Advanced Gait Training

For Above Knee Amputees
Todd Schaffhauser History

- Lost Leg At age 15 to Bone Cancer
- Followed by 18 months of chemotherapy
- Involved in 6-month research rehabilitation program “ASPIRE PROGRAM”
- My PT was David Balsley
- Started competing in Sept 1986
- First race 100m dash 25.8 seconds
- Started Training For 1988 Paralympics
1988 Seoul Paralympics

- Gold Medal in 100 meter dash
- 15.77 seconds
- 2\textsuperscript{nd} person ever to run under 16 seconds for 100 meters
- First to do it running leg over leg
- 14.55 seconds my fastest 100m
Programs

• Began training amputees in 1989
• Two Formats
• Full Day Clinic
• Amputee Walking School

ATTENDEES

• Seasoned amputees
• Amputees just finishing outpatient rehab
• Physical therapists, pta’s, pt students
Goals

• Teach strength training exercises

• Prosthetic control exercises

• Cardio Conditioning

• Proper running gait for above knee amputees
AK Training Series

• A sequence of exercises to improve strength and prosthetic knee control
  ✓ Hamstrings
  ✓ Hip Extensors
  ✓ Quadriceps
  ✓ Hip Flexors
  ✓ Abductors
  ✓ Adductors
Findings:

- Many Above knee amputees who have
  - Weak Hamstring
  - Weak Hip Extensors
  - Never use those muscle groups to stabilize prosthetic knee

- This leads to:
  - Poor knee control
  - Need for more stance control
  - Lesser functional ability
  - Lesser confidence in prosthesis
  - Smaller selection of prosthetic knees that can be prescribed
Ak Training Series

• These next sets of exercises are meant to build strength in the residual limb, hip extensors, and hip flexors.

• They will also increase your proprioception (where your leg is in space) after some time practicing.

• These exercises can be done with a temporary prosthesis (free swing) or with a permanent one.

• If you have a SNS Hydraulic Knee, turn off the stance phase by putting your prosthesis behind you, Stepping on the toe, and pull up the stance phase lever.
Ak Training Series

• You will also find out if your leg has a good form of suspension (suction) while doing some of these exercises.
• These exercises require some forceful movements of the hip.
• A full range of motion of the hip is critical to good form.
• The final goal is to increase control (awareness) of where your prosthesis is in gait training.
AK Training Series

• 1st Round
  1) Test Strength
  2) Leg Swings
  3) Heel Strikes
  4) Grid Work
  5) Baby Steps
  6) Odd Steps
  7) Step Ups

• 2nd Round
  1) Heel Strikes on different surfaces
  2) Power Walk
  3) Rebounder
  4) Lunges
  5) Squats/Sitting in a chair
  6) Fast timed walk
TEST STRENGTH

• My own observation of varying degrees

  • **Hip Extensor/Hamstring**
  • Have amputee lift prosthesis up as high as they can
  • Place hand on the back of the socket
  • Have them push down and try to drive heel into the floor

  • **Hip Flexor/Quadriceps**
  • Bend prosthetic knee from behind and grab at ankle
  • Have amputee push forward
  • Spotter release hold at the ankle once they give good push to see if leg goes into full extension
Resistance Test

- **Knee extension**
  - Hold back of knee
  - To resist amputee
  - Pulling into full extension

- **Knee Flexion**
  - Place hand in front of knee
  - To resist amputee
  - Pushing into knee flexion
Resistance Test

- Knee extension
- Knee Flexion
Leg Swings

• You may need to use a spotter, a wall, or the parallel bars as a form of balance support.
• You may also need to stand on a 2-4 inch step on the side you are not working for clearance of the floor.
• You are going to concentrate on developing a full swing range of motion of the knee and hip.
• So begin swinging your leg backwards, then forwards in an arc like a pendulum motion.
Leg Swings

• Building up the intensity of the swing requires a stronger push on the front and back walls of socket.
• The feeling is kind of like you want to throw your leg off.
• But of course you won't,

• **AT LEAST WE HOPE.**
• If that happens get back in to see your prosthesis and get a better form of suspension
Leg Swing

• START

• FINISH
Leg Swing

• Leg Swing

• Leg Swings Assisting
Leg Swings Assisting

- A physical therapist can help you perfect this movement by standing on the side of you, placing their hands on the socket (avoid placing your hands in the knee joint) and gently giving a push backwards and forwards.

- This will help you to achieve the full range of motion you are capable of as well as giving those quadriceps, hamstrings, and hip a little help.

- After some practice you'll be doing this on your own.
Leg Swings

• As a beginner this exercise will fatigue the muscles in the hip and residual limb very quickly.

