performance.

What are the benefits of isometric training?

Isometric training can improve an individual’s ability to produce and maintain force over time, leading to increased strength and numerous other benefits.

For example:

- Targeted training for a rehabilitating limb or a limb that is simply weaker, can increase the limbs’ contribution to movement and force production. This enables work to be more evenly distributed during bilateral actions (e.g., squatting, jumping) and improve unilateral performance (e.g., cutting, running); and

- Increasing maximum force output and/or reducing asymmetry can increase tissue resilience and reduce the chance of injuries induced by unbalanced workloads.

2 Test Types

This section aims to explain common ForceFrame tests types so that users can clearly understand test results.

Test Types	Description
Ankle Dorsiflexion	Unilateral/bilateral test of maximum ankle dorsiflexion force output.
Ankle Inversion / Eversion	Unilateral/bilateral test of maximum ankle inversion/eversion force output.
Elbow Extension	Unilateral/bilateral test of maximum elbow extension force output.
Elbow Flexion	Unilateral/bilateral test of maximum elbow flexion force output.
Hip Adduction/ Abduction	Unilateral/bilateral test of maximum hip adduction/abduction force output.
Hip Extension	Unilateral test for maximum hip extension force output.
Hip Flexion	Unilateral test for maximum hip flexion force output.
Hip Internal / External Rotation	Unilateral/bilateral test of maximum hip internal/external force output.
Knee Flexion	Unilateral test of maximum knee flexion force output.
Neck Extension	Sagittal test of maximum neck extension force output.
Neck Flexion	Sagittal and frontal plane test of maximum neck flexion force output.
Shoulder Adduction	Unilateral test of maximum shoulder adduction force output.
Shoulder Abduction	Unilateral test of maximum shoulder abduction force output.
Shoulder Internal / External Rotation	Unilateral test of maximum shoulder internal/external rotation force output.
Shoulder Extension	Unilateral test of maximum shoulder extension force in an overhead position.
Shoulder Flexion	Unilateral test of maximal shoulder flexion force in an overhead position.

2.1 Hip Adduction / Abduction

The Hip Adduction / Abduction is the most frequently used ForceFrame test.

The test is used to determine maximum force output of the primary hip adduction / abduction muscles and evaluate same-limb force ratios.

There are a number of test positions for Hip Adduction / Abduction:

Position	Advantages	Considerations
Seated 90º	Non-weight bearing; non-ground based; very easy and fast to test agonist and antagonist muscle groups; little setup change required for groups.	Does not produce the highest force output for the hip adduction/abduction test.
Standing (Ankle)	The position - long lever in single leg weight bearing stance, is very similar to some sport conditions like soccer; no setup change required for groups.	Difficult to maintain consistency in body position, joint angles, and movement strategies across trials; among the lowest force production values of all hip adduction/abduction tests.
Standing (Knee)	The position - medium lever in bilateral weight bearing stance, is very similar to some sport conditions like soccer; excellent substitute for those who cannot perform the ankle version due to medial/lateral knee issues; little setup change required for groups.	Difficult to maintain consistency in body position, joint angles, and movement strategies across trials; among the lowest force production values of all hip adduction/abduction tests.
All Supine Positions	Easy to transition between numerous lower and upper body tests.	Possible inconsistent testing position based on how the individual is placed; requires individuals to get down and up from the ground; some individuals will not fit comfortably on the ForceFrame platform and might need a pad or mat.
Supine 45º	Among the two highest force production positions; comfortable and intuitive for most individuals.	Requires attention to detail to ensure body position is correct; bar position, bar rotation, paddle position and foot position should be recorded.
Supine 60º	Among the two highest force production positions; comfortable and intuitive for most individuals.	

Position	Advantages	Considerations
Supine 90º	Unique open-chain position.	Might elicit core/pelvic discomfort in individuals with certain issues; awkward position requires more than just adduction/abduction muscle engagement; requires fine-tuned activation to maintain a stable/neutral posture from the same muscles being asked to fully engage.
Supine Neutral (Ankle)	Very easy to setup for the individual; longest lever supine position; no setup change required for groups.	Might elicit discomfort in individuals with knee, adduction, or pelvic issues; consistently the lowest force production values.
Supine Neutral (Knee)	Very easy to setup for the individual; no setup change required for groups.	

2.1.1 Protocols

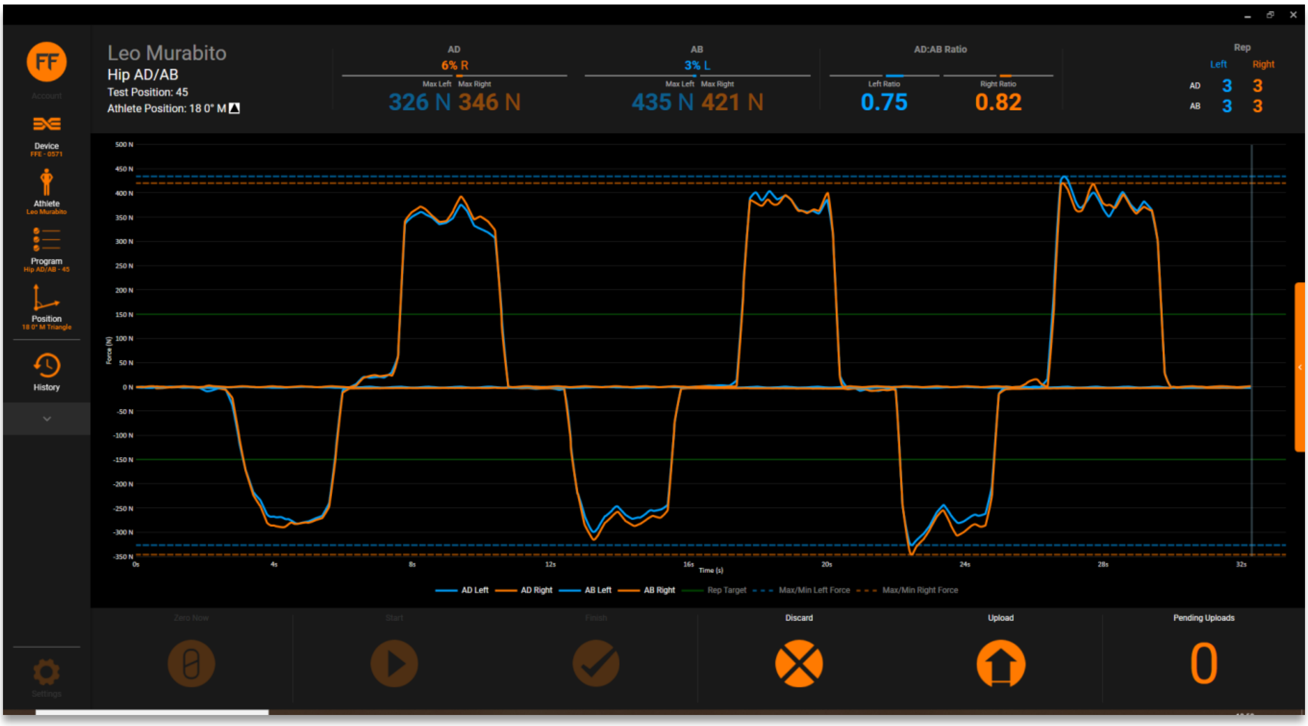
Follow the link to the VALD Support Site for the Hip Adduction / Abduction protocols.

