



*** Final Report ***
GAIT ANALYSIS REPORT
 Motion & Gait Analysis Lab

Patient Name: Max Conserva
Stanford/LPCH MRN: 2545892
Date of Birth: 2/2/1981
Date of Service: 7/31/2013
Referring Physician: Stuart Goodman, M.D.

Identification: Mr. Conserva is a 32 year old male with a history of (R) lower extremity trauma when he was hit by a truck at age 8. He is referred for a gait evaluation to assist with treatment management. Mr. Conserva's past medical history includes numerous surgeries and skin grafts, including a (R) posterior tibial tendon transfer for foot drop, a (L) epiphysiodesis, and a (R) limb lengthening. He is a community ambulator with the use of a (R) KAFO until 6 months ago, when he started using an AFO for community mobility, and the KAFO only for tennis, snowboarding, and other sports. Mr. Conserva reports pain in the (R) gluteal area when using the AFO for community ambulation compared to no pain with the KAFO, and (R) knee pain with running greater than 5 miles.

Physical Exam:

Range of Motion

| | | Degree R | Degree L |
|---------------------------|----------------------------------|-----------------|-----------------|
| Ankle | Dorsiflexion (Knee flexed) | 5 PF / 0 | 15 / 15 |
| | Plantar flexion | 40 | 30 |
| Foot | Full foot Pronation / Supination | 0 / 30 | 20 / 40 |
| | Hindfoot Eversion / Inversion | 0 / 20 | 10 / 0 |
| Knee | Flexion / Extension | 90 / 0 | 140 / 0 |
| | Popliteal Angle | 0 | 40 |
| | Straight Leg Raise | 90 | 60 |
| Hip | Flexion / Extension | 100 / 0 | 115 / 0 |
| | Internal Rotation | 75 | 45 |
| | External Rotation | 35 | 55 |
| | Adduction / Abduction | 35 / 40 | 30 / 40 |
| Thigh Foot Axis | | 35 ER | 10 ER |
| Malleolar Angle | | 40 ER | 20 ER |
| Forefoot Adduction | | 25 | NT |

Muscle Strength (scale: 0-5)

| | | R | L |
|--------------------------|--------------------|--------------|---------------|
| Hip | Flexion: Extension | 5 : 5 | 5 : 5 |
| | Abduction | 5 | 5 |
| Knee | Flexion: Extension | 5 : 4 | 5 : 5 |
| Ankle | DF: PF | 5 : 2 | 5 : 5 |
| Rectus Test | | NT | NT |
| Clonus Test | | NT | NT |
| Pain (0-10 scale) | | Pre-test = 0 | Post-test = 0 |

Leg length: There is a 2.5 cm leg length discrepancy in the distal segment (R)>(L).
 Measured supine: ASIS to knee joint line = 54 cm (R); 54 cm (L)
 ASIS to medial malleolus = 95 cm (R); 90 cm (L)

Observational Gait Analysis

Barefoot:

There is a reciprocal arm swing, bilaterally. There is a (L) lateral and forward trunk lean during (R) stance. The pelvis is in a posture of slight (R) downward pelvic obliquity, and rotation to the (R).

Both hips extend adequately in terminal stance to progress the thighs to a trailing position. The (R) hip is slightly adducted and internally rotates during stance.

At initial contact, the (L) knee is flexed and the (R) knee is extended. The (R) knee remains extended in stance. The (L) knee flexes in loading response, then extends in stance but remains slightly flexed. The (R) knee is in valgus in stance. Peak knee flexion occurs in initial swing with reduced magnitude on the (R).

At initial contact, the (L) ankle is dorsiflexed and the (R) ankle is plantar flexed. Peak dorsiflexion is in terminal stance, bilaterally, with reduced magnitude on the (R). The (R) ankle fails to achieve dorsiflexion in swing.

Initial contact is with a flat foot (R) and with the heel (L). There is a heel-to-toe progression on the (L) with heel rise in terminal stance. Heel rise on the (R) is in preswing. In stance, the (R) foot is in varus, and the (L) foot is in valgus. The foot progression angle is neutral, bilaterally. There is sufficient foot clearance in swing, bilaterally.

With (R) AFO + shoe lift:

There is less pelvic obliquity compared to barefoot walking.

The (L) knee is extended at initial contact. After increased flexion in loading response, the (L) knee extends fully in stance. He demonstrates a heel-to-toe gait pattern on the (R) with heel rise in terminal stance. There are no other functionally significant changes in his gait pattern compared to barefoot walking.

With (R) KAFO + shoe lift:

There is less (L) trunk lean and less forward lean during (R) stance compared to AFO. There is greater (R) hip extension in terminal stance compared to walking with the AFO. He has an increased stride length with the KAFO compared to the AFO.

There are no other functionally significant changes in his observed gait pattern compared to walking with the AFO.

Kinematics & Kinetics: Barefoot, Typical Walk

Trunk/Pelvis: The trunk is held upright with a slight tilt to the (L) throughout the gait cycle. The pelvis is level and positioned WNL for A-P tilt, but has a fixed 10 degree external rotation to the (R).

Hip: At initial contact, the hips are flexed 25 degrees (R) and 43 (L). In pre-swing, the hips extend to WNL degrees of extension. There is increased adduction (R) and abduction (L) during stance.

The hip extensor moment during stance is reduced.

The hip abductor moment is reduced during stance on the (L) and increased on the (R).

Knee: At initial contact, the knee is flexed 5 degrees (R) and 23 (L) and extends to WNL on the (L) The (R) knee fails to extend during stance. Peak knee flexion during swing is 44 degrees (R) and 60 (L).

The knee extension moment is increased on the (L) and decreased on the (R).

There is an increased knee valgus moment.

Ankle: At initial contact, the ankle is plantarflexed 7 degrees on the (R) and dorsiflexed 7 degrees on the (L). Peak dorsiflexion during stance is 5 degrees (R) and 20 degrees (L) and occurs during terminal stance, bilaterally. The (R) ankle remains plantarflexed throughout swing. The foot progression angle is externally rotated 10 degrees (R) and 5 degrees (L).

The ankle plantar flexor moment is reduced in terminal stance on the (R).
The ankle plantar flexor moment exhibits a slight “double bump” pattern.

Hamstring Analyses

A biomechanical analysis of medial hamstrings’ length and lengthening velocity during gait reveal that the hamstrings are short and lengthen with reduced velocity in swing on the (R), the (L) hamstrings are WNL.

With (R) AFO + shoe lift compared to barefoot:

There is reduced pelvic obliquity and anterior tilt. There is increased hip extension in terminal stance, bilaterally. The (L) knee extension at initial contact and in stance is WNL. Peak (R) knee flexion in swing is increased. There is reduced (L) ankle dorsiflexion during stance. The timing and magnitude of the (R) peak ankle PF moment are slightly improved. The (L) knee sagittal plane moments are normalized.

With (R) KAFO compared to (R) AFO:

Trunk obliquity and forward (anterior) tilt are improved. The pelvis is less rotated to the (L). The (R) hip extension is increased in terminal stance. The (R) ankle is held in dorsiflexion to 0 degrees in swing. The hip frontal and sagittal plane moments are normalized. The (R) knee valgus moment is changed to a varus moment, and there is an increased knee flexor moment. The timing and magnitude of the peak ankle plantar flexor moment is normalized.

Temporal/Spatial Parameters:

% Normal

| | Barefoot | (R) AFO | (R) KAFO |
|-----------------|----------|---------|----------|
| Velocity | 79 | 88 | 90 |
| Cadence | 111 | 111 | 108 |
| Stride Length | 71 | 79 | 83 |
| (R) step length | 91 | 95 | 98 |
| (L) step length | 76 | 89 | 95 |

Dynamic EMG: Dynamic EMGs were recorded with surface electrodes during barefoot gait.

Walking with (R) shoe only:

%Gait Cycle:

| | R | L | NORMAL |
|--------------------|-------------|-------------|---------------------|
| Stance | 63 | 70 | 62 |
| Swing | 37 | 30 | 38 |
| Gluteus Maximus | 0-48,94-100 | NT | 0-10, 96-100 |
| Gluteus Medius | 0-48 | NT | 0-40, 96-100 |
| Rectus Femoris | Absent | NT | 0-12, 48-70, 93-100 |
| Lateral Quadriceps | NT | 0-13,95-100 | 0-24, 89-100 |
| Medial Quadriceps | Absent | NT | 0-24, 89-100 |
| Medial Hamstrings | 0-12,95-100 | 60-66 | 0-10, 80-100 |
| Gastrocnemius | Absent | 14-56 | 9-50 |
| Tibialis Anterior | Continuous | NT | 0-13, 56-100 |

With (R) shoe only:

The stance-swing ratio is within normal limits (R) and greater than normal (L). The (R) gluteus maximus has prolonged activity in stance; the (R) gluteus medius activity in stance is WNL. The (R) medial hamstrings have a delayed onset in terminal swing with normal cessation in early stance. The (R) tibialis

anterior has continuous activity during gait. The (R) rectus femoris, medial quadriceps, and gastrocnemius have no clinically significant activity during gait. The (L) lateral quadriceps, and gastrocnemius activity is WNL. The (L) medial hamstring activity is limited to a brief burst in preswing.