• BEGINNER: GOAL 3 sets of 5

• INTERMEDIATE: GOAL 3 Sets of 12

• ADVANCED: GOAL 3 sets of 25
Heel Strikes

- This exercise will help you to develop where your foot is in space without having to always look down.

- Stand in between the parallel bars with the prosthetic foot behind you and begin to flex your hip/push on front wall of the socket and start moving your leg into swing phase.

- About half way through the swing phase motion stop pushing on the front part of the socket and make an aggressive push on the back wall of the socket.
Heel Strikes

• By pushing on the back wall of the socket you activated your hip extensors and hamstrings to bring the prosthesis back down to the ground.

• The overall idea is to drive your heel down into the ground in whatever spot you want.

• Remember it is an aggressive push on the back wall of the socket activating those hip extensors, which after typically weak post amputation.
Heel Strikes

• START

• FINISH
What To Watch For???

- 1) are they striking or floating the leg
- 2) are they leaning back
- 3) are they sitting back
- 4) are they shifting weight to the prosthetic side
- 5) are they able to bend the knee (what knee unit is it?)
- 6) does the knee buckle at point of heel strike
- 7) does the leg rotate too much internal or external
Heel Strikes Assisting

• Physical therapists can assist the movement by placing their hands on the socket, avoid the knee hinge, and aggressively push backwards to assist the hip extensors in striking the ground.

• Do this with someone who has weak extensors or a real lack of control.
Heel Strikes

- BEGINNER: GOAL 3 sets of 5
- INTERMEDIATE: GOAL 3 Sets of 12
- ADVANCED: 4 sets of 15
- As a beginner this exercise will fatigue the muscles in the hip and residual limb very quickly.
Grid Work

- This exercise has been called a "targeting" one.
- Take pieces of masking tape and place them on the ground in front of you and to the side's of you.
- Create a marker to stand on with the sound side.
- Make the pieces of tape big for beginners.
- The physical therapist will now number each piece of tape 1 to however many are on the floor.
- They then will call out each number in order as you go through the grid performing the Heel Strike exercise.
- After becoming more advanced call the numbers out of order and eventually make the markers on the floor smaller and smaller to further increase proprioception.
SET UP A GRID
Prosthesis is the back leg
• You want to transfer your weight onto prosthetic side
You want to transfer your weight onto prosthetic side
Baby Steps

- This exercise will help get rid of some bad habits like vaulting (rising up too much on the sound side). We start to introduce heel striking from the grid to an actual part of walking.
- By taking small "baby" steps in the length of the parallel bars practice a continuous Heel Strike exercise.
- Taking those small steps with both the prosthetic side and the sound side will not allow the vaulting action to take place.
What To Watch For:

• 1) are they vaulting
• 2) are they circumducting
• 3) are they floating
• 4) are they bending the knee; they must bend the knee to achieve proper movement
Baby Steps

- Physical therapists can again assist by standing on the side and putting their hand on the socket area and push backwards to assist the hip extensors and hamstrings in achieving a quick heel strike.
BABY STEPS GOALS

• MEASURING OUT A 10 FOOT DISTANCE:

• BEGINNERS WILL DO 3 to 5 BABY STEPS FOR EVERY 5 FEET

• INTERMEDIATE: WILL DO 5 TO 10 BABY STEPS FOR Every 5 FEET

• ADVANCED: WILL DO 10 TO 15 BABY STEPS FOR EVERY 5 FEET
Odd Steps

- This one will increase your stance time while walking on your prosthesis and force the knee to have to bend.
- Take a short step with your prosthesis and a long step with your sound leg.
- Do the opposite: a short step with the sound limb and a long step with the prosthesis.
STEP UP

• Place your prosthesis on a short step.
• Maybe use a Reebok step in between the parallel bars or a stairwell with handrails.
• Push really hard on the back wall of the socket to force the leg into full extension.
• This is teaching someone to lead with their prosthetic leg.
• If the person does not have the strength in the extensor muscles to push back, the prosthesis will buckle.
STEP UP

• START

• Push on back wall of socket

• FINISH

• Other foot comes up to be equal to prosthetic side
WHAT TO WATCH FOR:

• 1) Are the using the other leg to push up/jump up
• 2) Is the knee ending in full extension or is it slightly bent or any buckling
• 3) Do they need a lot of assistance from spotter
• 4) Are the in the end position have both feet are equal or is the sound side slightly behind
STEP UP ASSISTING