Common Hip Adduction / Abduction protocol errors:

Position	Common Errors
Seated 90º	Failing to place the knees on the most appropriate place on the sensors (i.e., point of force application should be at the centre of the sensor); not placing the feet directly under the knees; not maintaining the thighs parallel with the ground (i.e., with feet flat the knee should be at 90˚).
Standing (Ankle) Standing (Knee)	Non consistent and/or non-neutral body positions (e.g., leaning to one side, rotating).
Supine 45º Supine 60º Supine 90º	Torso and/or foot position are different, therefore affecting knee, hip, and Q angle; sensors do not contact the knees at the optimum position, resulting in inaccurate readings.
Supine Neutral (Ankle) Supine Neutral (Knee)	Not controlling/neutralising hip internal/external rotation.

2.1.2 Results

Example of force trace and metrics for Hip Adduction / Abduction, Supine 45º:



2.2 Ankle Dorsiflexion

The Ankle Dorsiflexion test is used to:

- Determine maximum force production balance across the ankle joint;
- Determine severity of shin splints/anterior compartment syndrome; and
- Help in rehab of shin splints/anterior compartment syndrome.

The Ankle Dorsiflexion test is performed in a seated position:

Position	Advantages	Considerations
Seated	Fixed seated position reduces variance; unilateral/bilateral options; single joint test makes results analysis easier; little to no setup changes required for groups.	Highly specialised test with lower relevance to large or diverse groups - when compared to other tests like hip adduction/abduction.

2.2.1 Protocol

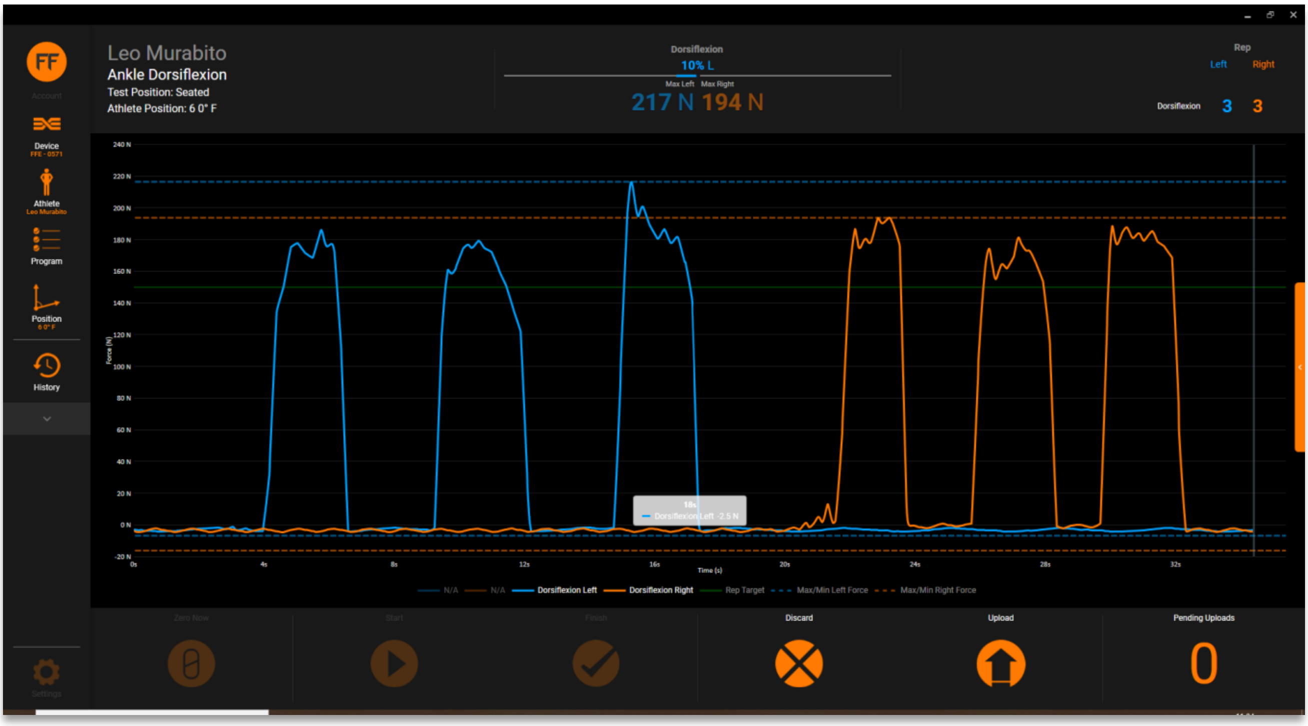
Follow the link to the VALD Support Site for the Ankle Dorsiflexion protocol.

Common Ankle Dorsiflexion protocol errors:

Position	Common Errors
Seated	Changing the point of sensor contact and/or footwear used will alter torque mechanics, therefore affecting force results. For example: • Tip of the foot vs close to the ankle • Barefoot vs with large heel running shoes

2.2.2 Results

Example of force trace and metrics for Ankle Dorsiflexion:



2.3 Ankle Inversion / Eversion

The Ankle Inversion / Eversion test is used for inversion/eversion ratio analysis to identify joint asymmetries. This will help with stratifying severity of acute or chronic ankle sprain issues.

The Ankle Inversion / Eversion test is performed in a supine position:

Position	Advantages	Considerations
Supine	Well-suited for a common injury mechanism (e.g., ankle sprains); little to no setup changes required for groups.	Awkward test setup may require familiarisation from both tester and individual; reliability may be lower compared to other tests.

2.3.1 Protocol

Follow the link to the VALD Support Site for the Ankle Inversion / Eversion protocol.

Common Ankle Inversion / Eversion protocol errors:

Position	Common Errors
Supine	Allowing the individual to use hip adduction/abduction to apply force; re-testing at various muscle lengths (i.e., different degrees of inversion/eversion).

2.3.2 Results

Example of force trace and metrics for Ankle Inversion / Eversion:

2.4 Elbow Extension

The Elbow Extension test is used to determine maximum force output and other characteristics of the primary elbow extensor muscles.