With (R) AFO and (R) shoe:

The (R) gluteus maximus is active from terminal swing to 40% of the gait cycle. The (R) gluteus medius timing is WNL: from terminal swing continuing to 48% of the gait cycle. The (R) medial hamstrings continue to nearly toe off (58% gait cycle.) The (R) gastrocnemius has a brief burst of activity in loading response. The (R) tibialis anterior onset is in midstance and continues to terminal swing. The (L) lateral quadriceps, and gastrocnemius activity is WNL. The (L) medial hamstrings have no clinically significant activity during gait.

With (R) KAFO and (R) shoe:

The (R) gluteus maximus is active from initial contact to 15% of the gait cycle. The (R) gluteus medius is active from 2-25%. The (R) rectus femoris has a brief burst of activity in preswing from 52-60% of the gait cycle. The (R) medial quadriceps has out-of-phase activity from 20-38% of the gait cycle. The (R) tibialis anterior has nearly continuous activity: from 17-98% of the gait cycle. [The (R) medial hamstrings and (R) gastrocnemius data were not recorded due to interference from the KAFO.] The (L) lateral quadriceps activity is WNL. The (L) gastrocnemius has a premature onset at initial contact and continues to toe-off. The (L) medial hamstrings have no clinically significant activity during gait.

Dynamic Plantar Pressures during walking:

With (R) shoe only:

RIGHT: Initial contact is with the heel, immediately progressing to 5th metatarsal contact then 1st metatarsal in loading response. There is no great toe contact. Heel rise is in terminal stance.

LEFT: Initial contact is with the heel, progressing to 5th metatarsal contact in loading response, then 1st metatarsal and great toe contact in single limb stance. Heel rise is in terminal stance.

With (R) AFO and shoe:

RIGHT: Similar pattern to (R) shoe only with the addition of great toe contact in preswing.

LEFT: No change from (R) shoe only pattern.

With (R) KAFO and shoe:

RIGHT: Contact pattern is similar to that with the AFO, but with a longer duration of heel only contact prior to forefoot contact.

LEFT: No change from (R) shoe only pattern.

Summary:

The EMG, kinematic, and kinetic data show improved gait mechanics with the KAFO compared to the AFO, or walking without an orthosis.

- Compared to barefoot walking, the (R) shoe lift with the AFO and KAFO improves the (L) knee position in stance from increased flexion, which is compensatory for the short (R) leg, and normalizes the pelvic obliquity.
- The gluteus maximus activity is significantly prolonged in stance while walking with and without the AFO. With the KAFO, the gluteus maximus timing is normalized.
- With or without the AFO, the gluteus medius timing is only slightly prolonged compared to normal. With the KAFO, the both the duration and magnitude of the gluteus medius are reduced reflecting the normalized hip kinetics with the KAFO: The (R) hip abductor moment is reduced and normalized with the KAFO compared to the AFO or barefoot walking. The (R) hip sagittal plane moment is normalized with the KAFO. The hip moments are similar with the AFO and barefoot.

- Compared to barefoot, the (R) AFO improves hip extension in terminal stance, and peak knee flexion in swing. The (R) hip extension is further improved with the KAFO, creating the longest stride length of the three conditions tested.
- The knee moment is shifted from a valgus moment to a varus moment with the KAFO. The sagittal plane knee moment remains a flexor moment throughout the gait cycle in all three conditions consistent with weak quadriceps.
- The KAFO holds the ankle in DF in swing better than AFO.
- The AFO slightly improves the magnitude of ankle plantar flexor moment in late stance, but there is greater improvement with the KAFO indicating the body weight progresses further over the forefoot which contributes to an increased step length on the (L).
- The temporal-spatial data are improved with the AFO compared to barefoot, and improved with the KAFO compared to the AFO.

Recommendations: The following recommendations are based on the results of the gait evaluation and information available at the time of this assessment.

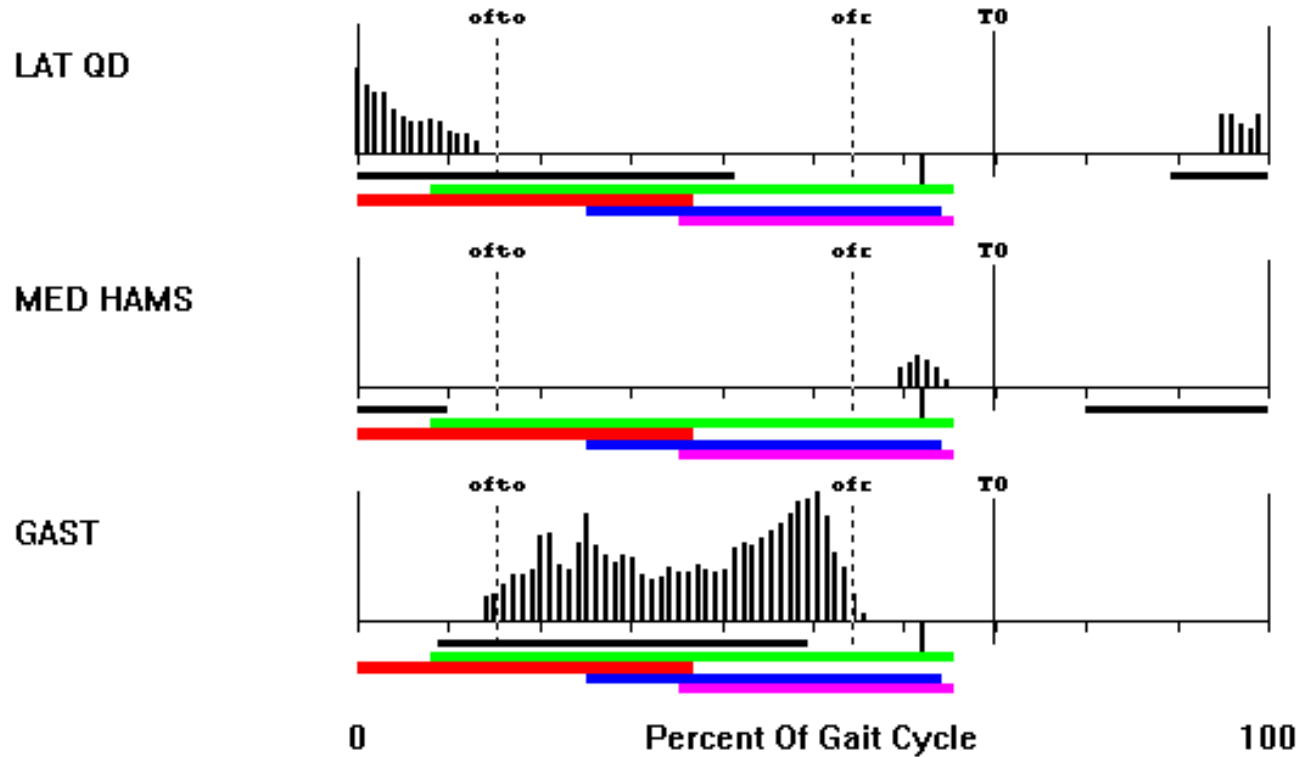
The EMG data demonstrate clearly increased activity of the (R) gluteus maximus and medius with the (R) shoe only and with the AFO compared to walking with the KAFO, possibly explaining the patient's reports of gluteal pain with the AFO. The clinical exam and kinematics show notable valgus of the (R) knee and varus of the (R) ankle. It is conceivable that the abductors are working to abduct the femur to compensate for the valgus of the knee that is not controlled with the AFO as it is with the KAFO. Reviewing the long leg xrays, there is a deficit of the lateral condyle of the femur. The data support continued use of a KAFO, which should be re-evaluated by an Orthotist in order to protect the knee, provide support the for limb, and maintain his current function.