• Spotting is very important for beginners.
• This will help build strength for escalating stairs and curbs
• A physical therapist can help in two ways.
  • One is pushing cradle backwards and the socket forward to help out those extensors.
  • Secondly would be to hold the prosthetic foot that is on the step from turning side to side.
• This side to side motion is happening because the AK amputee is not putting enough weight on the prosthesis.
• By holding the foot you are giving them security in only having to control the prosthesis with the hip extensors and hamstrings.
STEP UP GOALS

• BEGINNERS: Can **USUALLY ACCOMPLISH** a 2 to 4 inch STEP) with assistance)

• INTERMEDIATE: A 4 to 8 INCH STEP (moderate to no assistance)

• ADVANCED: 12 INCHES AND ABOVE(NO assistance)
Heel Strikes On Different Surfaces

- Balance Discs, Steps, Balance Pads
Walking Up & Over

• Step On

• Step Over
POWER WALK WITH THERABAND

- Spotter wraps t-band around ak side (midway length of residual limb), and holds from behind as amputee powers through walking gait.
- Use heavy resistance t-bands.
- When the bands come off, the ak amputee will feel like the prosthesis is super light and now be able to walk much quicker and stronger.
- One important note is that you want to make sure the person is bending the knee on the prosthesis side while the t-band is attached.
Power Walk Goals

- Beginners: Start inside parallel bars (10 Ft)
- Intermediate: turn around and walk back (20 FT)
- Advanced: Work up to 50FT adding 10Ft more at a time
Rebounder

- This is heel striking into mat
- Hit center of mat
- Set up grid work
- Make sure they shift weight onto prosthetic side after striking it
- The feeling is like trying to push into the mat
- Work sound side too but not striking it, just stepping onto mat
Test Of Weight Shift

- After amputee hits mat with heel strike have them hold position for 5 seconds.
- Spotter try and move prosthetic side in all different directions.
- If the foot moves then they are not shifting enough weight and holding the shift onto mat.
- Are they leaning back.
LUNGES

• With spotter in the front amputee will step out with prosthesis then bend the knee until the foot is flat on the ground and hold
• Ways to evaluate and set Goals
  • DISTANCE: from the toes of the back foot to the heel of the front foot that we can measure
    • 4 inches for a beginner
    • 8 inches for an intermediate
    • 12 inches higher for advanced
SITTING IN A CHAIR/SQUATS

- Have the amputee sit in a chair
- 1) do they collapse into the chair
- 2) do they lift prosthesis of the ground to sit in the chair

I recommend 3 exercises:

1) **Total Gym Squats**
2) Leg Press machine
3) Squatting using ball
One Leg Squat

- Start
- Finish
One Leg Squat Foot Position

- Amputee’s foot is positioned about half way off the front of the squat stand.

- This allows amputee to squat down into 90 degree angle.
One Leg Squat

• Slowly guide amputee down to finish position
• If they need help assist by pushing knee back into full extension
FAST WALK TIMED SETS

- A good test and great workout
- The right candidates/ A very advanced workout
- Have amputee walk as fast as they can
- NOT ON TREADMILL
- Tests prosthetic control
- Reinforces “Push & Pull” socket training
- Mark out distance of 50 feet

- Just over 20 seconds beginner
- Just over 15 second for intermediate
- Just over 10 seconds for advanced
AK RUNNING STEP 1

• Start with prosthetic side behind you having weight on the ball of your foot
• Aggressively push on the front wall of the socket to initiate start of swing phase
• At the same time take a hop/strong push off of your sound side
• Once you hop/push off immediately pull on the back wall of the socket, driving the heel into the ground and landing on the prosthetic side
• Do this with spotter or into wall
AK RUNNING

STEP 2

• Once you completed STEP 1 positioning, continue forward bringing your sound side through full step
• Now press on the front wall of the socket to cause the knee to break/bend
• Continue moving till you finish in end position (sound side forward-prosthetic side knee bent and weight on the ball of the foot)
• Keep weight on the prosthetic side (practice holding this ending position)
• Repeat this sequence until you’ve mastered it
• First 2 times, then 3 times, etc.
Running Sequence
Running Sequence
WHAT TO WATCH FOR

• **STEP 1**
  • One spotter in front and one on the side
  • One spotter on the side using wall or parallel bars
  • AK does not initiate hop/strong push off
  • AK does not push enough on back wall of socket causes buckling
WHAT TO WATCH FOR

• STEP 2
• AK does not initiate bend of the knee causing them to become LOCKED UP at the knee
• AK does not stick the landing by putting and keeping weight on the prosthetic side
Advanced Training
Todd Schaffhauser’s AK Running Pathway

- My opinion has always been that all ak amputees need to first learn to run on their walking leg before getting a running leg. It helps to teach many things while learning to run including:
  - 1- Balance
  - 2- Leg turnover speed
  - 3- Strength
  - 4- Endurance
  - 5- Targeting
- If a person is taught to run on a running leg first, they may encounter problems such as:
  - 1- Arching their back too much to power prosthesis forward
  - 2- No leg turnover speed just bouncing on sprint foot
  - 3- No targeting of where to land prosthesis
Opinion

• Based on my experience, a running leg should be introduced after the person learns to run heel to toe on the walking prosthesis. The athletes I have trained waited until they could run 100 meters in under 17 seconds before I would introduce the running leg.