The Elbow Extension test is performed in a seated position:

Position	Advantages	Considerations
Seated	Can be used as a secondary test for shoulder injuries since this test requires upper body stability - this test can be used to elicit reactions in the affected shoulder; little to no setup changes required for groups; fast to change to shoulder flexion; great for throwing athletes and/or upper body injuries.	Highly specialised test with lower relevance to larger applications.

2.4.1 Protocol

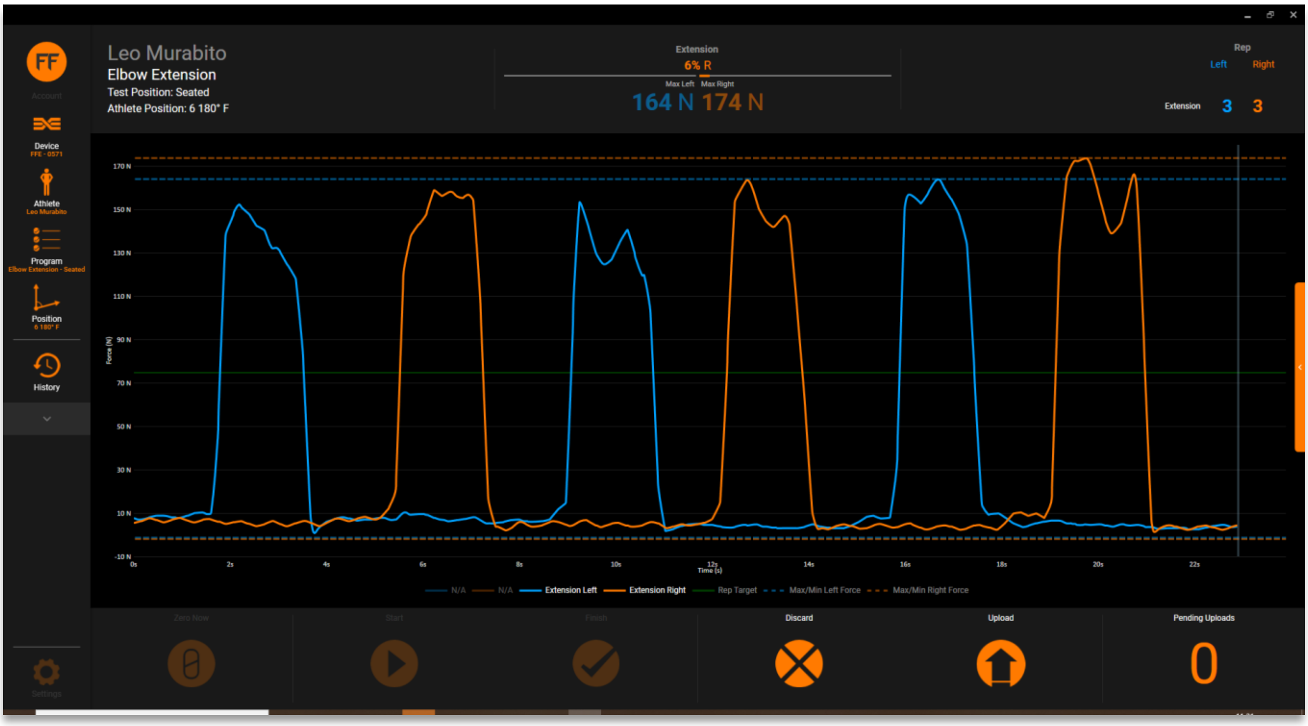
Follow the link to the VALD Support Site for the Elbow Extension protocol.

Common Elbow Extension protocol errors:

Position	Common Errors
Seated	Testing position can be easily varied (e.g., shoulder inversion/eversion, adduction/abduction, flexion/extension, protraction/retraction can all alter mechanics and results).

2.4.2 Results

Example of force trace and metrics for Elbow Extension:



2.5 Elbow Flexion

The Elbow Flexion test is used to determine maximum force output and other characteristics of the primary elbow flexor muscles and secondary shoulder flexor muscles.

The Elbow Flexion test is performed in a seated position:

Position	Advantages	Considerations
Seated	Can be used as a secondary test for shoulder injuries since some elbow flexors cross both the elbow and shoulder joints - these may elicit symptoms during the test; little to no setup changes required for groups; fast to change to elbow extension; great for throwing athletes and/or upper body injuries.	Highly specialised test with lower relevance to larger applications; relies on postural stability as a weak core or back may compromise results.

2.5.1 Protocol

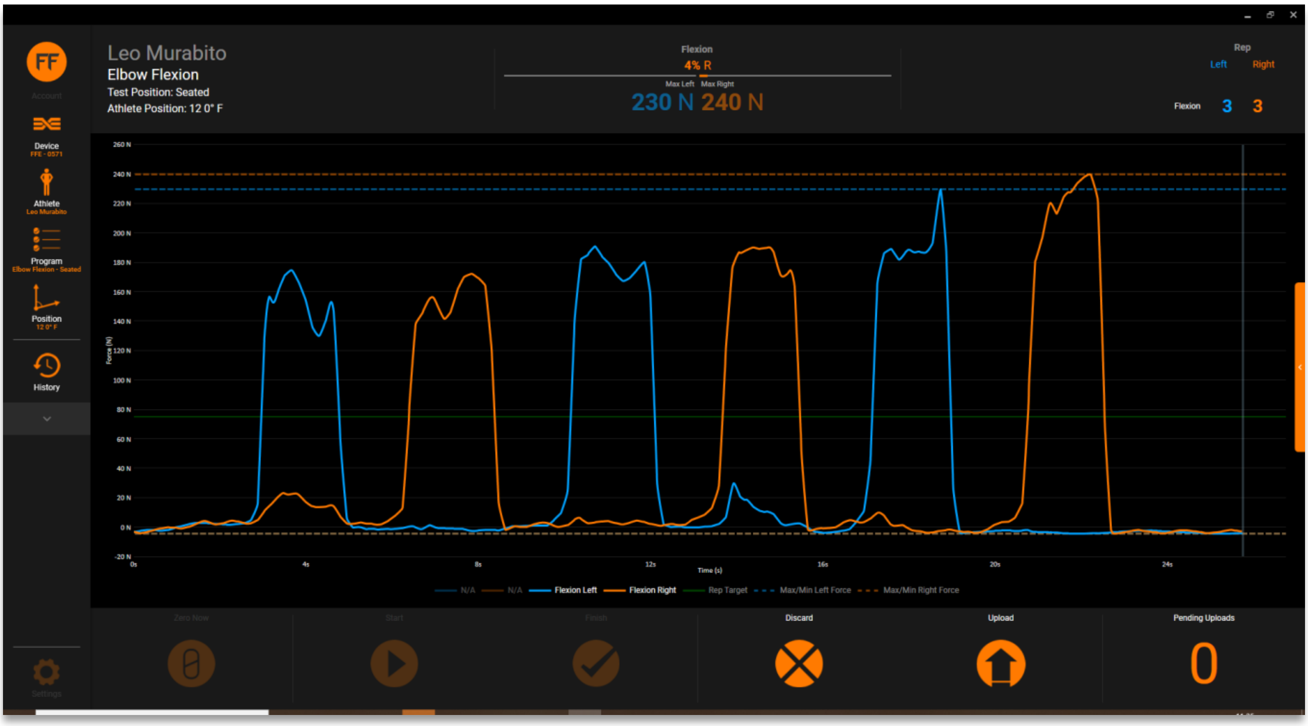
Follow the link to the VALD Support Site for the Elbow Flexion protocol.