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CC: Patient
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Gary Berke, MS, CP, FAAOP
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LEFT

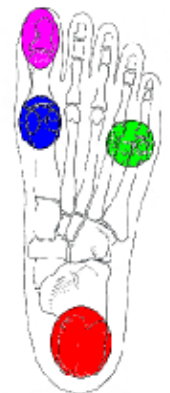
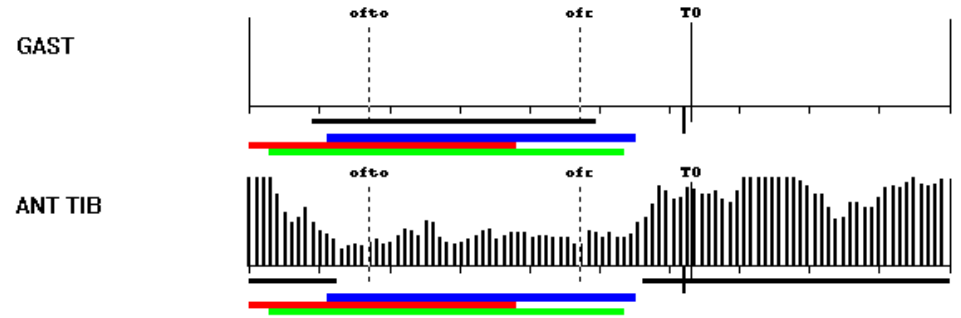
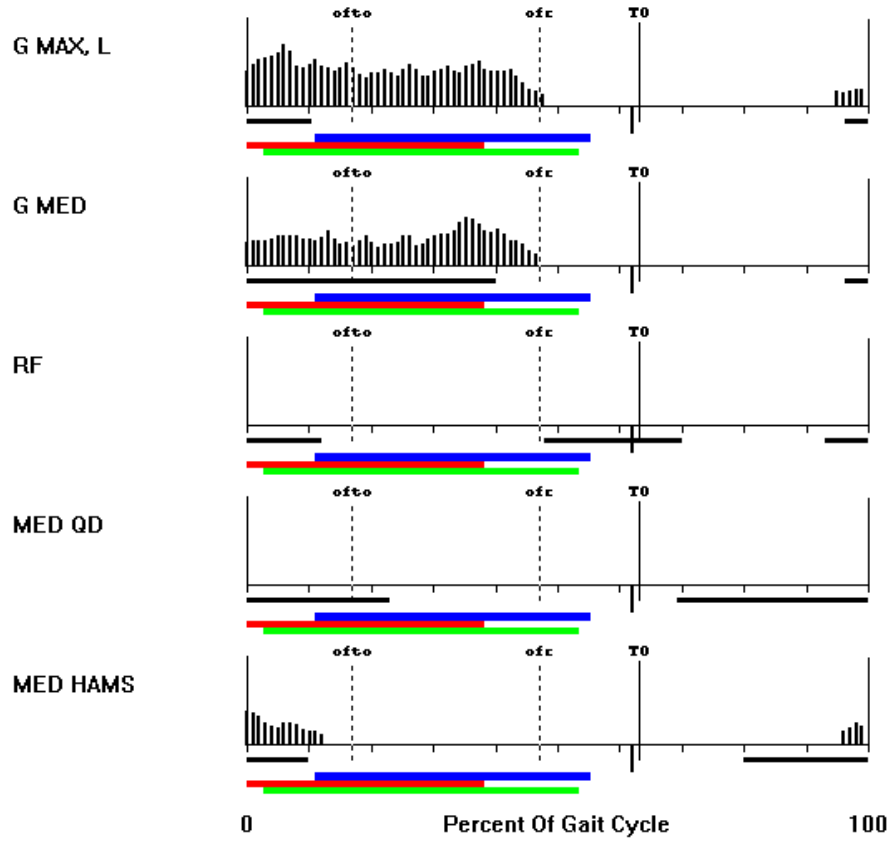
Foot Contact Pattern

— Normal Timing



Normal Contact Pattern





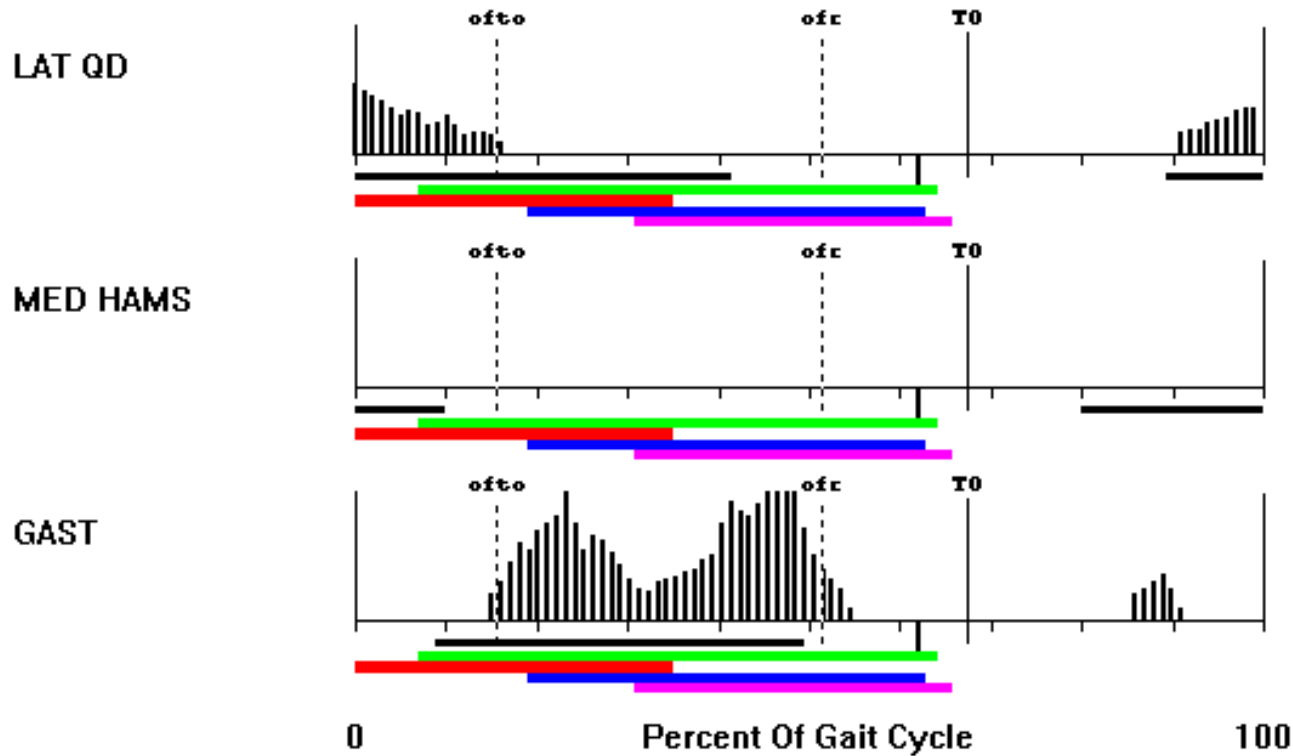
RIGHT
Foot Contact Pattern

— Normal Timing



Normal Contact Pattern





LEFT

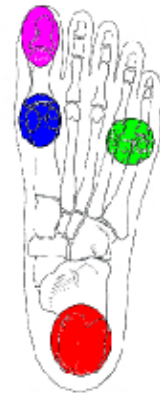
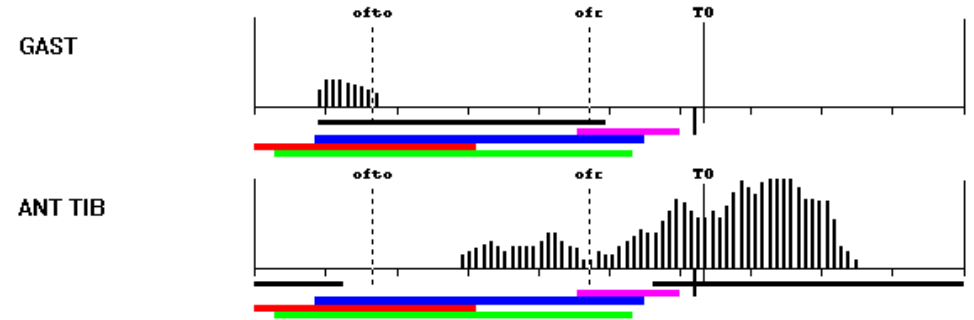
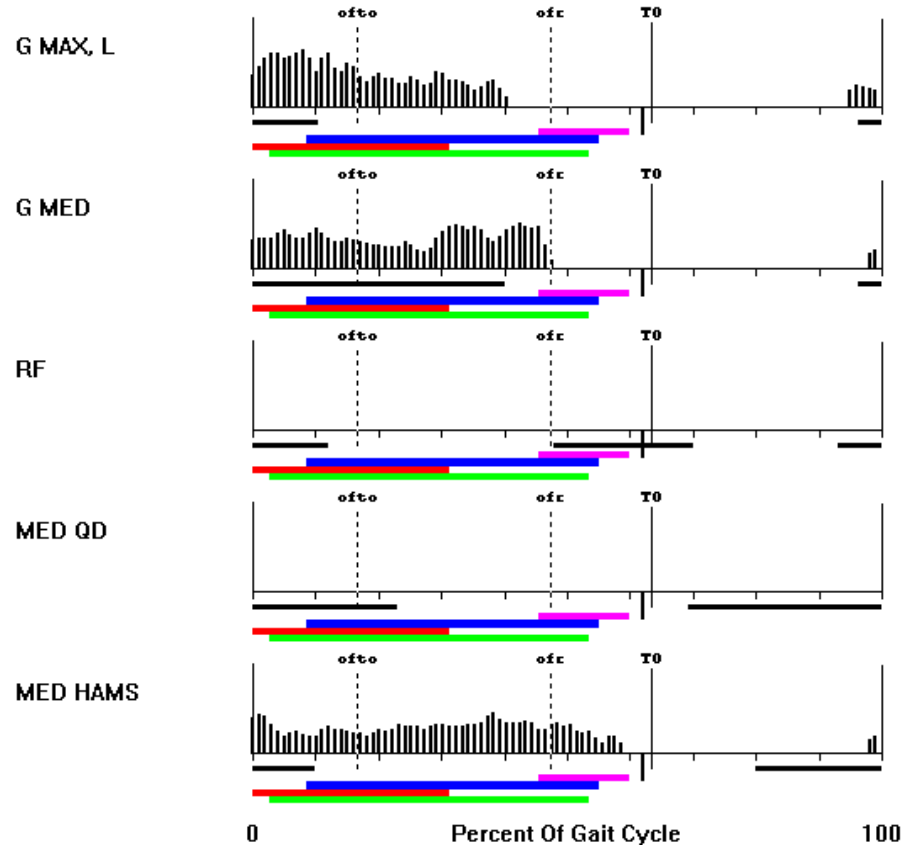
Foot Contact Pattern