• I competed on my walking leg for 8 years and ran the fastest time on it of 15.09 seconds. I was consistently under 16 seconds.

• Then I switched to my running leg and went under 15 seconds.
Heel to Toe

• The athletes need to learn to run heel to toe and be able to build leg turnover speed- maintaining proper form and balance with incredible power.
• The method I used was the rebound technique, where the prosthesis has a flexion stop at about 120 degrees knee flexion.
• The athlete then learns to run building up enough speed that the prosthesis goes into full knee flexion.
• They rebound off that flexion stop, and this helps to assist in knee extension.
• It helps to assist the movement, but you still need to use your quadriceps.
• The hydraulic settings are set at as minimum as possible. The foot should be an energy storing foot.
Heel to Toe & Rebounding
Rebound Technique Treadmill Training

- The amputee knows how to run step over step already
- They have mastered leg swings exercise
- Needs to learn stronger push to the back of the socket to initiate REBOUND
- Begin with walking on a treadmill starting with a normal walk, increasing to a fast walk, and eventually running, where the amputees have to keep up with the leg turnover speed and the rebound technique will naturally happen.
- Once you get over 5mph to 6mph on the treadmill, the rebounding will happen.
- The person should hold on to the side handrails the first time trying this.
- Then I would just do intervals - maybe 8 to 12 of them
- Amputee holds speed for 5 to 10 seconds
What To Watch For

Then practice this on a long straight away. This is where you see bad form breakdown:

• Longer stride with AK side than sound side

• Jumping too much in the air for clearance of
  AK side instead of leaning forward

• Arm swinging not coordinated

• No endurance
To Increase Speed

1) On a treadmill, do interval training- 8 to 12 sets of walking then slightly increasing speed 1/2-1mph over the point of when the athlete began to rebound

2) Power walk with theraband.

3) A great speed building exercise is fast feet plyometrics. This is kind of like running in place except that you are not looking for high knees. Instead, you are looking for low knee drive and fast movement from side to side.

4) Count how many times the prosthetic side touches the ground.
To Increase Speed

• A beginner will do sets of 15-30 touches;
• intermediate will do 30-60 sets,
• advanced athlete should be able to do over 60 touches.

• Two key things to look for are:
• the knee on the prosthetic side must bend and
• good arm drive.
Increase Stride On Prosthetic Side

- Put 2 lines on the floor
  - one for front foot
  - one for back foot (prosthetic side)
- Put targets (x’s) on the floor in front of prosthetic side a foot apart for 5 feet
- Amputee will now target each (X) doing step 1 and then transition into step 2 forcing increase in hip and quadriceps push on front of socket
- Put a Reebok step on the floor
- Amputee while running has to jump/stride over Reebok step with prosthetic side
Nick
Todd
Prosthesis Notes

- 2 good knee frames are Endolite Hi-Activity and Ossur Gaitmaster because both have flexion stops at 125 degrees.
- 2 good hydraulics are Catech and Mauch, because the person can start out with a swing and stance knee and later, when strong enough, can switch to a swing only hydraulic knee.
- 2 good feet are Flexfoot Modular 3 and Springlite 2 Gold.
- A suction socket.
- A silesian belt will help eliminate rotation as well as increase suspension if the belt stretches it won't work. These belts are custom made.
- No cosmetic cover because they are limiting in knee flexion and extension plus they add unnecessary weight.
KNEES
FEET
ONCE THE AK ATHLETE CAN RUN UNDER 17 SECONDS ON THE WALKING LEG

- Now switch them to training on a RUNNING LEG.
- The rebound technique will no longer work because you don't have a heel to land on the running leg.
- So we have to change the hydraulics to start to limit knee flexion.
- On the walking leg, we had 120 degrees knee flexion.
- But, now we want to work our way down to around 60 degrees knee flexion by increasing hydraulic resistance in flexion.
- At this time, the extension is adjusted as well.
- This takes time for the athlete to adjust.
- With this hydraulic knee setting change, the athlete will now have the targeting skill and come through swing phase enabling them to land on the ball of the sprinting foot while the prosthesis is underneath them.
Thanks