Common Elbow Flexion protocol errors:

Position	Common Errors
Seated	Testing position can be easily varied (e.g., shoulder internal/external rotation, adduction/abduction, extension/flexion, protraction/retraction can all alter mechanics and results).

2.5.2 Results

Example of force trace and metrics for Elbow Flexion:



2.6 Hip Extension

The Hip Extension test is performed in a prone or standing position:

- Prone - used to determine hip extension force output at the longest lever arm possible without involving other joints (behind and just above the knee).
- Standing – used to determine maximum hip extension force output in an upright, contralateral load bearing position.

Position	Advantages	Considerations
Prone	Isolates hip extension; quick to set up.	Hip extension range of motion is very low (roughly 15-20° from neutral) and individuals might not be familiar with active engagement in this narrow range; does not differentiate between hamstring and glute contribution.
Standing	Leverages spinal extension/flexion reflex (i.e., one leg flexion and the other extension) to partly replicate walking/running; no setup change required for groups.	If the individual straightens the knee to create a ridged leg for testing, that will inhibit the hamstring - a secondary hip extension that many people use as a primary. Alternatively, the individual might bend the knee to press into the sensor more, thus asking the hamstring to flexion and extension simultaneously; cramps, reduced force, and/or losing the individual's belief in the test may occur; force production is limited by the contralateral flexion force (i.e., if the left hip flexion is injured the right hip extension will be very low.

2.6.1 Protocols

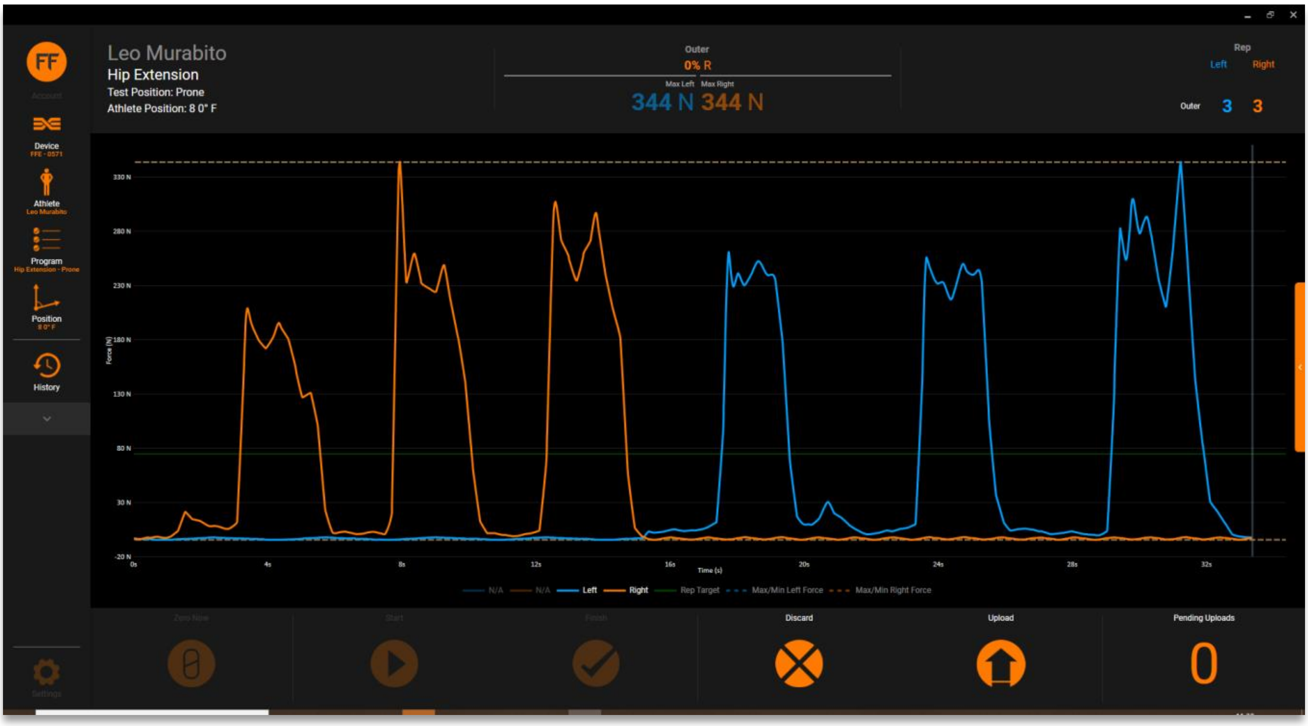
Follow the link to the VALD Support Site for the Hip Extension protocols.

Common Hip Extension protocol errors:

Position	Common Errors
Prone	Placing the sensor below the knee joint, therefore including knee flexion into the test (a possible limiting factor).
Standing	Refer to the test Considerations listed above

2.6.2 Results

Example of force trace and metrics for Hip Extension, Prone:



2.7 Hip Flexion

Hip Flexion tests are used to determine maximum hip flexion force output in a number of different positions:

- Kicker – an upright, contralateral load bearing position.
- Prone – a ground based, non-load bearing position.
- Seated – a seated, non-load bearing position.
- Standing – an upright, contralateral load bearing position.

Position	Advantages	Considerations
Kicker	Very specific hip and knee orientation; ideal position for kicking sports.	Inexperienced individuals may not be sure if they should extend the knee and/or flex the hip - a leak or weakness in either will limit the result.
Prone	Non-weight bearing; requires quad engagement.	Might be incredibly easy for some individuals, essentially turning the test into an elevated plank - since the torso is not restricted from rising upward.
Seated	A short lever, near end range of motion.	Highly specific since support musculature is minimally active (e.g., pelvic, core) and it approaches end range of motion.
Standing	Weight bearing; requires quad engagement.	Narrow base of support requires greater proprioceptor ability; large hip flexion forces require opposite limb stability; significant ankle dorsiflexion force is required; bar position will affect starting hip flexion angle and results.
Supine	Non-weight bearing short lever, near end range of motion.	Strong individuals might pull themselves downward without proper torso fixation.