— Normal Timing



Normal Contact Pattern





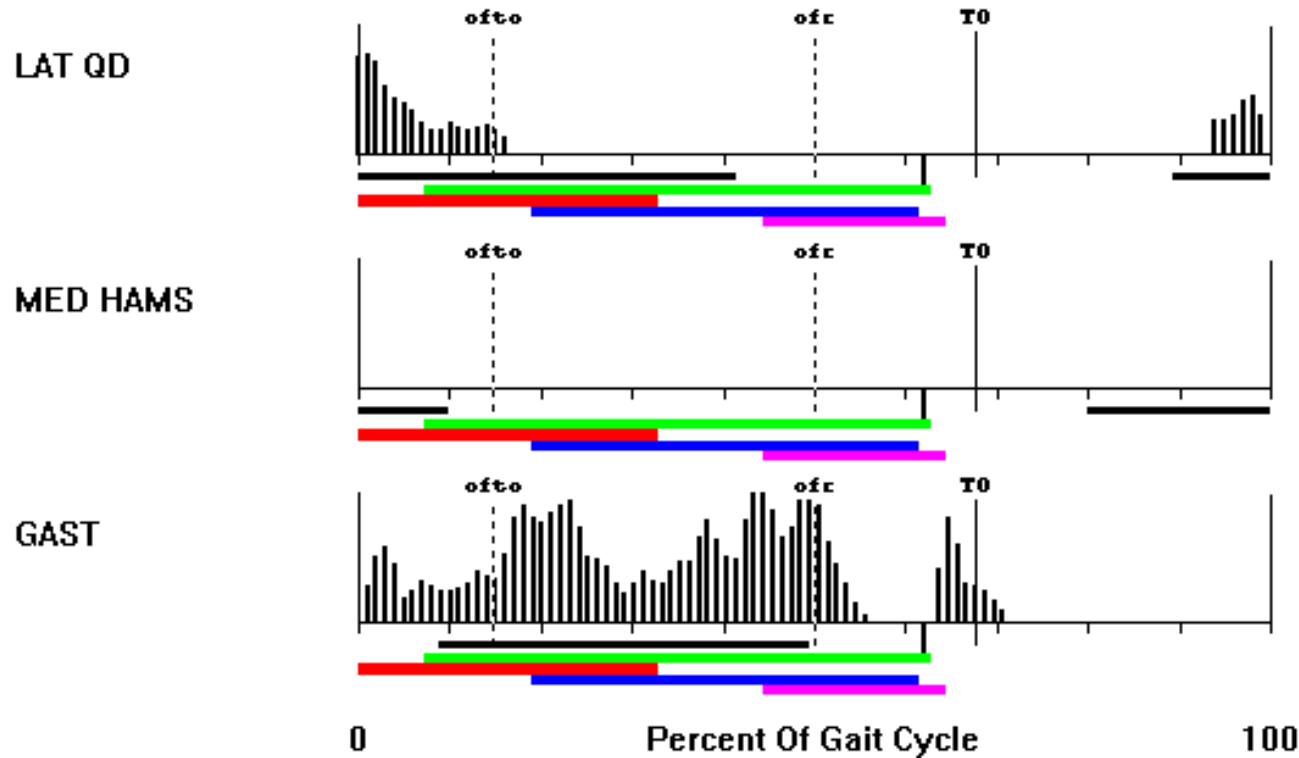
RIGHT
Foot Contact Pattern

— Normal Timing



Normal Contact Pattern





LEFT

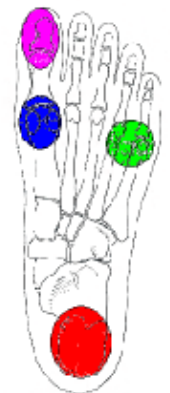
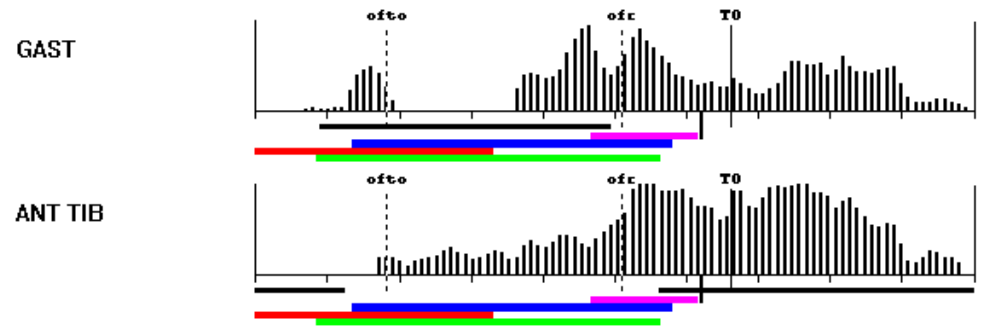
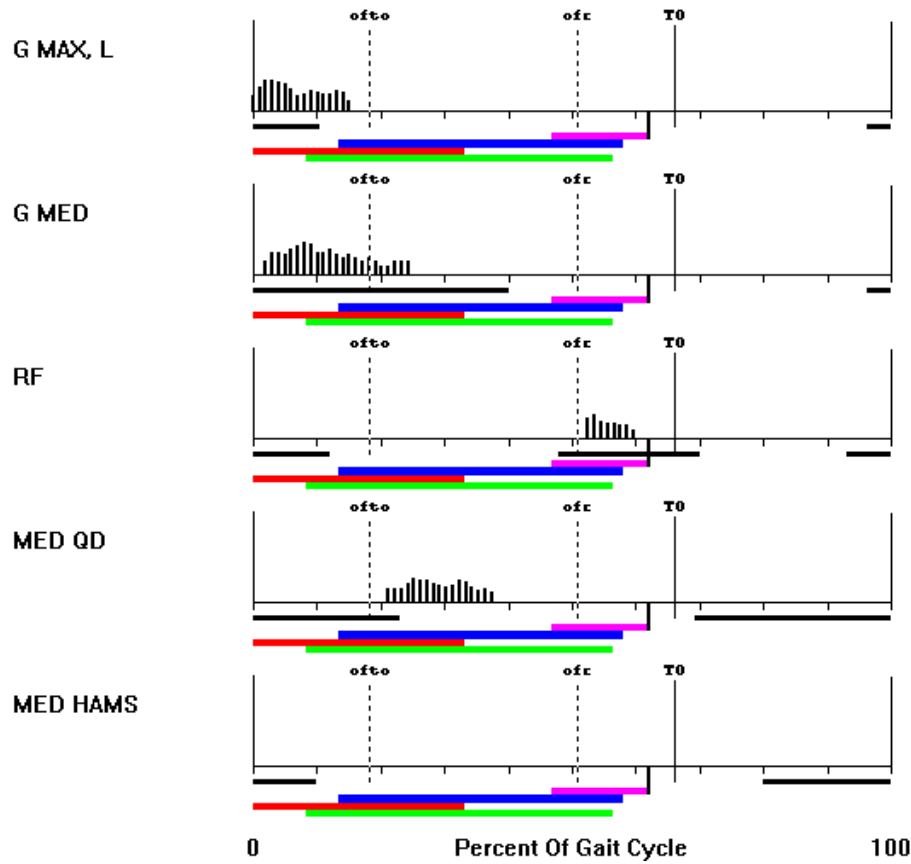
Foot Contact Pattern

— Normal Timing



Normal Contact Pattern





RIGHT
 Foot Contact Pattern

— Normal Timing

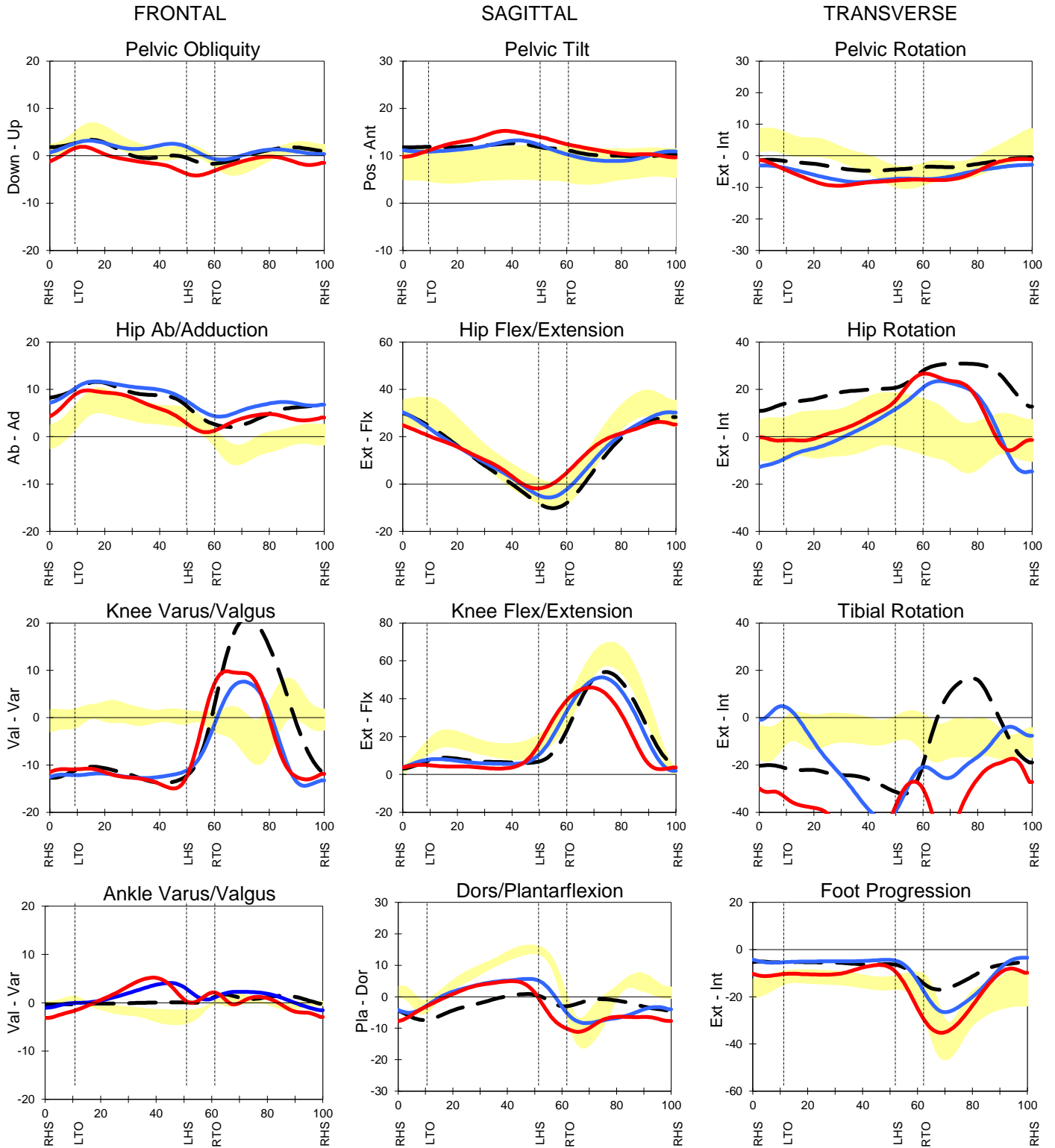


Normal Contact Pattern

RIGHT KINEMATICS

Name: Max Conserva
 Condition1: — Barefoot
 Condition2: — Shoes and AFO
 Condition3: - - - Shoes and KAFO

Patient Number: 2545892-8
 Strides: 12
 Date: 7/31/2013
 Age: 32.0
 Examiner: LPCH Motion & Gait Lab

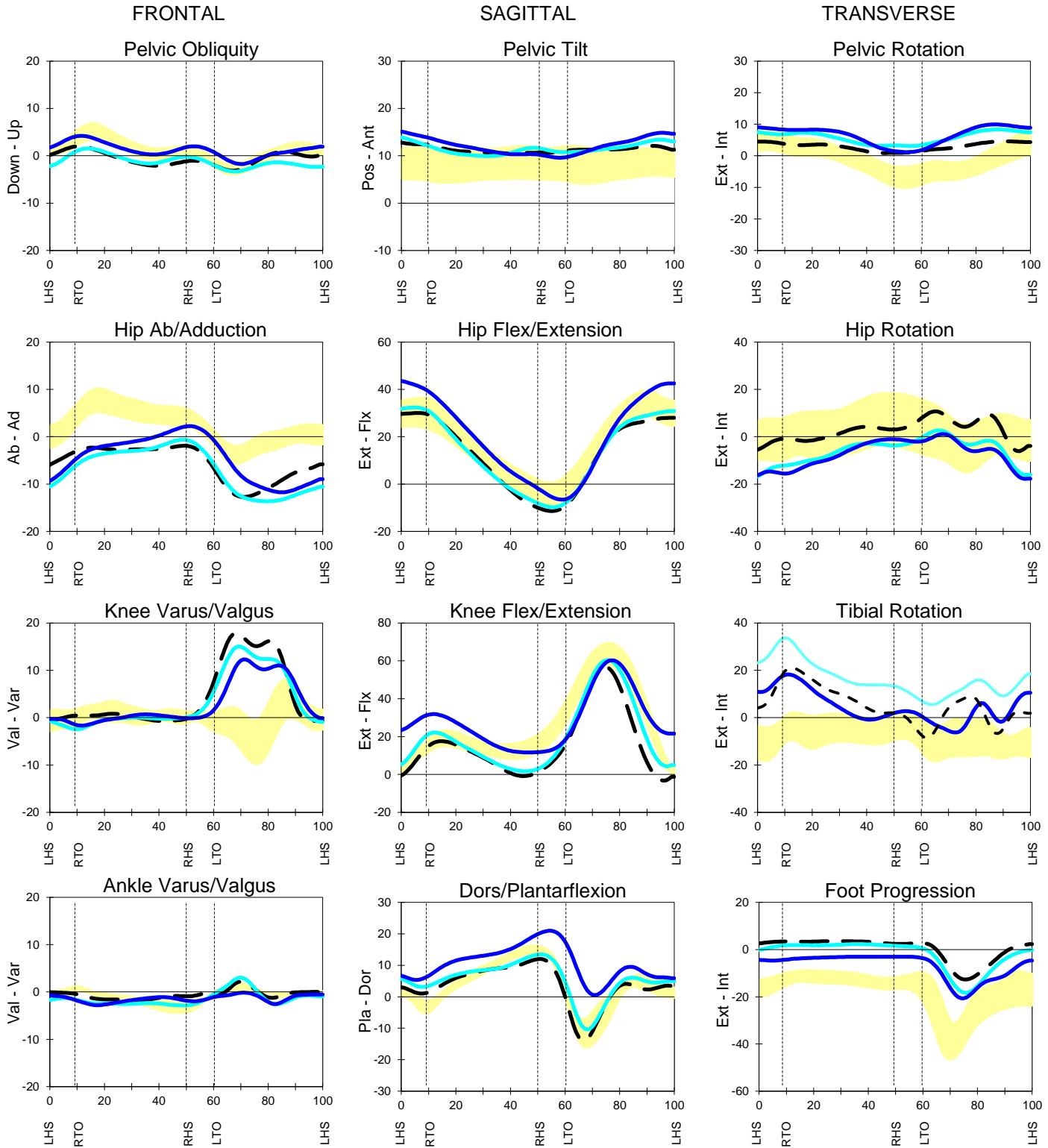


LEFT KINEMATICS

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 Condition1: Barefoot
 Condition2: Shoes and AFO
 Condition3: Shoes and KAFO

Patient Number: 2545892-8
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 Examiner: LPCH Motion & Gait Lab