2.7.1 Protocols

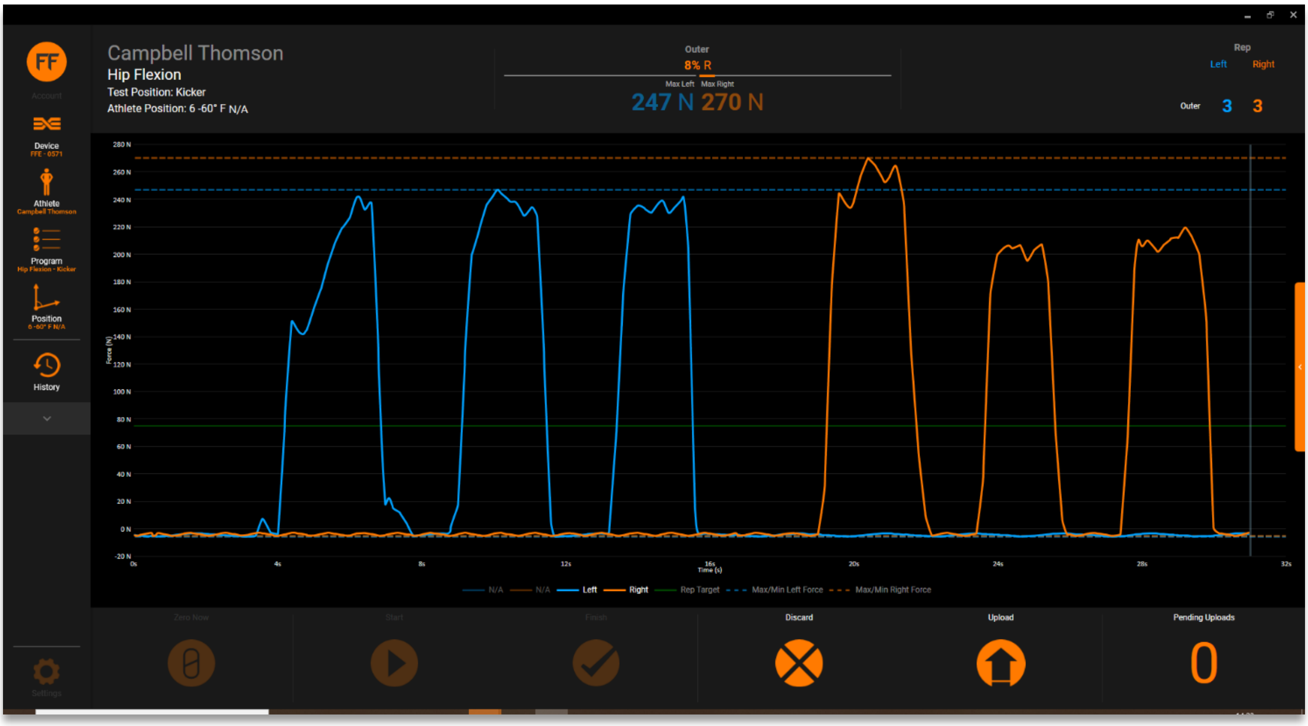
Follow the link to the VALD Support Site for the Hip Flexion protocols.

Common Hip Flexion protocol errors:

Position	Common Errors
Kicker	Changing the point of sensor contact and/or body position will affect results.
Prone	Changing torso orientation will affect results (e.g., rotation, hips rising).
Seated	Changing the point of sensor contact and/or degree of hip flexion, by leaning downward or backward will affect results.
Standing	Individual may attempt to pull on the ForceFrame cross bar for balance and reciprocal force production for stability.
Supine	Movement of the body at test initiation.

2.7.2 Results

Example of force trace and metrics for Hip Flexion, Kicker:



2.8 Hip Internal / External Rotation

The Hip Internal / External Rotation test is used for internal/external ratio analysis to identify joint asymmetries.

The Hip Internal / External Rotation test is performed in a prone or supine position.

Position	Advantages	Considerations
Prone	ForceFrame platform supports proper rotation - the individual cannot easily pass into hip adduction/abduction or flexion/extension.	Unilateral tests allow for more body movement and thus reduced confidence in results.
Supine	Good option for advanced individuals to challenge their core control whilst also producing hip internal/external rotation - results can be compared to prone position to determine deficit.	Very awkward test position for many individuals since they must balance core control, restrict hip adduction/abduction and flexion/extension, and minimising arm involvement.

2.8.1 Protocols

Follow the link to the VALD Support Site for the Hip Internal / External Rotation protocols.

Common Hip Internal / External Rotation protocol errors:

Position	Common Errors
Prone	Keeping a consistent Q angle; individual may try adduction/abduction due to force sensors being medial/lateral to the limbs.
Supine	Refer to test Considerations listed above.

2.8.2 Results

Example of force trace and metrics for Hip Internal / External Rotation, Prone:

2.9 Knee Flexion

Knee Flexion tests are used to determine maximum knee flexion force output in a number of different positions:

- Prone – in a ground based, non-load bearing position.
- Standing – in an upright, contralateral load bearing position.
- Supine – in a reclined, non-load bearing position.

Position	Advantages	Considerations
Prone	Holds the hip and leg (thigh) into place and allows only knee flexion.	Strong individuals might pull themselves downward without proper torso fixation.
Standing	Isolates knee flexion; relatively quick setup; easy testing protocol.	Individuals with a weak core and/or pelvic musculature will struggle to maintain an upright posture.
Supine	Holds the hip and leg (thigh) into place and allows only knee flexion.	Strong individuals might pull themselves off the ground if they engage their primary hip extension (glutes).