Date: 7/31/2013
 Age: 32.0

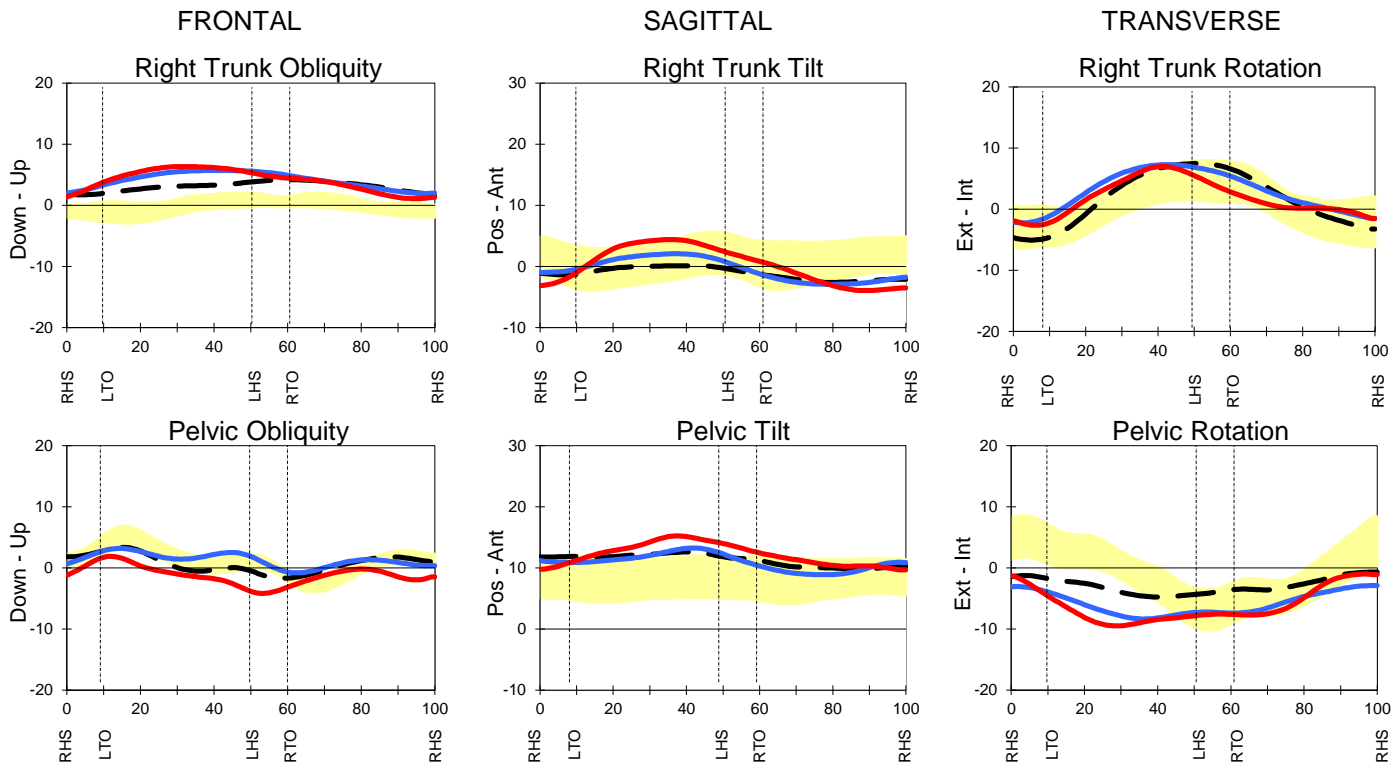


TRUNK & PELVIS

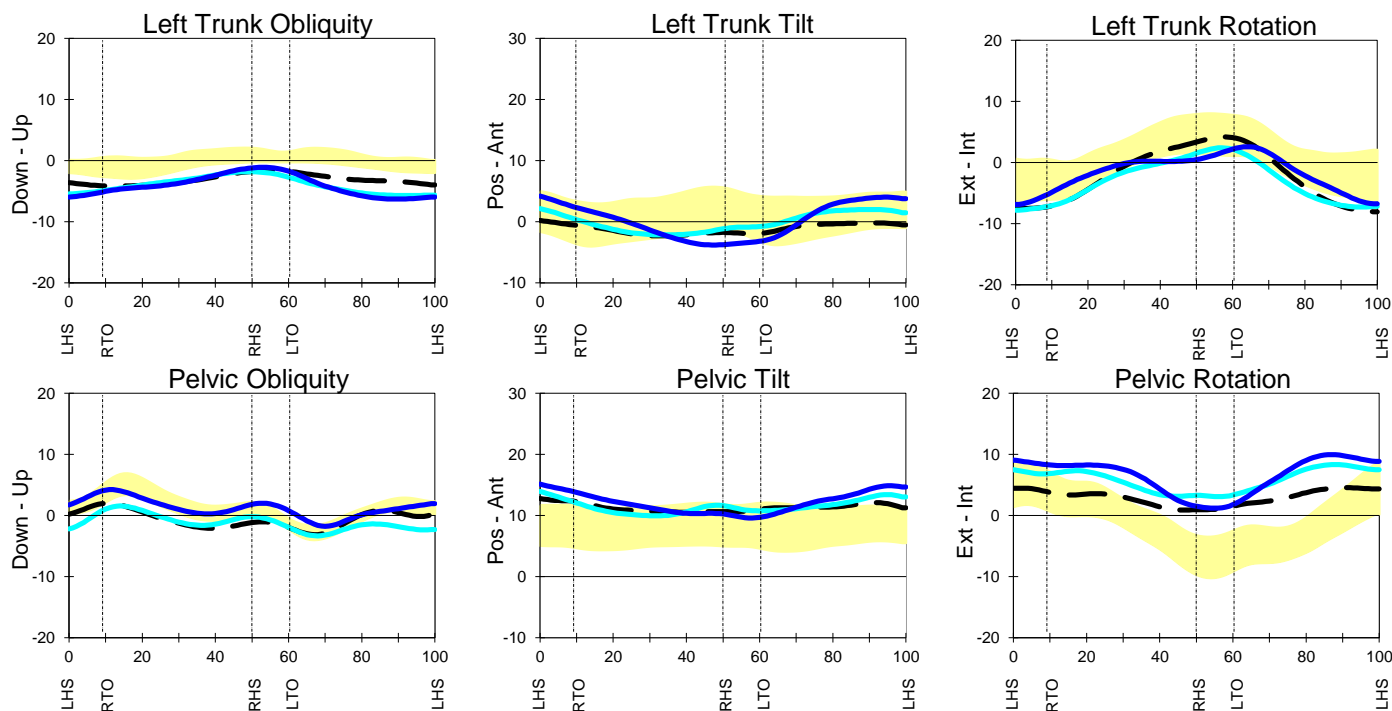
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Contents: Condition1 — Condition2 — Condition3 - - -

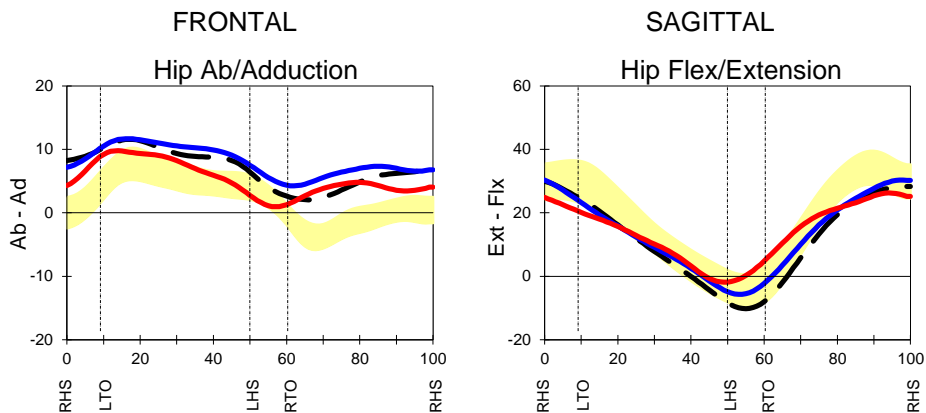


RIGHT HIP KINETICS

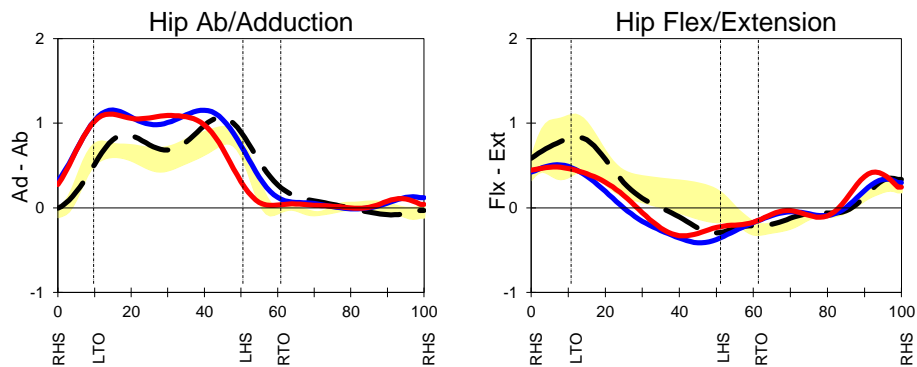
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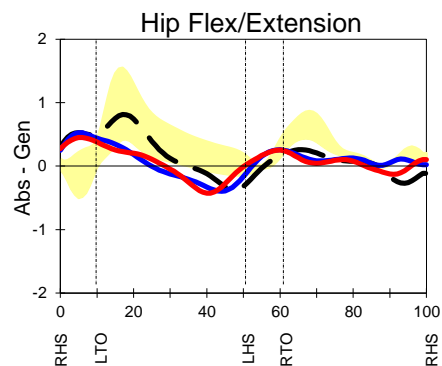
Kinematics



Moments (Nm/kg)



Powers (Watts/kg)



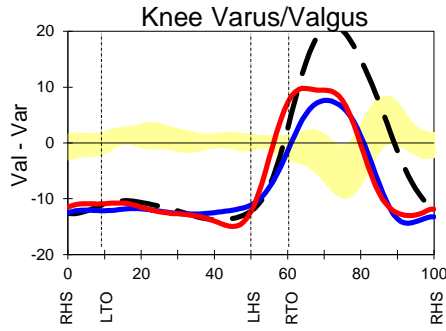
RIGHT KNEE KINETICS

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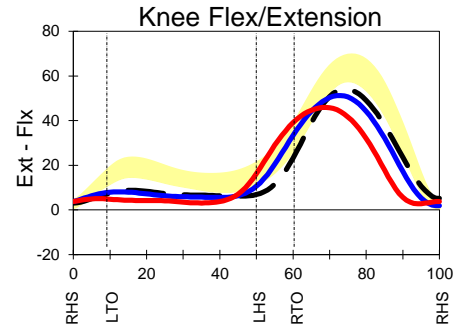
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Kinematics

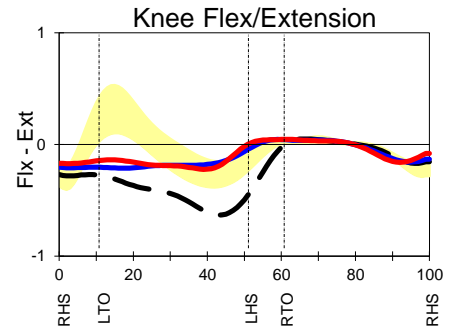
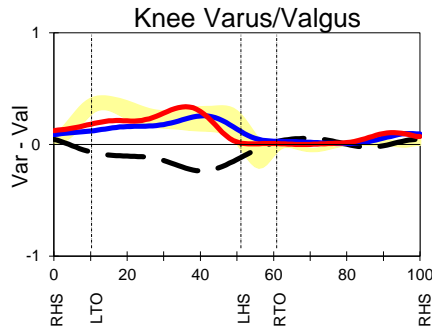
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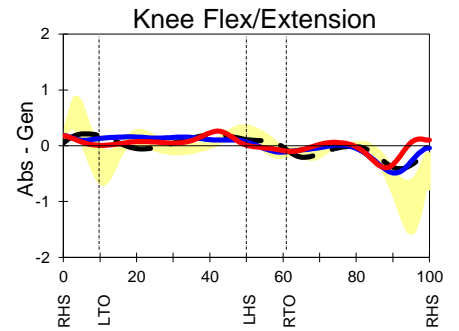
SAGITTAL



Moments (Nm/kg)



Powers (Watts/kg)



RIGHT ANKLE KINETICS

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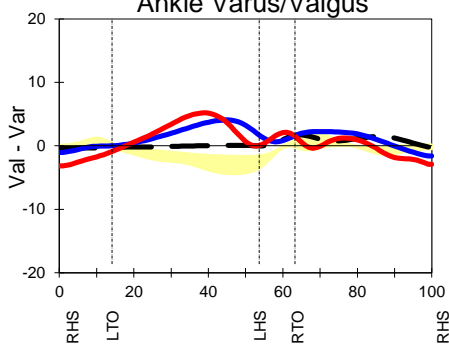
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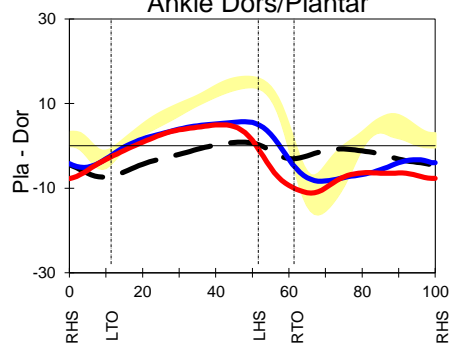
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Ankle Varus/Valgus



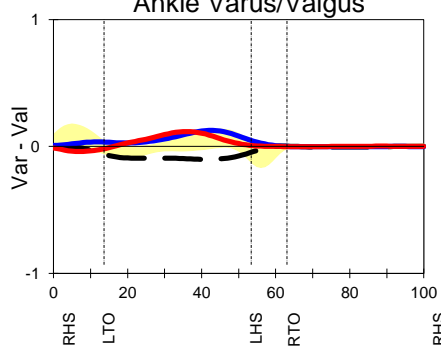
SAGITTAL

Ankle Dors/Plantar

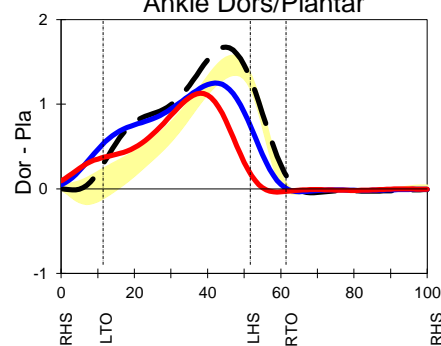


Moments
(Nm/kg)

Ankle Varus/Valgus

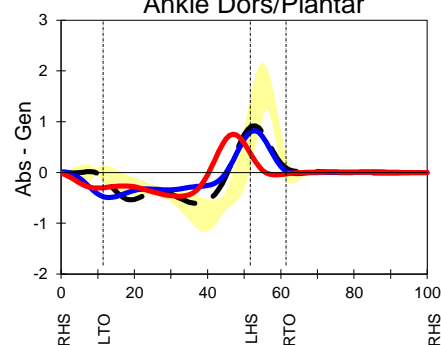


Ankle Dors/Plantar



Powers
(Watts/kg)

Ankle Dors/Plantar



LEFT HIP KINETICS

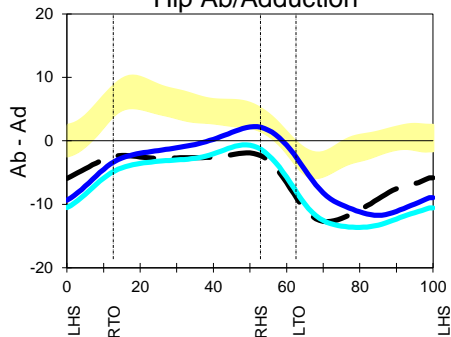
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Kinematics

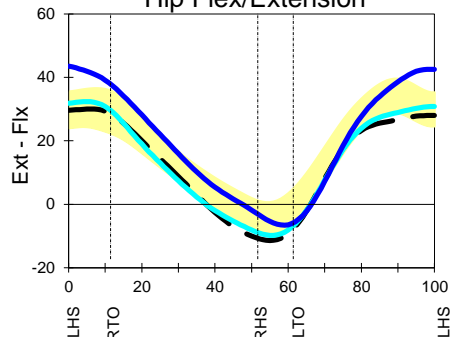
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Hip Ab/Adduction



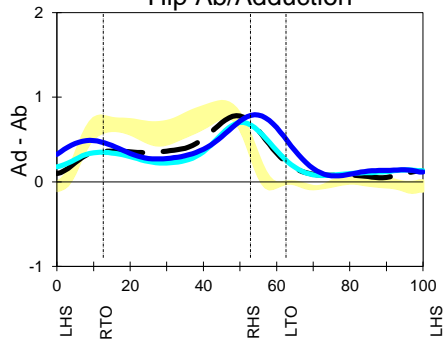
SAGITTAL

Hip Flex/Extension

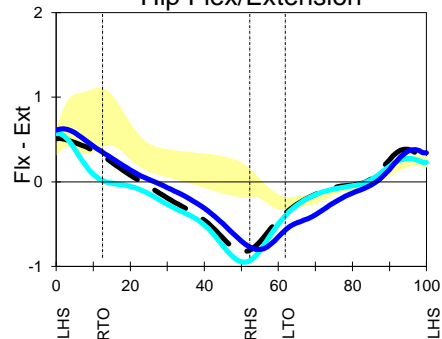


Moments (Nm/kg)

Hip Ab/Adduction

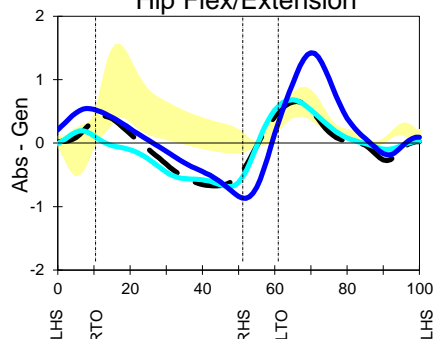


Hip Flex/Extension



Powers (Watts/kg)

Hip Flex/Extension

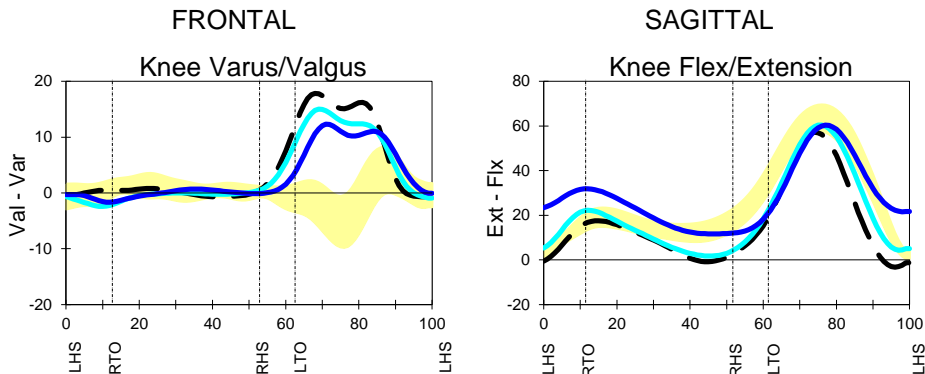


LEFT KNEE KINETICS

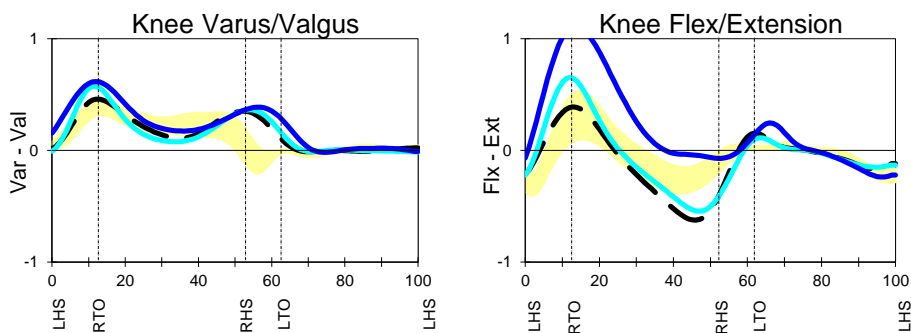
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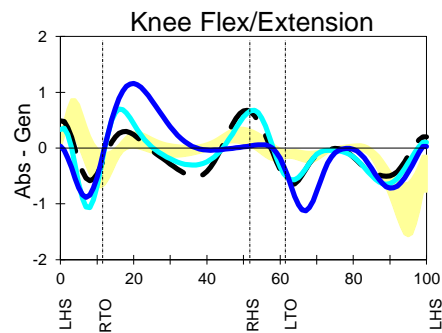
Kinematics



Moments (Nm/kg)



Powers (Watts/kg)

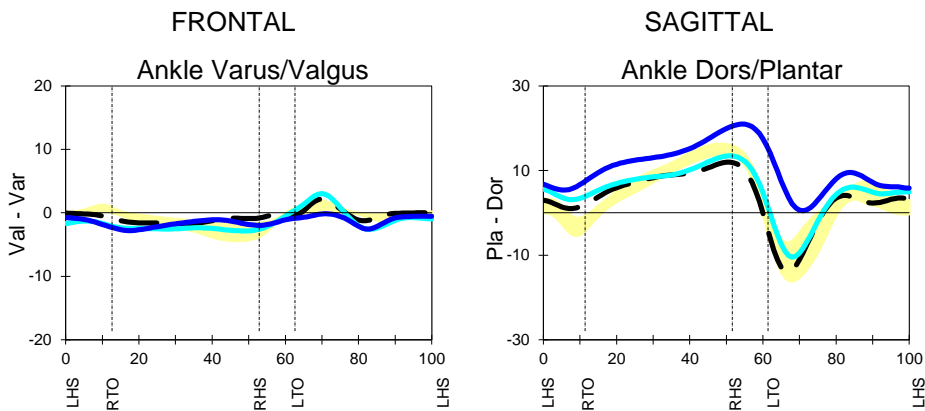


LEFT ANKLE KINETICS

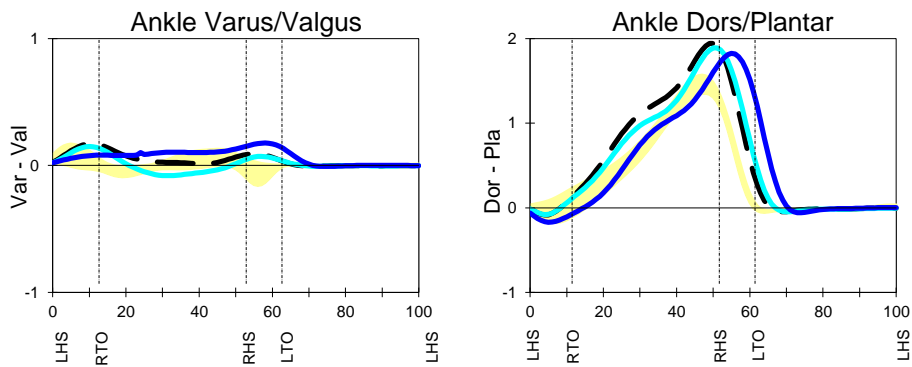
Name: Max Conserva
 Condition1: Barefoot
 Condition2: Shoes and AFO
 Condition3: Shoes and KAFO

Patient Number: 2545892-8
 Strides: 12
 Date: 7/31/2013
 Age: 32.0
 Examiner: LPCH Motion & Gait Lab

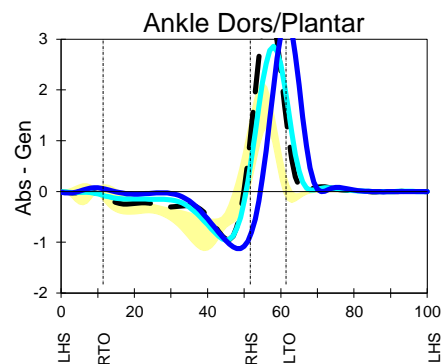
Kinematics



Moments (Nm/kg)



Powers (Watts/kg)



Name: Max Conserva
 Condition1: — Barefoot
 Condition2: — Shoes and AFO
 Condition3: — Shoes and KAFO

Patient Number: 2545892-8 Date: 7/31/13
 Strides: 12 Age: 32.0
 Examiner: LPCH Motion & Gait Lab

Temporal Spatial

| | | Condition 1 | Condition 2 | Condition 3 | Norm | Cond 1 %Norm |
|----------------------|-------------|-------------|-------------|-------------|--------|--------------|
| Velocity | (cm/s) | 98.2 | 109.45 | 111.3 | 124.10 | 79% |
| Cadence | (steps/min) | 109.2 | 109.29 | 106.1 | 98.18 | 111% |
| Stride Length | (cm) | 108.1 | 119.96 | 125.6 | 151.68 | 71% |
| Step Width | (cm) | 15.4 | 16.60 | 17.0 | 11.97 | 129% |
| Pelvic Width | (cm) | - | - | - | - | |
| Pelvic to Step Ratio | (cm) | - | - | - | - | |
| Right | | | | | | |
| Step Length | (cm) | 59.1 | 62.45 | 63.9 | 65.23 | 91% |
| Weight Accept | (% cycle) | 9.9 | 11.29 | 12.9 | 10.24 | 97% |
| Single Support | (% cycle) | 32.0 | 34.91 | 35.2 | 39.37 | 81% |
| Weight Release | (% cycle) | 12.4 | 12.83 | 13.3 | 10.81 | 115% |
| Stance | (% cycle) | 54.7 | 59.90 | 61.7 | 60.49 | 90% |
| Swing | (% cycle) | 45.3 | 40.10 | 38.3 | 39.51 | 115% |
| Left | | | | | | |
| Step Length | (cm) | 49.1 | 57.65 | 61.6 | 64.54 | 76% |
| Weight Accept | (% cycle) | 12.4 | 12.83 | 13.3 | 10.81 | 115% |
| Single Support | (% cycle) | 45.3 | 40.10 | 38.3 | 39.51 | 115% |
| Weight Release | (% cycle) | 9.9 | 11.29 | 12.9 | 10.24 | 97% |
| Stance | (% cycle) | 68.0 | 65.09 | 64.8 | 60.63 | 112% |
| Swing | (% cycle) | 32.0 | 34.91 | 35.2 | 39.37 | 81% |

Hamstrings Analysis

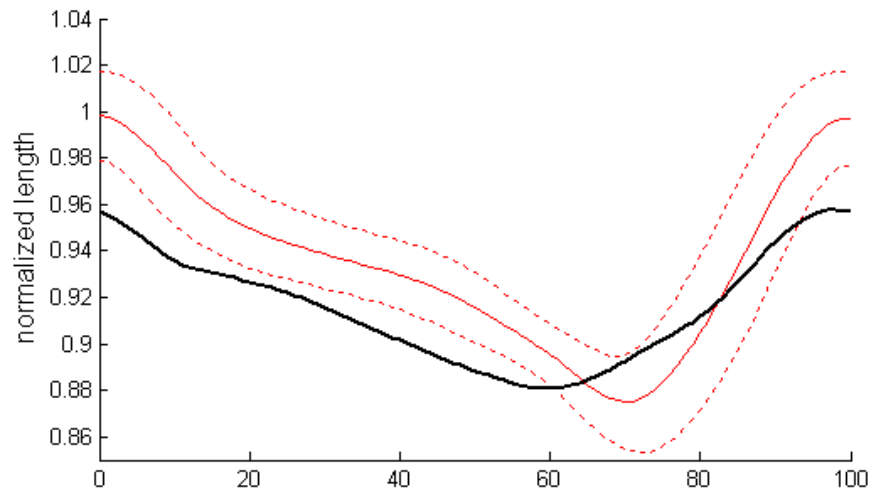
Length & Velocity

Patient Name: Max Conserva

Date of Study: 7/31/2013

Age: 32

Right Leg



Left Leg