2.9.1 Protocols

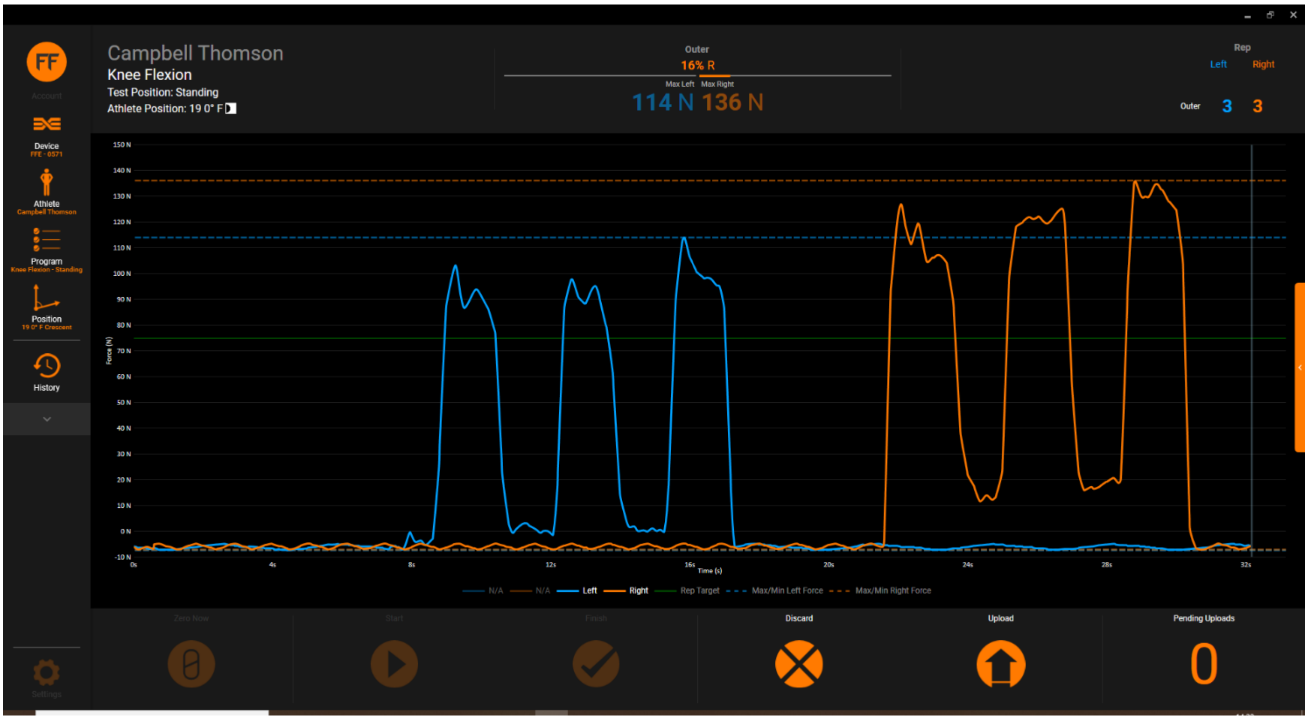
Follow the link to the VALD Support Site for the Knee Flexion Protocols.

Common Knee Flexion protocol errors:

Position	Common Errors
Prone	Keeping a consistent Q angle; engaging the glutes.
Standing	Keeping a consistent Q angle.
Supine	Keeping a consistent Q angle; engaging the glutes.

2.9.2 Results

Example of force trace and metrics for Knee Flexion, Standing:



2.10 Neck Extension

The Neck Extension test is used to determine maximum neck extension force output in a quadruped position.

Position	Advantages	Considerations
Quadruped	Can be used as a secondary test for shoulder issues; cervical spine incorporates numerous related muscles and movements.	Sagittal test - Neck flexion/extension ratio should be taken with caution since one is gravity assisted (flexion) and the other gravity resisted (extension).

2.10.1 Protocol

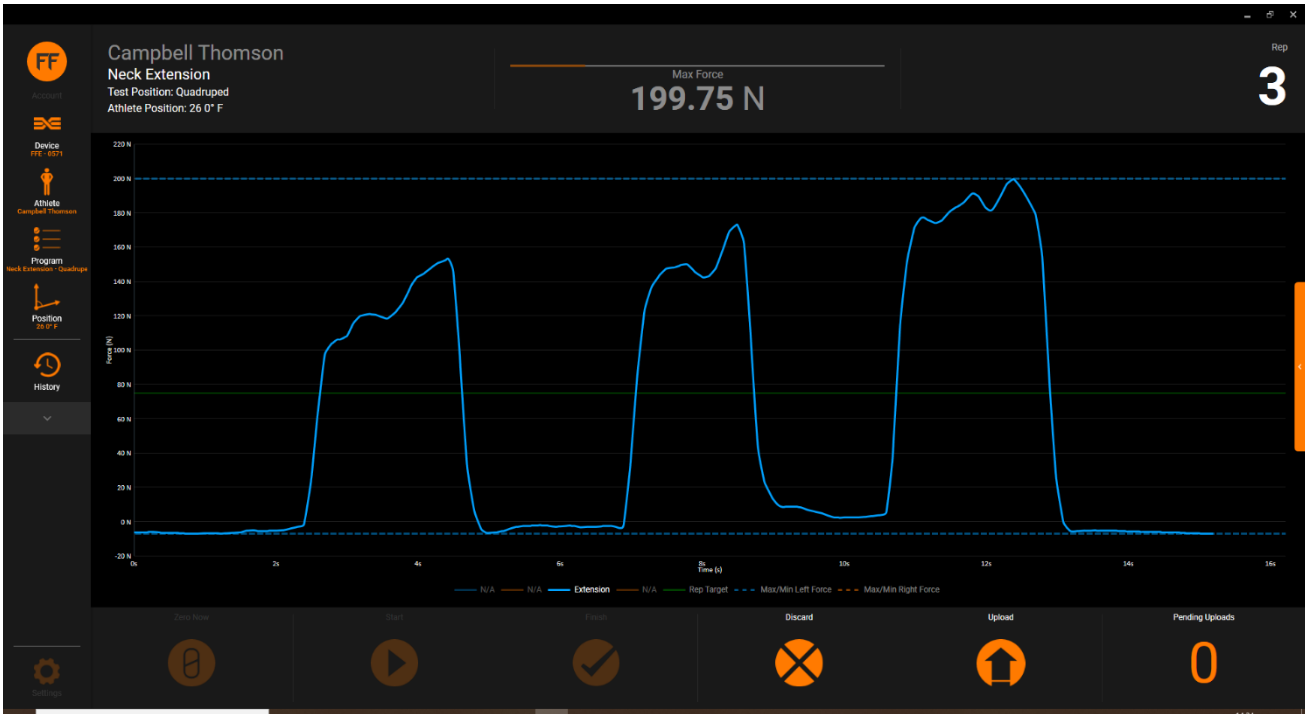
Follow the link to the VALD Support Site for the Neck Extension protocol.

Common Neck Extension protocol errors:

Position	Common Errors
Quadruped	Inconsistent sensor position on the back of the head will increase variance; further away from the base of the neck creates a longer lever arm and various head shapes and/or hair styles may interfere with consistency if not accounted for.

2.10.2 Results

Example of force trace and metrics for Neck Extension:



2.1 Neck Flexion

The Neck Flexion test is used to determine maximum neck flexion force output in a quadruped position.

Position	Advantages	Considerations
Quadruped	Can be used as a secondary test for shoulder issues; cervical spine incorporates numerous related muscles and movements.	Sagittal test - neck flexion/extension ratio should be taken with caution since one is gravity assisted (flexion) and the other gravity resisted (extension).

2.1.1 Protocol

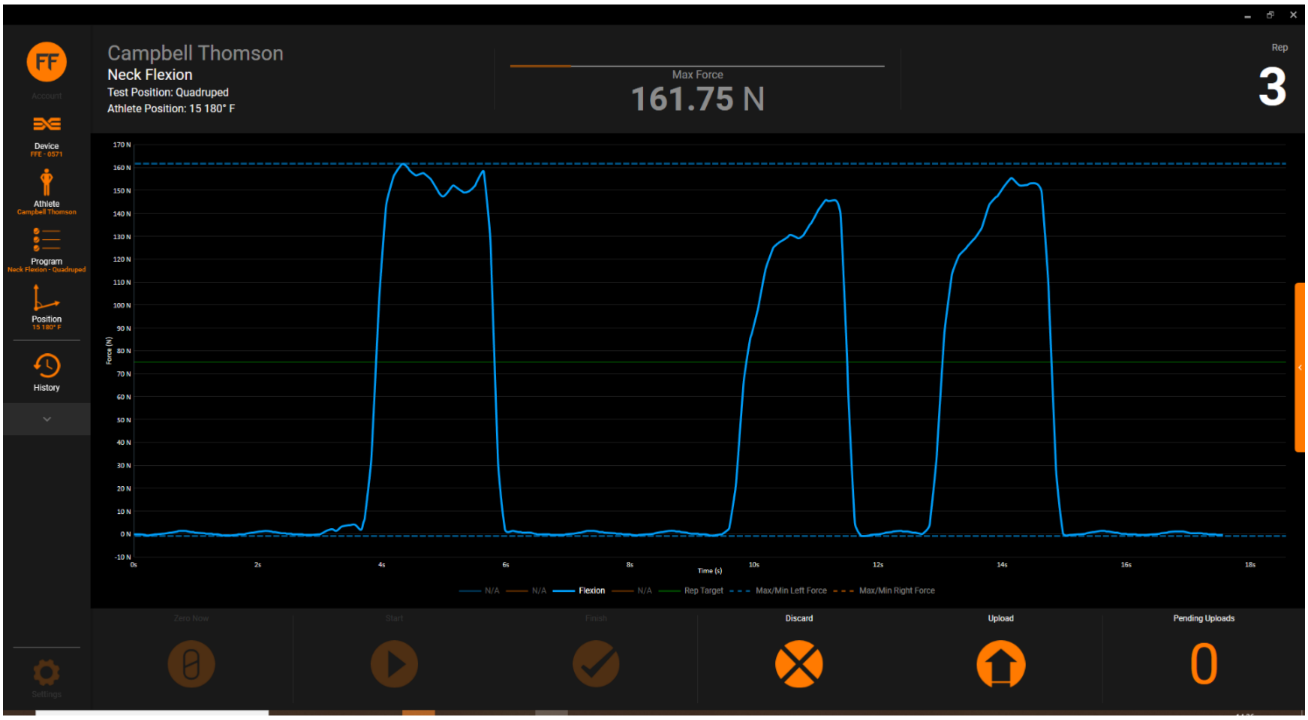
Follow the link to the VALD Support Site for the Neck Flexion protocol.

Common Neck Flexion protocol errors:

Position	Common Errors
Quadruped	Allowing shoulders to protract or retract will change cervical spine dynamics and affect results.

2.1.2 Results

Example of force trace and metrics for Neck Flexion:



2.2 Shoulder Adduction

The Shoulder Adduction test is used to determine maximum shoulder adduction force output in a side lying position.

Position	Pros	Considerations
Side Lying	Individual cannot brace with the torso or opposite leg - therefore it is a pure shoulder force test.	Sensor position is critical to maintain consistent lever arm for retests; individual must get on/off the ground.

2.2.1 Protocol

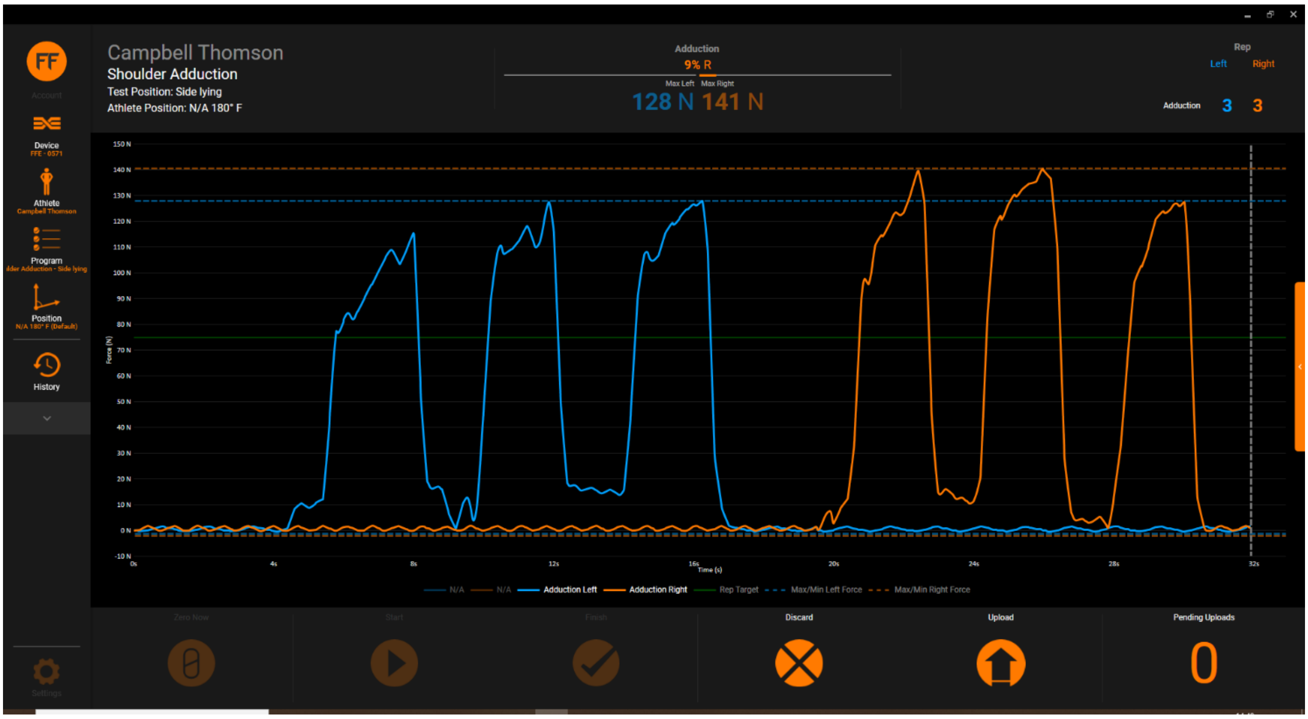
Follow the link to the VALD Support Site for the [Shoulder Adduction test](#).

Common Shoulder Adduction protocol errors:

Position	Common Errors
Side Lying	Incorrect sensor placement; rotating the torso to increase torque or leverage the body.

2.2.2 Results

Example of force trace and metrics for Shoulder Adduction:



2.3 Shoulder Abduction

The Shoulder Abduction test is used to determine maximum shoulder abduction force output in a side lying position.

Position	Pros	Considerations
Side Lying	Individual cannot brace with the torso or opposite leg - therefore it is a pure shoulder movement test.	Sensor position is critical to maintain consistent lever arm for retests; individual must get on/off the ground.

2.3.1 Protocol

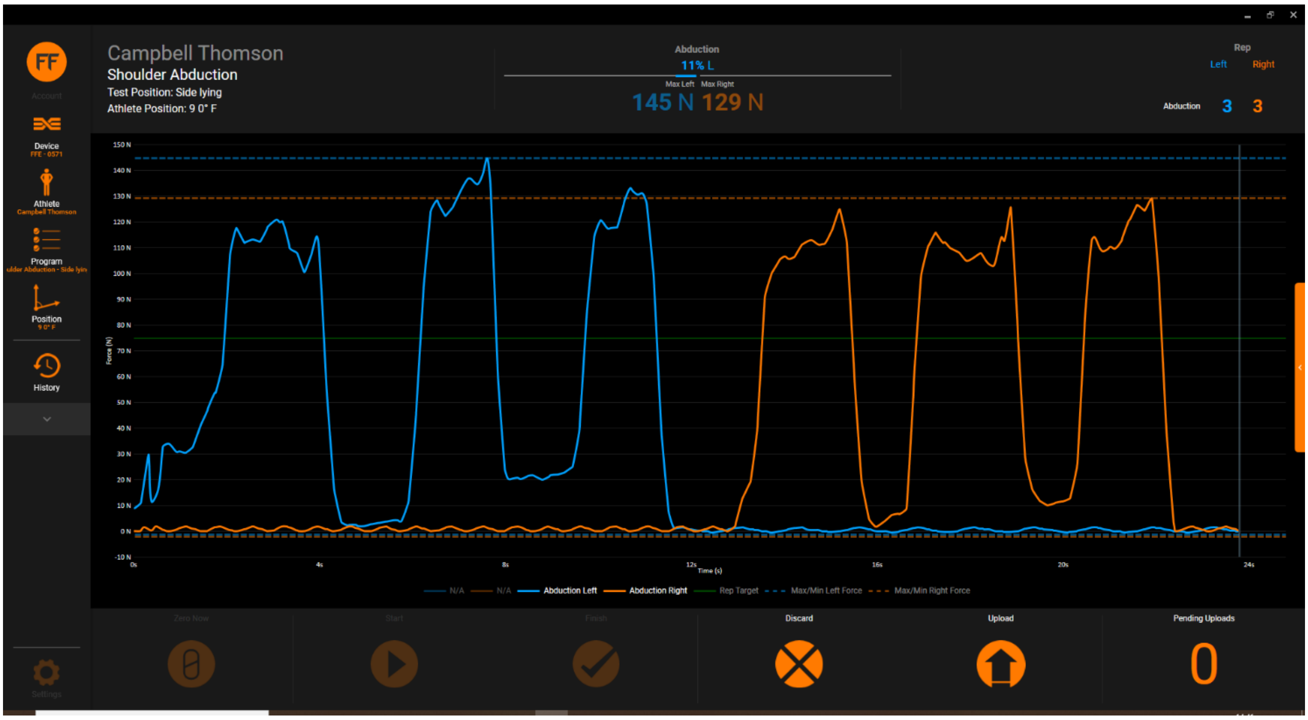
Follow the link to the VALD Support Site for the Shoulder Abduction protocol.

Common Shoulder Abduction protocol errors:

Position	Common Errors
Side Lying	Incorrect sensor placement; rotating the torso to increase torque or leverage the body.

2.3.2 Results

Example of force trace and metrics for Shoulder Abduction:



2.1 Shoulder Internal / External Rotation

The Shoulder Internal / External Rotation test is used for internal/external ratio analysis to joint asymmetries.

The Shoulder Internal / External Rotation test is performed in a prone or supine position.

Position	Pros	Considerations
Supine 90º	The ForceFrame shoulder mount improves reliability; tests shoulder in an abduction/vulnerable position.	Unwanted shoulder movement can affect validity; individual must get on/off the ground.
Supine Neutral	The ForceFrame shoulder mount improves reliability; tests shoulder in a neutral and supported position.	Unwanted shoulder movement can affect validity; individual must get on/off the ground.

2.1.1 Protocols

Follow the link to the VALD Support Site for the Shoulder Internal / External Rotation protocols.

Common Shoulder Internal / External Rotation protocol errors:

Position	Common Errors
Supine 90º	Improper and/or inconsistent hand placement on the sensors; possible for an individual to apply force through shoulder adduction rather than internal rotation or abduction rather than external rotation.

2.1.2 Results

Example of force trace and metrics for Shoulder Internal / External Rotation, Supine 90º:

2.2 Shoulder Extension

The Shoulder Extension test is used to determine shoulder extension force output in an overhead position.

Position	Advantages	Considerations
Prone	The prone position reduces the ability to rotate the torso; better isolates shoulder extensors.	The individual must get on/off the ground.

2.2.1 Protocol

Follow the link to the VALD Support Site for the Shoulder Extension protocol.

Common Shoulder Extension protocol errors:

Position	Common Errors
Prone	Placing the sensor on the hand can underestimate results since wrist flexion/extension force may act as a limiting factor.

2.2.2 Results

Example of force trace and metrics for Shoulder Extension:

2.3 Shoulder Flexion

The Shoulder Flexion test is used to determine maximum shoulder flexion force output in an overhead position.

Position	Advantages	Considerations
Prone	Laying in a prone position removes the individual's ability to rotate torso therefor better isolating the shoulder flexors.	The individual must get on/off the ground.

2.3.1 Protocol

Follow the link to the VALD Support Site for the Shoulder Flexion protocol.

Common Shoulder Flexion protocol errors:

Position	Common Errors
Prone	Placing the sensor on the hand can underestimate results since wrist flexion/extension force may act as a limiting factor.

2.3.2 Results

Example of force trace and metrics for Shoulder Flexion: