SPARG
SCOTTISH PHYSIOTHERAPY AMPUTEE RESEARCH GROUP

NHS
Greater Glasgow and Clyde

WestMARC Knee Guide for the Prosthetic Multidisciplinary Team 2020

Laura Brady

Bruce Carse

David Morrison

Alison Morton

Nikki Porteous

Helen Scott

Citing the guideline document: -

'WestMARC Knee Guide for the Prosthetic Multidisciplinary Team' (2020) Brady L, Carse B, Morrison D, Morton A, Porteous N, and Scott H. 3rd Edition, http://www.knowledge.scot.nhs.uk/westmarckneeguide.aspx

Review date: November 2025

Authors: -

Laura Brady, Team Lead Prosthetist, WestMARC: laura.brady2@ggc.scot.nhs.uk

Bruce Carse, Clinical Scientist, WestMARC: bruce.carse@ggc.scot.nhs.uk

David Morrison, Lead Prosthetist, WestMARC: david.morrison2@ggc.scot.nhs.uk

Alison Morton, Senior Prosthetist, WestMARC: alison.morton@ggc.scot.nhs.uk

Nikki Porteous, Specialist Physiotherapist, WestMARC: Nicola.porteous@ggc.scot.nhs.uk

Helen Scott, Team Lead Physiotherapist, WestMARC: Unavailable

Contact address: -

Prosthetic Service

West of Scotland Mobility and Rehabilitation Centre (WestMARC)

Queen Elizabeth Hospital Campus

1345 Govan Road,

Glasgow G51 4TF

Table of Contents

Acknowledgements

The authors are very grateful to Mr John Colvin, WestMARC Clinical Services Manager for his support and the time he has allowed for staff to rewrite this knee guide. Also, we are indebted to the wider prosthetic team for their assistance in all the discussions, debates and proof reading over the past year.

We would also like to thank the expert advisors and prosthetic companies for their interest and invaluable feedback (see Appendix 1). Additional thanks to Lynne Powell for her contribution of the bilateral transfemoral pathway used at WestMARC and Nicola Watson for her prosthetic updates.

Finally, we would like to thank the Scottish Government for awarding the funding that has given the authors the opportunity to work with microprocessor technology and gain the skills and expertise contained in this document. We hope that sharing this knowledge will benefit other prosthetic teams and their patients.

Glossary of terms and abbreviations

Activate yield: engage yield either by positioning knee in extension and loading, or just loading.

Activity levels: systems of defining the way a patient uses a prosthesis according to their level and type of activity. They are used in conjunction with the patient's weight to guide correct prosthetic prescription. How activity levels are defined can vary between Prosthetic Companies (see Appendix 2).

Adaptive swing: responds to alter resistance in knee if weight of shoe is changed

Adaptive yield: microprocessors alter resistance in the knee in response to increasing or decreasing loads.

Alignment: this refers to the position of the prosthetic components relative to the socket to ensure the optimum function and stability of the prosthesis.

Default stance: refers to yielding / fluidic / microprocessor knees that will have stance flexion resistance on unless it is deactivated by the forces around the knee i.e. knee hyperextension moment.

Default swing: refers to yielding / fluidic / microprocessor knees that will not have stance flexion resistance on unless it is activated by the patient loading the limb.

Fluidics: the patented means of using the rate of fluid flow within a prosthetic knee joint to moderate the flow and therefore the resistance within the knee.

Fluidic knee: a fluidic knee functions in response to patient movement using internal and external sensors to inform the fluidic processing units to moderate knee resistance.

Geometric lock: polycentric knees with multiple linkages that are designed to lock in extension for increased stance stability i.e. when the knee swings into extension it will stay in extension until the amputee bears weight through the prosthetic toe.

Ground reaction force: force that the ground applies to the body.

Heel dwelling: delayed weight transference forward from heel in early stance i.e. prolonged first rocker.

Hip flexion contracture: fixed flexion deformity of the hip that should be measured using Thomas Test and re-checked in prone or side lying and standing.

Hydraulic knee: stance and/or swing resistance is controlled using hydraulic fluid and a system of valves (see also 'yielding').

Inclined thigh/shank: 'forward tilt' of the thigh/shank.

Initial contact (IC): first phase of gait (in weight acceptance).

Initial swing (ISw): sixth phase of gait (in swing limb advancement).

Instantaneous centre of rotation (ICOR): the true centre of rotation of the shank relative to the thigh segment.

Intuitive stance: sometimes referred to as 'stop and lock' or manual stance. It is a static stance hold function which can allow the patient to stand on a flexed knee. In this guide this term applies only to microprocessor knees.

Knee giving way: sudden loss of stance stability/control and knee collapses ('disappears')

Load toe: this term is used if weight transference through the toe is required to release stance control to destabilise prosthetic knee for swing knee flexion. It is normal to transfer weight along the foot to the toe during walking but in most prosthetic knees stance control will disengage irrespective of the level of load exerted through the prosthetic toes as long as the body moves ahead of the foot, weight is transferred along the foot and the ground reaction force moves behind the knee to create a knee flexion moment.

Load dependent yield: yield / stance flexion resistance activated by loading (knee in any position), deactivated by offloading or reaching TSt (default swing – see above).

Loading response (LR): second phase of gait as limb accepts weight.

Loading response stance flexion: knee flexion under load in early stance (IC through LR) up to 20 °.

Manual knee lock/ Hand operated knee lock: optional patient operated lock.

MDT: Multi Disciplinary Team

Mechanical knee: a knee that functions according to its mechanical design in response to patient movement.

Microprocessor knee (MPK): an electronic knee (with battery) that functions in response to patient movement using sensors and a microprocessor to moderate knee resistance.

Mid stance (MSt): third phase of gait, beginning to middle of single limb support.

Mid swing (MSw): seventh phase of gait, middle of swing limb advancement.

Microprocessor modes: knee joint settings that are actively changed for specific activities e.g. cycling, golfing.

Polycentric knee: a knee that has a centre of rotation based upon multiple linkages rather than being a simple hinge. Similar to the human knee, these knees have a variable centre of rotation during flexion of the knee. This may allow functional shortening of the limb during swing thus aiding toe clearance.

Position dependent yield: yield / stance flexion resistance activated by full knee extension and loading, deactivated by knee hyperextension moment (default stance – see above).

Reclined thigh/shank: 'backward tilt' thigh/shank.

Pre swing (PSw): fifth phase of gait, end of stance and preparing for swing limb advancement.

Riding yield: continuing loading response knee flexion into pre swing knee flexion rather than extending knee for mid stance.

Single axis knee: a knee that is characterised by a single centre of rotation i.e. a simple hinge.

Single limb support: second task of gait.

SAKL: semi-automatic knee lock.

Stance knee flexion: knee flexion under load at any point in stance.

'Step-to' pattern: walking up or down stairs one step at a time or walking on level ground or a slope without one foot passing the other.

Stumble recovery: when stance resistance is used during swing phase extension to ensure knee stability should the patient stumble.

Swing limb advancement: third task of walking**.**

Terminal stance (TSt): fourth phase of gait, end of single limb support.

Terminal swing (TSw): eighth phase of gait, end of swing limb advancement.

Unload toe: off load prosthetic limb.

Unaccommodated hip flexion contracture: this is a hip flexion contracture that has not been accommodated in the alignment of the prosthetic socket. It will affect stability of the prosthetic knee in early stance and transition from stance to swing, making it happen earlier and the knee less stable at TSt. Even if a knee is locked unaccommodated hip flexion will place the patient's centre of gravity posterior to the ideal foot position which the patient will counteract by leaning forward.

Walk to run mode: When the knee joint automatically recognises and adapts appropriately when the patient begins to run.

Weight acceptance: first task of gait.

Weight activated lock: braking mechanism which adds resistance to the knee on weight bearing preventing knee flexion. The brake is activated on weight transference through the foot within the knee flexion range of 0-30 °.

Yielding knee: yielding knees allow patients to achieve foot over foot descent on stairs and slopes and generally a small degree of stumble recovery. The yield is achieved by an increased resistance to knee flexion during stance using a fluid within the knee to mimic the action of an eccentric muscle contraction of quadriceps muscle. The level and timing of this resistance is set by the Prosthetist.

Introduction: scope of guideline and background

This document is intended as a guide to assist the prosthetic multidisciplinary in prescribing and training patients to use prosthetic knee joints. It is the thrid edition of the 'Physiotherapist's Guide to Prosthetic Knees' published by Scottish Physiotherapy Amputee Research Group (SPARG) in 2007. Information on normal gait and prosthetic knees has been updated and more information on microprocessor technology has been included.

The guide has been written by NHS clinicians who use these products on a daily basis and who have no commercial interest in their prescription. It is not an evidence based guideline but it is formed from clinical staffs' expert opinion and guidance supplied by the manufacturers.

It includes information on the various categories or 'families' of knee joints, from mechanical to microprocessor controlled devices. The authors have defined and described each category including examples of specific knees that fit into each category. These examples have been chosen as they are the most common types of knee used in clinical practise in the UK but they do not constitute a definitive list due to the number of prosthetic knees available. Many knees will have similar features within their "family" and any significant differences will be explained. For more in-depth or practical training the reader should contact the manufacturer or supplier of each knee joint.

The hints and tips section is intended to facilitate problem solving when teaching patients to use a particular knee ensuring they gain maximum benefit from the different features and functions.

All the information supplied about each knee joint has been checked and approved by the appropriate manufacturer and is up to date at time of publishing. The authors recognise that as prosthetic components and clinicians experience are constantly evolving, this document will require updating within the next 5 years. Ongoing feedback would be welcomed by the authors (see page 2 for contact details).

Normal Gait and Implications for Gait Training

Normal gait pattern

Perry[1] has described gait in terms of 3 key tasks; weight acceptance, single limb support and limb advancement. There are eight distinct phases within these tasks as follows (see figure 1): -

- Weight acceptance
  - Initial Contact (IC)
  - Loading Response (LR)
- Single limb Support
  - Mid Stance (MS)
  - Terminal Stance (TS)
- Swing limb advancement
  - Pre Swing (PSw)
  - Initial Swing (ISw)
  - Mid Swing (MSw)
  - Terminal Swing (TSw)

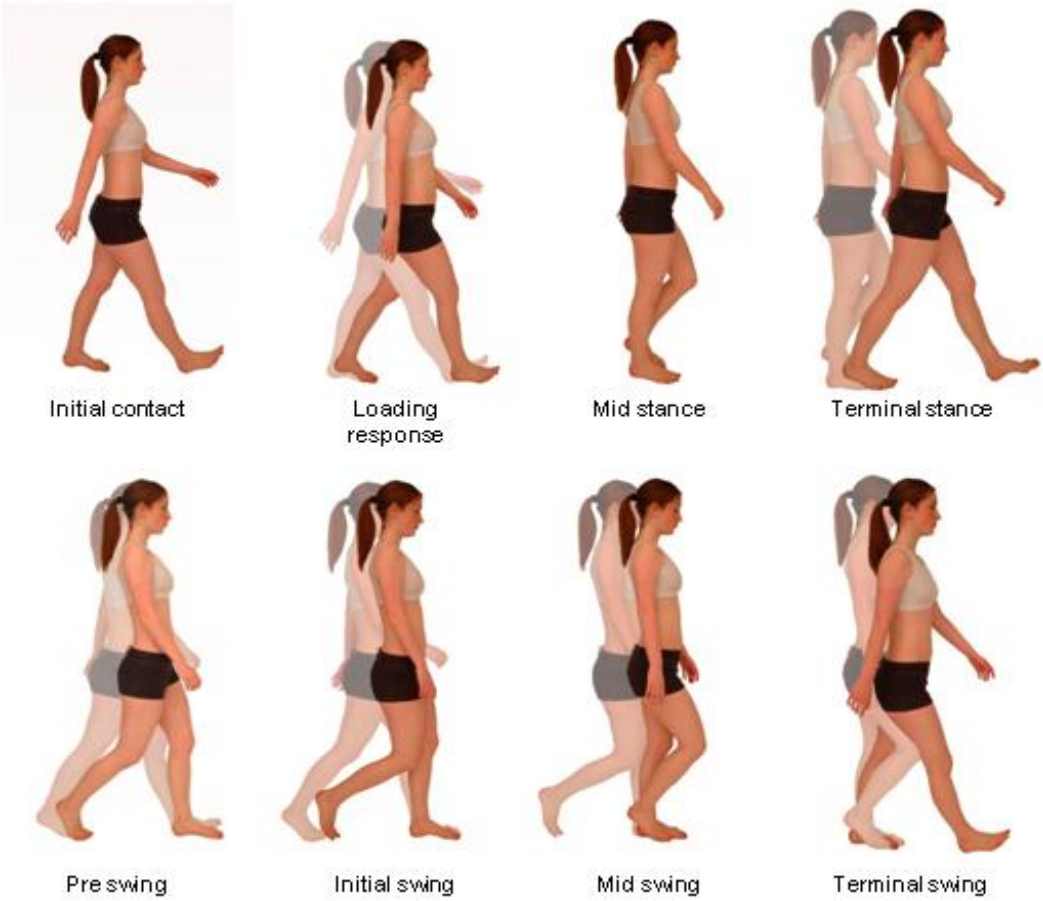


Figure 1: Phases of Normal Gait 1[1] relating to the subject's right leg

Stance begins and terminates with a period of double support. There is one period of single support from Mid Stance (MS) to Terminal Stance (TS), which accounts for 40% of the gait cycle (see figure 2).

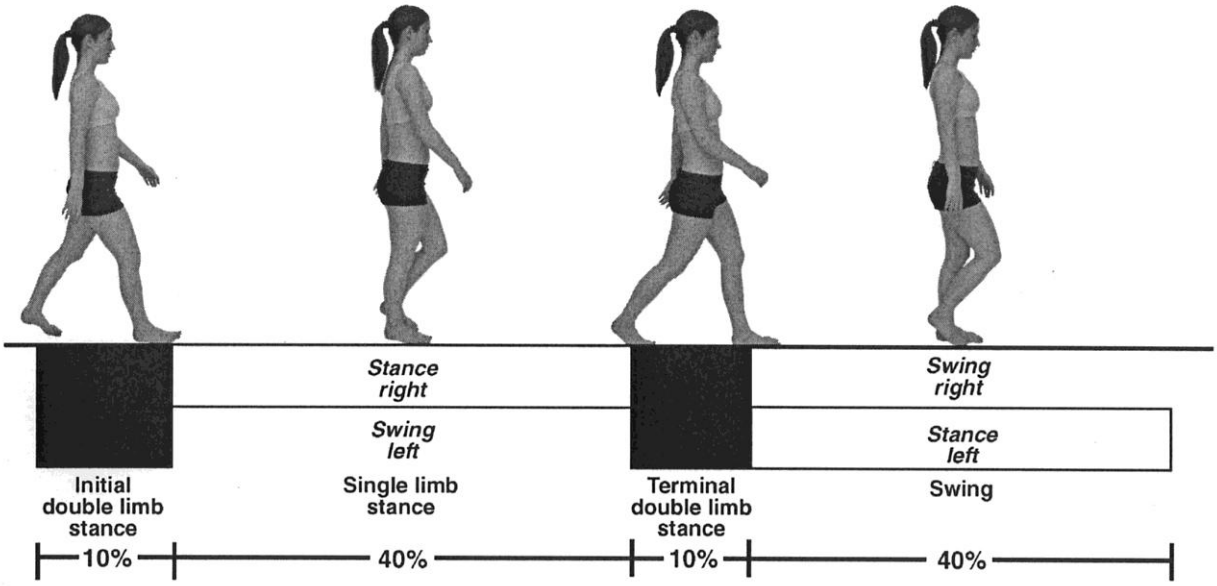


Figure 2: Phases of Normal Gait[1] relating to the subject's right leg

Pelvic Movement During Gait

It has been suggested that since the weight of the upper body acts downwards through the pelvis with the body's centre of gravity sitting within the pelvic girdle, all movement begins at the core of the body[2]. A good gait pattern therefore begins with normal pelvic movement and control. The importance of pelvic movement in normal gait has been recognised since 1953 [3] although the exact function and sequencing of the movements is currently under debate. [4]

Recent work by Michaud has been carried out to investigate pelvic movement in normal subjects and amputees specifically measuring vertical pelvic tilt (drop) or pelvic obliquity.[4] These authors discovered a slightly different sequencing of vertical pelvic tilt in normal subjects than previously described by Saunders et al.[3] Work by Michaud suggests that in normal subjects the greatest vertical pelvic tilt (drop) occurs immediately after pre swing during loading response of the lead leg, offering a degree of shock absorption. In addition, it would appear from Michaud's work that both trans-tibial and transfemoral amputees demonstrate a loss of vertical pelvic tilt (drop) which is replaced at pre swing with vertical pelvic tilt (hip hitching).

Definition of pelvic movement:

- ***Pelvic Rotation:*** this is rotation of the pelvis about the vertical axis visible from above in the transverse plane and rotation is described as ‘protraction’ or ‘retraction’ (see figure 3).

Figure 3: Pelvic rotation as viewed in the transverse plane.

- ***Pelvic obliquity:*** this is rotation of the pelvis around the anterior-posterior axis visible from the front or back in the coronal plane and rotation is described as ‘up’ or ‘down’ (see figure 4).

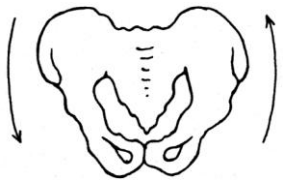


Figure 4: Pelvic obliquity as viewed in the coronal plane.

- ***Pelvic tilt:*** this is rotation of the pelvis about the medio-lateral axis, visible from the side in the sagittal plane. It is normal for the line between the posterior and anterior superior iliac spines to give an anterior pelvic tilt of 7-14° (see Figure 5)

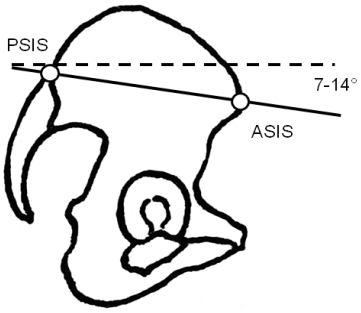


Figure 5: Pelvic tilt as viewed in the sagittal plane.

- ***Anterior/posterior shift***: this is movement of the pelvis forwards and backwards visible from the side in the sagittal plane.

- ***Lateral Shift***: this is movement of the pelvis from side to side visible from the front or the back in the coronal plane (see figure 6).

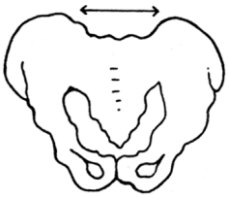


Figure 6: Lateral shift of the pelvis as viewed in the coronal plane.

Human Knee

When considering gait training of the transfemoral amputee it is useful to be reminded of the characteristics of the human knee.

- It is a polycentric joint that permits 0-140^0 flexion and extension with additional transverse rotation when flexed.
- It provides shock absorption by flexing during early stance.
- It is stable during stance by virtue of its muscular control.
- It has the ability to lock in full extension.
- It allows shortening of the limb to provide toe clearance during mid swing.
- It is cadence responsive.

The Ground Reaction Force (GRF)

When the body contacts the ground it exerts a force on the ground, and the ground exerts an equal and opposite force to the body. The force that the ground applies to the body is called the ground reaction force (GRF).

The GRF is a vector which can be split into three components; anterior-posterior (Fx), medio- lateral (Fy) and vertical (Fz) as shown in Figure 7.

The magnitude and alignment of the GRF vector relative to the joint centres determine how our body segments, and ultimately centre of mass, move as we walk.

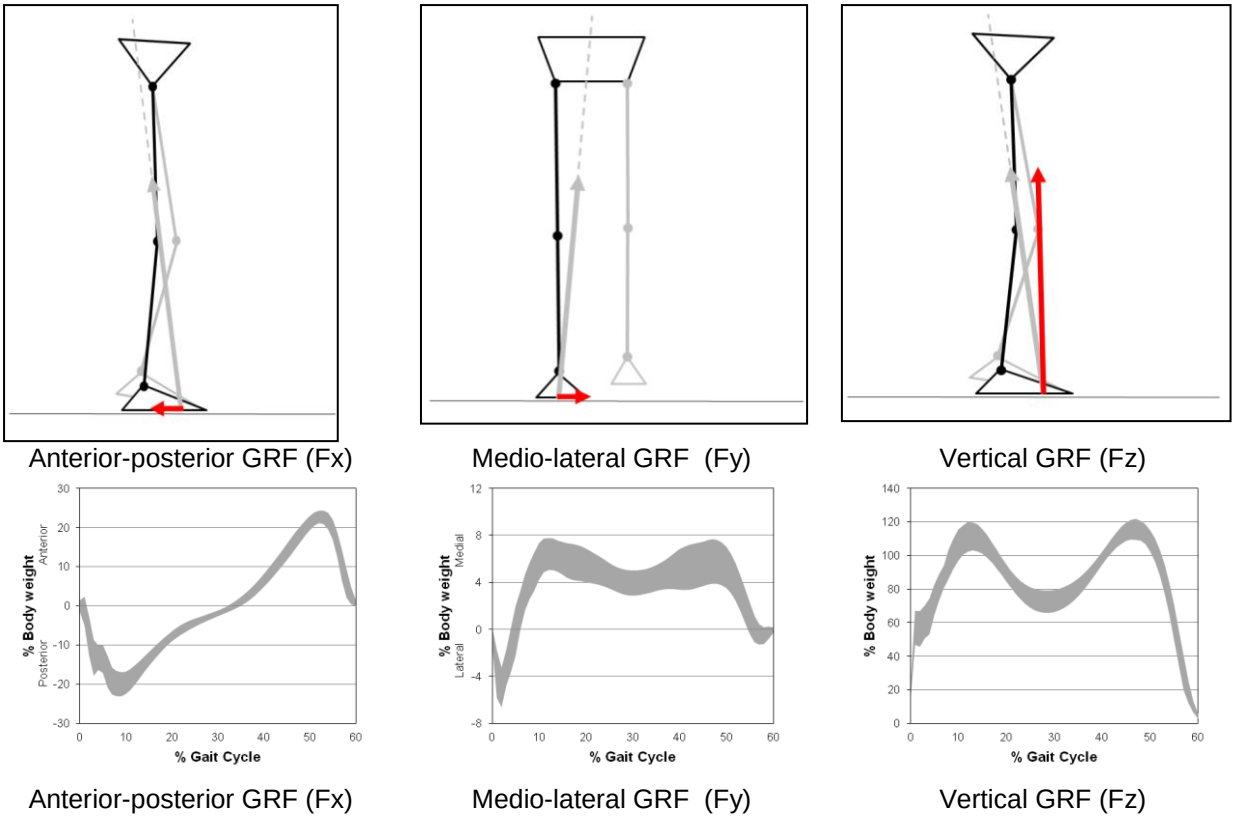


Figure 7: Normal adult ground reaction force (GRF) profiles normalised to percentage of body weight (grey band denotes mean ± 1 SD)

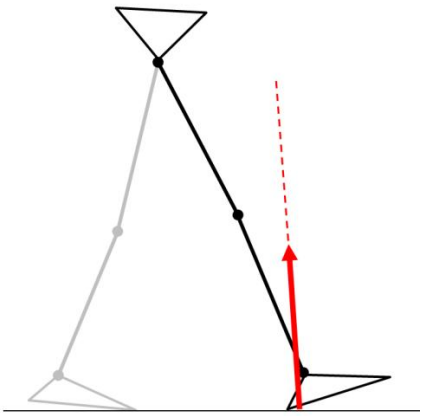
Gait Training and Prosthetic Knee Issues

The following pages describe each of the phases of the normal gait cycle whilst also commenting on any gait training and prosthetic knee issues.

Perry's[1] method of defining and analysing normal and pathological gait may be used to establish the requirements for prosthetic knee replacement and the subsequent gait training needs. Supplementary information on normal gait kinematics are provided in appendix 3. Detailed muscle activation during the gait cycle can be found in Kirtley (2006)[6] which was originally published by Sutherland (1984)[7].

Normal gait phase 1: Initial Contact (IC)[1,2,4]

Objective: Begin stance, and first period of double support



Pelvis: Protracted

Hip: Flexion increases slightly after IC, followed quickly by extension

Knee: Extended (0-10° flexion)

Ankle: Dorsiflexed to neutral

GRF: Anterior to knee giving a knee extension moment.

Muscles: Tibialis anterior

Prosthetic Issues to consider

The user may walk by digging their heel into the ground with rapid hip extension to ensure prosthetic knee extension and therefore stability. This is usually a habit due to lack of trust in the prosthetic knee that may be the result of falls and/or an unstable knee joint.

Too little extension resistance could cause rapid knee extension (bounces back), or too much, delayed knee extension (knee lands flexed)

Points for Gait Training

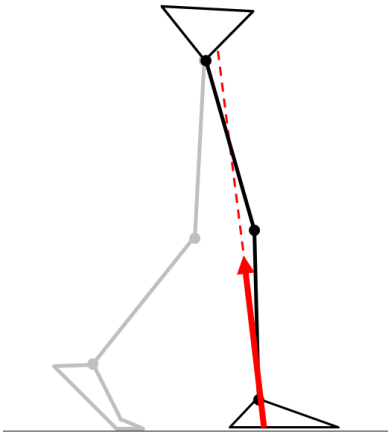
Ensure soft heel contact and equal stride length. If step length is short check for limited ankle dorsiflexion range of movement in contralateral (trailing) limb. If step length is long check for ipsilateral hip flexion contracture and if it has been adequately accommodated within the prosthesis. Also check for prosthetic knee instability which may be causing the patient to take a long step and dig their heel in an attempt to stabilise the knee.
Hip extension should be initiated just before IC.

Normal gait phase 2: Loading Response (LR)[1,4,5]

Objective:

- Optimum weight acceptance
- Shock absorption through knee flexion
- Weight bearing stability
- Preservation of forward progression
- Continues first period of double support

First Rocker[1]**:** body rolls forward around the calcaneus destabilising the knee.



Pelvis: Anterior and lateral shift as the leg accepts weight, with obliquity 'up' to ipsilateral side

Hip: Extending from flexion

Knee: Flexing to 15-25^0

Ankle: Plantar flexing to foot flat

GRF: Anterior to the hip and posterior to the knee causing a flexion moment at both joints

Muscles: Gluteus maximus, quadriceps and tibialis anterior.

Prosthetic Issues to consider

Only some prosthetic knees allow loading response (LR) stance knee flexion. Those that do not cause the body's centre of gravity to be higher than normal preventing the shock absorption function of the knee and perhaps increasing the energy cost of walking.

Most prosthetic knees that do flex for loading response will have a self limiting or mechanical 'give' or 'bounce' of up to 15^0. This LR flexion is not usually 'truly' at the knee joint as this would make the knee unstable. There is normally either a bumper above the knee or below and the action may (or may not) be determined by a linkage system in the knee (polycentric).
Other knees that have stance flexion resistance throughout knee flexion can allow LR stance flexion without a mechanical stop. Some patients who may not have the control to extend after LR knee flexion can end up flexing their knee throughout stance or 'riding the yield' - this should be corrected.

Heel dwelling can occur at this stage, but is usually an alignment (knee instability) or foot prescription issue. An unaccommodated hip flexion contracture can be the cause of the knee instability.

Points for Gait Training

Only some prosthetic knees allow stance knee flexion. The action the patients has to

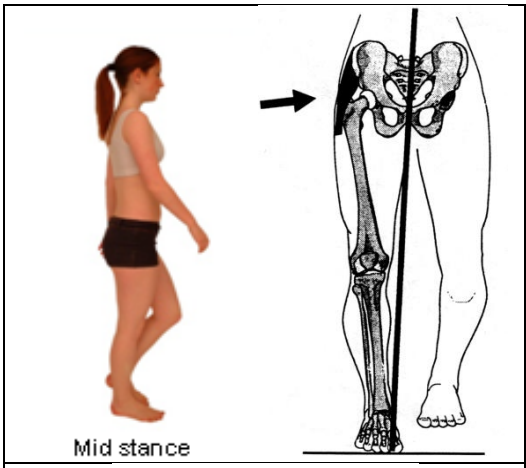
learn at loading response (LR) will depend on the function of the prosthetic knee joint: -

- If no LR knee flexion: teach patient to extend the hip (feel for gluteus maximus contraction) from IC throughout stance.
- If LR Knee flexion (normally a mechanical 'give') – teach the patient not to brace their knee back with hip extension but allow the hip to relax and knee to give.

Changing from a knee without LR knee flexion to one with it can be a challenge as pulling the prosthetic knee back at IC is a hard habit to break. Also, patients often do not like the feeling of the knee bending as they may associate it with instability and/or falls.

Look out and correct for patients 'riding the yield' (see point above).

Normal gait phase 3: Mid stance (MSt)[1,4,5]



Objective:

- Begins stance limb support i.e. full weight bearing requiring maximum stability
- Forward trunk and stance limb progression
- Raise body – increase clearance for swing of contralateral leg.

Second Rocker[1]**:** Ankle

Pelvis: Maximum lateral shift resulting in a hip adductor moment controlled by eccentric contraction of ipsilateral gluteus medius

Hip: Extension

Knee: Extension to - 5^0

Ankle: Dorsiflexion

GRF: Initially through the hip and posterior to the knee giving a knee flexion moment, then anterior to the knee and ankle giving a knee extension moment

Muscles: Quadriceps and soleus early MSt then just soleus

Prosthetic Issues to consider

Mid-stance requires maximum knee stability which can be provided prosthetically in several ways: -

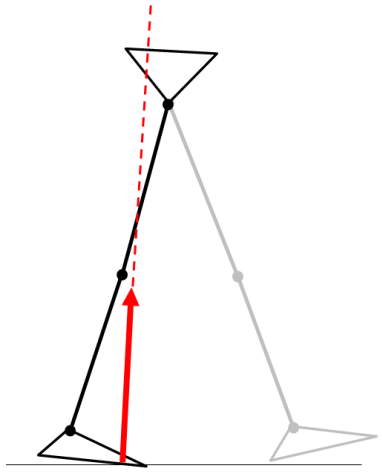
- Alignment (all knees will be aligned for stability at MSt)
- Knee mechanics e.g. geometric lock, weight activated lock, or yield and augmented as necessary by active hip extension.

If knee is unstable, ensure correct alignment and accommodated hip flexion contracture.

Points for Gait Training

Patient must learn full weight transference with normal lateral shift of the pelvis.
Patient will require good ipsilateral gluteus medius strength to control pelvic stability.
It is crucial that gluteus medius is strengthened to function well isometrically, concentrically and eccentrically and this should be started as soon as possible.
Re-educate hip extension and anterior pelvic shift with upright posture and normal lumbar lordosis.
Ensure patient understands when his/her prosthetic knee is stable for full weight bearing and how to augment knee stability by generating a hip extension moment if required. Learning to trust the knee is an integral part of gait training.

Normal gait phase 4: Terminal Stance (TS)

 Terminal stance	**Objective:** Forward trunk progression beyond the trailing limb. **3rd Rocker[1]:** Forefoot
	**Pelvis:** Beginning to retract **Hip:** Extension to 10^0 allowing the body to advance beyond the stance leg. **Knee:** Extending then flexion just begins. **Ankle:** Plantar flexion to heel rise **GRF:** Posterior to hip and anterior to the knee generating a hip and a knee extension moment and then just posterior to the knee generating a knee flexion moment **Muscles:** Soleus and gastrocnemius

Prosthetic Issues to consider

Continue full weight transference.

Encourage anterior pelvic shift with hip extension and weight transference through the prosthetic forefoot.

Check for anterior thigh inclination. If not, re-measure hip flexion contracture and ensure it is fully accommodated.

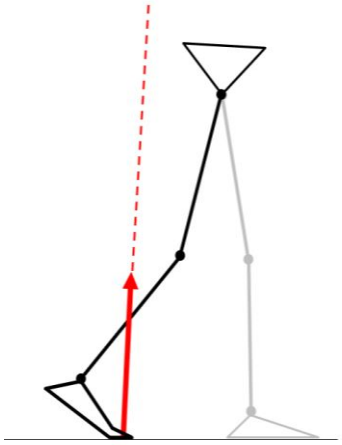
Points for Gait Training

Prosthetic knees that prevent knee flexion under full load delay swing phase and forward progression therefore increasing the energy cost of walking e.g. poorly adjusted mechanical or hydraulic weight activated stance controls.

Note: some knees require offloading to release stance control, for example, sensitive weight activated knees so patients using these knees will have to hip hitch to augment swing.

Prosthetic knees that require weight transference through the prosthetic toe to release stance control will encourage normal movement.

Normal gait phase 5: Pre swing (PSw)[1,4,5]

 Pre swing	**Objective:** • Position limb for swing • Begin second period of double support **Fourth Rocker**[1] **:** Toes
	**Pelvis:** Retraction, and medial shift as the weigh is transferred on to the contralateral limb, and obliquity 'down' to ipsilateral side **Hip:** Extension decreases and flexion begins **Knee:** *Passive* knee flexion to 40^0 due to rocker and GRF being posterior to the knee **Ankle:** Plantar flexion **MTP joints:** Dorsiflexion **GRF:** Posterior to knee **Muscles:** Gastrocnemius and soleus, rectus femoris and flexor component of adductor longus.

Prosthetic Issues to consider

Lack of pre swing knee flexion caused by; the knee too stable, high flexion resistance, overly sensitive brake, insufficient toe load or posterior knee alignment.

Points for Gait Training

Ensure patient gets anterior thigh inclination and is coming on to the toes of the prosthetic foot to destabilise and flex the prosthetic knee. Some prosthetic knees may not allow this (refer to section on locked and weight activated knees).

A hip flexion contracture not accommodated will reduce anterior pelvic shift and the ability of the amputee to get weight through the prosthetic toes. This can make releasing the stance control of some prosthetic knees difficult. It may also shorten the step length on the contralateral side.

Correct any tendency for the patient to have upwards pelvic obliquity (hitch). The pelvis should be dropping very slightly to the ipsilateral side controlled by an eccentric then isometric contraction of the contralateral gluteus medius.

Normal gait phase 6: Initial Swing (ISw)[1,2,5]

Objective:	Advance limb during contralateral single limb support.
Pelvis:	Greatest pelvic tilt (drop) of 5^0 just after toe off and anterior rotation (about vertical axis).
Hip:	Flexion
Knee:	Flexion to 60^0.
Ankle:	Dorsiflexion to neutral.
Muscles:	Iliopsoas, biceps femoris and tibialis anterior.

Prosthetic Issues to consider

If excessive or insufficient heel rise then adjust swing flexion resistance (if an option).

Check prescription against patient's walking speed: is knee cadence responsive or only appropriate for single speed walking.

Prosthetic knees that have difficulty controlling heel rise during increased cadence delay swing.

Reduced PSw knee flexion and delayed swing will cause the patient to hip hitch, vault or circumduct at ISw. However, with prosthetic knee prescriptions, PSw flexion will be delayed to ensure safety.

Points for Gait Training

In PSw then at ISw the hip should begin to flex to continue forward limb movement.

If swing has been delayed either due to reduced PSw knee flexion or excessive heel rise and/or if the amputee has weak hip flexors he/she will augment hip flexion with

- vertical pelvic tilt (hitching)
- and/or vaulting
- and/or posterior pelvic tilt.
- Hip circumduction

It is important to correct hip hitching, vaulting and initiation of swing with posterior pelvic tilt. Physiotherapist should re-educate anterior pelvic rotation throughout swing beginning at ISw

Normal gait phase 7: Mid Swing (MSw)[1,2,5]

Objective:	Advance the limb during contralateral single limb support
Pelvis:	Reducing vertical pelvic tilt (drop) and continuing anterior rotation
Hip:	Flexion
Knee:	Begins to extend reversing the direction of the shank.
Ankle:	Neutral
Muscles:	Iliopsoas and tibialis anterior.

Prosthetic Issues to consider

Most prosthetic knees simulate this phase well unless excessive heel rise at ISw has delayed forward progression of the shank. This will cause a long prosthetic step by the time the knee begins to extend.

Polycentric knees shorten during swing so facilitating ground clearance of the swinging limb.

Fine adjustment of swing control is required to ensure prosthetic foot is in a natural position.

Points for Gait Training

Due to the lack of quadriceps and therefore active knee extension the amputee will require to generate a hip extension moment earlier than normal to decelerate the extending prosthetic knee.

Check for delay in swing by noting the position of the swing leg relative to the stance leg in MSw

Check for anterior pelvic rotation – the patient should be able to maintain it against resistance.

Normal gait phase 8: Terminal Swing (TSw)[1,4,5]

Objectives:	• Preparation for stance and optimum weight acceptance. • Still single limb support, which began with a vertical tibia and ends with the heel on the ground.
Pelvis:	Slight vertical tilt (drop). Greatest degree of anterior rotation ready for IC
Hip:	Reducing flexion
Knee:	Extension – the hip and knee are in the same attitude as in MS while limb advancement is controlled by knee extension.
Ankle:	Dorsiflexion
Muscles:	Hamstrings, quadriceps and tibialis anterior.

Prosthetic Issues to consider

Most prosthetic knees with pneumatic or hydraulic swing control should, with the proper adjustments, accommodate fast walking.

Some knees however may still have difficulty controlling deceleration resulting in terminal swing impact, conversely increased extension resistance may prevent full knee extension at terminal swing.

Disrupted swing alters forward progression of the body increasing the energy expenditure of walking.

Points for Gait Training

The transfemoral patient will require to extend their hip to extend the prosthetic knee.

Most patients will require to practise co-ordinating flexion and extension muscle activity from ISw through MSw to TSw. This will re-educate control of step length and deceleration.

Gait Training Summary

Aims for re-education of prosthetic stance

- Weight transference through the prosthetic foot from the heel at Loading Response (LR) to the toes at Pre –Swing (PSw)
- Hip extension with anterior pelvic shift maintaining upright posture and normal lumbar lordosis.
- Anterior pelvic rotation at Initial Contact (IC) to posterior pelvic rotation at PSw with reciprocal rotation of the shoulders.
- Vertical pelvic tilt (drop) at PSw. NO VERTICAL PELVIC TILT (HITCHING).
- Stability and confidence with full weight bearing and lateral pelvic shift at Mid Stance (MSt) and Terminal Stance (TSt).
- Ability to use prosthetic knee to its full potential i.e. wherever possible LR knee flexion and PSw knee flexion.

Aims for re-education of prosthetic swing

- Pre Swing knee flexion with weight transference through prosthetic toe, hip extension, anterior pelvic shift, normal lumbar lordosis and upright posture.
- Vertical pelvic tilt (drop) from PSw to ISw
- Hip flexion from toe off at IS to extension from MS to TS. ***NO POST PELVIC TILT, HITCHING OR VAULTING.***
- Controlled, soft IC with heel and even step length and normal step width.
- Full knee extension for Initial Contact

Sitting and stairs

Re-education of sitting

The goal of re-educating any functional activity must be to restore normal movement. However, the type of prosthetic knee a patient has been prescribed may alter the method he/she will require to adopt to stand and sit down and/or ascend and descend stairs.

Stand to sit: Try as normal but if the patient is unable to bend the prosthetic knee they may need to do one or more of the following: -

- Alter the position of the foot either to be in front or behind the hip
- Off load or load the knee
- Activate or deactivate the yielding mechanism
- Actively extend or flex the hip

Please check the individual knee sheets to confirm the exact method that should be used.

Sit to stand: Again try as normal but the patient may require to off load the knee as it is extended. Please check the individual knee sheets to confirm the exact method that should be used.

Re-education of stairs

Most amputee patients will ascend and descend stairs one step at a time ('*step together')* as this is all they are fit to do and should do due the condition of their remaining foot.

However, if a patient is fit, strong and mobile they should be able to do foot over foot descent if they are prescribed a knee with this function. This would be a knee with a hydraulic yielding mechanism (whether mechanical, fluidic or microprocessor controlled) that offers resistance and allows the patient to lower the leading foot down in a controlled manner ('*foot over foot yield*'). The correct positioning of the prosthetic foot on the step is crucial both to enable the patient to achieve this but also for safety reasons – please consult individual knee sheet for further information.

Foot over foot ascent is possible with some microprocessor knees (see that section of the knee guide) but is still not practical with most prosthetic knees currently on the market.

Quick reference guide links

Click on the hyperlinks below to view the quick reference guides for the knee which are describe in full in the following chapters:

Chart 1: locked, mechanical

Chart 2: free, mechanical single axis

Chart 3: free, mechanical polycentric

Chart 4: free, microprocessor controlled

Alternatively, if you copy and paste the link below to the Knee Guide website all of the about quick reference guides can be downloaded:

http://www.knowledge.scot.nhs.uk/westmarckneeguide.aspx

Youtube channel links:

The companies also have online video channels where educational and informative videos can be found on various components, exercises and functional activities.

Blatchford - YouTube

Ortho Europe - YouTube

Össur Academy - YouTube

ottobock - YouTube

Generic Knee Types

Locked knees

Semi-automatic knee lock (SAKL)

Examples

- **Blatchford** Compact SAKL
  S200: benefits from a side mounted lever that allows the therapist to release the knee while kneeling in front of the user. It also unlocks without a toe load.
- **Ottobock** 3R33
  3R41
  3R31 (Prosedo)
- **Össur** NOFM0

Description: Single axis knee unit with locking mechanism that is released to sit down and is locked before walking.

Activity: Low activity (see Appendix 2) individuals who require complete stance stability.

Patient requirements: For use with less active patients who require additional stability. They may have history of falls and balance issues.

Stance control: this knee is locked at all times during walking

Swing control: this knee is locked at all times during walking

Gait Training requirements

Walking: -
Stance: teach the patient to weight bear and learn that knee is locked and will never give way unless they forget to lock it by not fully extending the knee joint when they stand up.

Swing: teach the patient to hip hitch as without knee flexion this is the only way they can gain clearance. Normally, the prosthesis will be a little shorter than the intact limb to facilitate clearance in swing.

Stand to sit: patient will require to unlock the prosthetic knee whilst standing, normally by pushing down/pulling up on a small lever fixed proximally to the socket. All knees will unlock more easily if foot is slightly behind and weight is on the toe or the prosthesis is unloaded. Following this method also reduces strain on the cable.

	
Lever: pull	Lever: push

Note that there is an Ottobock SAKL called the ***Prosedo*** *that has a hydraulic cylinder which will offer some resistance as the patient sits down to help slow descent and take the strain off the remaining limb.* The patient will require to be taught to feel this yield to use it correctly.

Sit to stand: as normal and once upright patient must be taught to straighten and lock the knee by maintaining an upright posture and extending their hip. Occasionally, a patient may prefer and/or be safer to lock the knee before standing.

Stairs: One step at a time i.e. ‘step to pattern’ leading with intact limb when ascending and prosthetic limb when descending.

EXAMPLE: Semi-automatic Knee Lock

Make	**Blatchford**
Name	**Blatchford compact SAKL**
	
	Weight of unit: 325g, slim, low profile
Activity Level	Low activity transfemoral
Suitability	High degree of stance stability Max Patient weight: 125Kg Range of knee flexion: 140 °
Distinguishing features	Stance control: Locked Swing Control: Locked
Adjustments	Screw to adjust play in knee that should be maintained annually (see manufacturer's instructions)
Implications for physio	Patients will require to hip hitch to facilitate clearance in swing
Sitting	***Stand to sit:*** To release the knee lock push down on lever that is attached to socket making sure a flexion load is NOT being applied to the knee and that the foot is on the ground. There are various ways of doing this: - • Have foot slightly behind and weight on the toe • Have foot underneath patient and flat but push residuum back OR patient can sit down with the knee locked but to release it once sitting they should: - • Have heel on ground and push through prosthesis • Or pull on toe with walking stick or push toe against wall. Patient should never try to unlock the knee when sitting with foot off floor. Clear patient instructions can be found via the following link: http://www.blatchford.co.uk/catalogue/knees/compact-sakl/ifu/938089WEB-GB%20Iss9.pdf ***Sit to stand:*** As normal and once upright patient must be taught to straighten the knee to lock it by maintaining an upright posture and extending their hip. Occasionally, a patient may prefer and/or be safer to lock the knee before standing.
Stairs	'Step to pattern'

EXAMPLE: SAKL with resistance for balanced stand to sit

Make	**Ottobock**
Name	**3R31 Prosedo**
	
	Weight of unit: 600g (inclusive of a full length tube and female adaptor)
Activity Level	Low activity transfemoral/knee disarticulation/hip disarticulation
Suitability	High degree of stance stability Max Patient weight: 125Kg Range of knee flexion: 145 °
Distinguishing features	Connector: standard pyramid or threaded for a longer residuum Stance control: Locked with hydraulic cylinder to resist sitting down Swing Control: Locked Lock is sided i.e. cable has to run up the lateral aspect of socket but is easily changed if required
Adjustments	Resistance (from hydraulic cylinder) for sitting down is adjusted to suit individual's weight and needs
Implications for physio	Patients will require to hip hitch to facilitate clearance in swing
Sitting	***Stand to sit:*** Patient should unlock the prosthetic knee whilst still standing, by pulling up on a small lever fixed proximally to the socket. It will unlock when partially loaded so the patient does not have to unload it or put the foot behind them when doing so. ***This knee has a hydraulic cylinder which will offer some progressive resistance as the patient sits down to help slow descent and take the strain off the contralateral limb.*** The patient should be taught how to activate the yield by keeping their weight on the limb as they sit so they sit down in a balanced fashion with weight equally distributed between both feet. Occasionally, a patient may prefer and/or be safer, sitting with the knee locked. In this case a standard SAKL would be a more appropriate prescription. There is a manual lock release button underneath the blue front cap that the patient can press to release the knee lock should they need to do so.
Sit to stand:	As normal and once upright, patient must be taught to lock the knee by maintaining an upright posture and extending their hip. Occasionally, a patient may prefer and/or be safer to lock the knee before standing.
Stairs	'Step to' pattern

Manual knee lock (HOKL)

Examples

- **Össur** — Balance Knee
  NOFM1 (4 bar)
  NOFM2 (weight activated, extension assist)
- **Ottobock** — 3R93 (weight activated)
- **Blatchford** — Stabilised Knee with Manual Knee Lock (ESK & MKL)
  S400 knee (4-Bar)

Description: free knee unit (see following sections descriptions of each generic knee type) with optional locking mechanism.

NB some of higher activity knees have an optional lock that can be for specific activities e.g. KX06, but these are not included in this section

Activity: low to medium activity (see Appendix 2) individuals who require complete stance stability at certain times or for specific tasks.

Patient requirements: for use with less active patients who require the additional stability of a locked knee at certain times or during specific activities. Alternatively, a primary amputee who is considered to be borderline for managing a free knee, may also benefit from this knee.

Stance control: will depend on the type of knee chosen, it may be weight activated e.g. ESK, Balance Knee, NOFM2 or 3R93 or polycentric 4 bar knee e.g. NOFM1, S400, Balance Knee (see following sections for more information).
The knee can be locked by the patient; the locking mechanism varies depending on make of knee.

Swing control: this knee is free (may be weight activated or polycentric 4 bar knee) with various controls of swing (refer to following sections for more information once the knee type is known) and can be locked by patient.

The patient may require the prosthesis to be shortened if using it locked for the majority of the time.

<u>Gait Training requirements</u>

*****Patient must be taught how to use the manual lock i.e. what position the lever requires to be in for knee to be locked and then unlocked for sitting and the position for it to be free for walking. They should be familiar with how to change between these positions.***

Walking: -
Stance: teach the patient to weight bear and learn when the knee is stable if unlocked (see following sections) and that when the knee is locked it will never give way unless they forget to lock it when they stand up.

Swing: teach the patient to use free knee as per instructions in following section and how to use it when locked i.e. hip hitch. *Patient may require prosthesis to be shortened if using it locked for the majority of the time.*

Stand to sit: teach the patient to use free knee as per instructions in following section. If they are using the knee locked, the patient will require to unlock it whilst standing, normally by pushing down on a small lever fixed proximally to the socket. All manual knee locks will require the patient to offload or put the foot slightly behind them to be able to release the lock. This is for safety as the knee will remain initially stable and also to prevent strain on the cable.

Sit to stand: as normal if using free. If using the lock the patient must be taught how to straighten the knee to lock it by maintaining an upright posture, extending their hip and moving position of lever to manually lock the knee.

Stairs: 'step to' pattern

EXAMPLE: Hand Operated Knee Lock: weight activated

Make	**Blatchford**
Name	**Blatchford Stabilised Knee (ESK) with Manual Knee Lock**
	 
	Unit weight: 1200g
Activity Level	Low to moderate activity transfemoral (1-3) Cadence responsive
Suitability	High degree of stance stability or require lock for specific task Max Patient weight: 125kg Range of knee flexion: 140 °
Distinguishing features	Optional manual, patient operated lock Stance control: weight activated stance control with lock option Swing Control: pneumatic swing phase control (PSPC) with lock option
Adjustments	Proximal full alignment Pneumatic cylinder can be adjusted (flexion and extension resistance) to suit the individual wearer's gait characteristics. Brake sensitivity can be increased or decreased
Implications for physio	Patients will require to learn how to walk with knee locked (as per SAKL) and as a free weight activated knee (see below). They should be shown how to operate manual lock, see following point.
Sitting	***Stand to sit:*** Teach the patient to use free knee as per instructions in following section. If they are using the knee locked the patient will require to unlock it whilst standing by pushing down on the lever fixed proximally to the socket. Patient will require to off load or put the foot slightly behind them to be able to release the lock. ***Sit to stand:*** As normal if using free. If using the lock, patient must be taught how to lock the knee by maintaining an upright posture, extending their hip and moving the position of lever to manually lock the knee (push down will make it free and pulling up will lock it). NB remember that patient must re-lock knee if it has been unlocked. Pt can lock the knee before standing if stability is an issue.
Stairs	**'Step to' pattern**

EXAMPLE: Hand operated Knee Lock: polycentric 4 bar

Make	**Össur**
Name	**NOFM1** (or **NKFM1** with a laminated adapter to allow lower build height)
	 
	Unit weight: 590g – 720g (depending on connector)
Activity Level	Low activity transfemoral or knee disarticulation Single speed walking
Suitability	High degree of stance stability or require locked knee for specific activity Max patient weight: 136 Kg Range of knee flexion: 150 °
Distinguishing features	Polycentric 4 bar knee Stance control: axial geometry (aligned for stability – see following section for more information on polycentric knees) with lock option. Swing Control: integrated extension spring with lock option and adjustable axial friction to dampen extension. Also, prosthesis effectively shortens in swing due to polycentric knee design. Stability can be adjusted. To use as a free knee the patient would pull the locking lever up and 'hook it' so the knee stays in an unlocked position.
Adjustments	Extension assist and dampening.
Implications for physiotherapy	If using free: patients will require to learn how to walk with a free polycentric knee (see following section). Patients must be clear on how the manual lock functions and be able to use it safely – see following point. If using locked: patients will require to hip hitch to facilitate clearance in swing. **CAUTION:** the patient must understand that this knee will give way/ 'collapse' if not locked and not in full extension on weight bearing. If the MDT is issuing this knee to a less active patient with a hip flexion contracture they must consider the risk of this contracture increasing between visits to prosthetic service and the impact this will have on knee stability and falls risk.

Sitting

Stand to sit:

Teach the patient to use free knee as per instructions in following sections. If they are using the knee locked they will require to unlock it whilst standing to sit by pulling up on the lever fixed proximally to the socket (see manufacturer's instructions). They should be shown how to offload or put the foot slightly behind to release the lock easily and reduce wear on the cable.

Sit to stand:

As normal if using free. If using the lock, the patient must be taught how to lock the knee by maintaining an upright posture and extending their hip and moving the position of the lever to manually lock the knee i.e. 'unhooking' it.

Stairs

'Step to' pattern

Free Knees

Mechanical

Single Axis – weight activated

Examples

- **Össur** Balance Control Knee
  NOP4
- **Ottobock** 3R15/3R49
  3R90
  3R92
- **Blatchford** Stabilised Knee (ESK)
  Smart IP (weight activated stance control with microprocessor control pneumatic cylinder swing resistance)

Description: Single axis knee unit with additional weight activated breaking mechanism.

Activity: Low to medium activity (see Appendix 2)

Patient requirements: adequate strength and balance to activate/control a free knee joint and able to demonstrate adequate cognitive ability to follow instructions to use the device safely.

Stance control: This knee will be aligned for stability with an additional weight activated braking mechanism, which adds resistance to the knee on weight bearing preventing knee flexion. The brake is activated on weight transference through the foot within the knee flexion range of 0 – 30^0. The brake is primarily designed for stability in stance but can be set to be more or less stable depending on the needs of the patient. The more sensitive the brake in the 3R49, NOP4 and ESK the more the patient will have to offload it to initiate swing flexion and sitting. However, the ESK will allow a smooth transition from stance to swing if the patient can load the toe and the brake is not set to be too sensitive (for details of this see individual ESK descriptor). If the patient is fighting an oversensitive braking mechanism they will feel this as a ‘popping’ sensation and the brake should be adjusted to be less sensitive. The brake in the Balance Control Knee, the 3R90 and 3R92 automatically releases during forefoot loading at terminal stance allowing effortless initiation of swing phase without the patient requiring to hip hitch irrespective of how sensitive the weight activated brake has been set.

Swing control: There are various controls depending on the patient’s requirements i.e. pneumatic, microprocessor pneumatic (SmartIP) hydraulic or friction.

Gait Training requirements

Walking: -
Stance: teach the patient to extend the hip and the prosthetic knee from IC. ESK has stance flexion bumper which allows stance flexion so in this case the patient

should learn to trust this to feel a small ‘bounce’ at IC. This should be tuned to the amputee’s weight/activity.

Swing: At PSw aim to re-educate normal movement. If the brake is very sensitive the patient will usually require to off load the limb and initiate swing with hip flexion at ISw when the toes are off the ground. If the patient tries to fight the brake it is likely that he/she will develop a painful distal end of femur. Loss of PSw knee flexion is inevitably replaced by increased pelvic obliquity (hitching) to aid swing limb advancement.

Stand to sit: try as normal but if lock is holding patient back teach off loading the knee to release braking mechanism.

Sit to stand: as normal but may require to off load the knee as it is extended if weight activated brake is very sensitive.

Stairs: ‘step to’ pattern

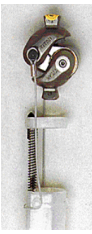
EXAMPLE: Weight Activated Single Axis Knee

Make	**Össur**
Name	**Balance Control Knee**
	 Weight of unit: 590g
Activity Level	Low activity transfemoral or knee disarticulation who use walking aids
Suitability	High degree stance phase stability – weight activated friction brake and alignment Patient needs to be able to understand knee and have enough residual limb control to activate and deactivate braking mechanism. Swing phase control: mechanical friction and extension assist Suitable for single walking speed Max Patient weight 125kg Range knee flexion 130°
Distinguishing features	Adjustable stance control - weight activated knee brake. Allows normal gait pattern to occur as patients do not need to hip hitch at terminal stance for swing to occur therefore lower energy expenditure
Adjustments	Optional extension assist (adjustable) Sensitivity of friction braking mechanism
Implications for physio	At loading response teach patient to actively extend hip and prosthetic knee Teach normal movement at pre swing for initiation of swing phase.
Sitting	Foot behind or simply offload
Stairs	Step together with prosthetic knee in extension when weight bearing.

EXAMPLE: Weight Activated Single Axis Knee

Make **OTTOBOCK**

Name **3R15 / 49 modular single axis knee joint**



Weight of unit 355g

Activity Level Low to moderate activity transfemoral

Suitability
High degree stance phase stability – weight activated brake.
Moderate swing phase control suitable for single walking speed
Max Patient weight 100kg (220lbs)
Range knee flexion 150°

Distinguishing features
Stainless Steel
Adjustable stance control - weight activated knee lock i.e. brake.
Swing - constant friction, extension assist
The point at which the brake activates is dependent on how sensitive it is set to be and how well the patient loads it.
If set up correctly for a low mobility patient then brake will activate at IC

Adjustments can be difficult
This knee can be difficult to adjust. Ideally, the Prosthetist will use alignment as the main source of stance stability rather than relying on the friction brake.
Swing: increase or decrease friction and extension assist (brake and friction are linked)
Common faults with this knee -

- **Reduced knee flexion in swing:** caused by loading knee at PSw and activation of friction brake which can prevent knee flexion. This is more of a problem if the brake is set to be very sensitive.
- **Increased heel rise +/- terminal swing impact**: caused by insufficient knee friction, this can be increased.

Implications for physio
Teach normal movement at pre swing for initiation of swing remembering that patient may need to off load to deactivate friction brake. If this is the case, they will commonly hip hitch at this point.
Gait training can produce distal femur pain if patient does not off load when the brake is set too sensitive.

Sitting Take weight off limb to sit down.

Stairs Step together

EXAMPLE: Weight Activated Single Axis Knee

Make	**OTTOBOCK**
Name	**3R90 and 3R92 single axis modular knee joints**

	Weight of unit 3R90=660g, 3R92=760g
Activity Level	3R90 Low to moderate activity transfemoral 3R92 mod to high activity transfemoral
Suitability	High degree stance phase stability –weight activated at heel strike Swing phase control • *3R90* is friction controlled and includes mechanical extension assist for the patients who need more stability • *3R92* is controlled by a pneumatic cylinder suitable for varying walking speeds Max Patient weight 125kg Range Knee flexion 135 °
Distinguishing features	Adjustable stance control - weight activated knee lock i.e. brake. Allows normal gait pattern to occur as the break releases automatically during forefoot loading therefore does not require a hip hitch at PSw for swing clearance to occur. The point at which the brake activates is dependent on how sensitive it is set to be and how well the patient loads it. If set up correctly for a low mobility patient then brake will activate at IC
Adjustments	Adjustable mechanical extension assist with 3R90 Independent adjustment of flexion and extension resistance with 3R92 Ability to adjust sensitivity of braking mechanism
Implications for physio	At IC teach patient to actively extend hip and prosthetic knee. Check brake is activating, if it is not, liaise with Prosthetist. Teach normal movement at PSw for initiation of swing phase and release of weight activated brake i.e. weight transference forward over the toe. Hip hitching is not necessary as there is no brake to release at the end of stance.
Sitting	Foot behind or simply offload
Stairs	Step together only.

EXAMPLE: Weight Activated Single Axis Knee

Make **BLATCHFORD**

Name **ESK with PSPC or SMART IP**

Weight of unit 1130 -1150 g

Activity Level Low to moderate activity transfemoral (2-3)

Suitability High degree of stance stability – weight activated brake mechanism with pneumatic control of swing and optional stance flexion feature

Max Patient weight: 125Kg

Range of knee flexion: 140 °
Cadence responsive

Distinguishing features **Stance control:**

Load activated mechanical stance control

Stance flexion feature: knee unit uses compressible rubber elements (four different types to suit different activity levels) to give knee flexion following initial contact for cushioning.

The ESK has the ability to work in 2 different ways.

1. The ESK will allow a smooth transition from stance to swing so long as it is not set at maximum stability and adjusted for that particular patient. This means that the patient will not have to offload the knee to initiate flexion. If the unit does not release smoothly, get your Prosthetist to check/adjust the unit until it does. Using this setting it is possible for most people to have leg over leg descent on gentle slopes once the unit is adjusted correctly.
2. If the patient requires the unit to be set to maximum stability the ESK works like the other safety knees already mentioned i.e. the patient would have to offload the knee unit to initiate flexion. Leg over leg descent on gentle slopes ***is not*** possible with this setting.

Swing Control: The ESK is available in various shin models offering different methods of swing control as follows: -

- Pneumatic with Pneumatic Swing Phase Control (PSPC)
- Pneumatic – electronic: Intelligent prosthesis SMART IP

Adjustments	Independent control of swing and stance Three Stanceflex bumpers are available – white, orange and blue. The knee is supplied with orange as standard. Excessive stance-flexion with a heavier pt can cause the brake to work much harder.
Implications for physio	Stance flexion from IC i.e. 'bounce'/give from rubber bumper. Weight activated lock therefore cannot do step ups, free fall stairs, stepper machine Teach normal movement at pre swing for initiation of swing remembering that amputee may need to off load to deactivate friction brake if set to be very sensitive. The more sensitive the brake is set up the more the patient will have to offload and hip hitch to facilitate clearance in swing. Gait training can produce distal femur pain if patient is not off loading when the brake is set to be sensitive. If patient is controlling prosthetic knee really well liaise with Prosthetists to reduce sensitivity of braking mechanism.
Sitting	*Stand to sit:* try as normal but if weight activated brake is making this difficult ensure they have off loaded the knee and/or are loading prosthetic toe to release braking mechanism. *Sit to stand:* as normal but may require to off load the knee as it is extended.
Stairs	Step together

Single axis - alignment controlled only

Example

- **Ottobock** 3R95 (original model = 3R45)

Description: Single axis knee aligned for stability

Activity: High

Patient requirements: full hip extension and good residuum strength. Patients do require exceptional control as there are no additional features to augment stability and stance beyond posterior placement of the knee centre.

Stance control: alignment only

Swing control: adjustable Hydraulic Swing Phase Control; controlling flexion and extension resistance

Gait Training requirements

Walking: -
Stance: Teach patient to extend their hip and prosthetic knee from IC and maintain this strongly through single limb support until PSw. Patient will have to be careful on slopes and uneven terrain as this knee has no additional stance control and relies on the patient to generate a hip extension moment to augment the alignment stability of the knee.

Swing: aim for normal knee movement with PSw knee flexion.

Stand to sit: as normal

Sit to stand: as normal

Stairs: one step at a time

EXAMPLE OF Alignment Controlled single axis knee

Make	**OTTOBOCK**
Name	**3R95 modular knee joint**  **Unit weight 360g**
Activity Level	High activity transfemoral
Suitability	Variable walking speeds, minimal stance stability. Good residual limb strength and full hip extension required to control knee. Good for active person but not for someone who participates in sporting activities. Good for limited space due to small dimensions Stiff heel required Max Patient weight 150kg Range knee flex ion 135°
Distinguishing features	Lightweight (aluminium alloy) Hydraulic swing phase control Small joint Stance stability - by alignment and active residual limb extension on initial contact
Adjustments	Independent swing phase flex and ext resistance - small range of adjustment. Extension resistance automatically increases at end of swing. Sagittal alignment of knee is altered to increase or decrease stability – if the knee centre is aligned posterior relative to the reference or weight bearing line this will result in increased stance stability and may make initiation of swing more difficult.
Implications for physio	Patient needs good control of hip joint and good residual limb strength. Teach hip extension from initial contact throughout stance to control knee. CAUTION: if patients are falling and this is affecting their confidence check for changes in hip extension range of movement and always inform the Prosthetist if they are developing a hip flexion contracture.
Sitting	As normal.
Stairs	Step together

Hydraulic yielding

Examples

- **Ottobock** 3R80
- **Ortho Europe** Sensor knee
- **Össur** Mauch
- **Blatchford** KX06 ***NB this is a polycentric knee
  Mercury

Description: yielding knees allow patients to achieve foot over foot descent on stairs and slopes and generally offer a small degree of stumble recovery. The yield is achieved by an increased resistance to knee flexion during stance using a fluid within the knee. The level and timing of this resistance is set by the Prosthetist. The yield is not intended as the main control of stance but as an added feature to allow stair and slope descent

Activity: moderate to high activity.

Patient requirements: all of the above units require good hip extension range of movement or any flexion contracture accommodated and sufficient muscle strength in the residuum to activate and deactivate stance control.
Each yielding knee has specific requirements for activation and deactivation of stance control **(refer to individual knees on following sheets)**

Stance control: will be alignment controlled with the added safety of the hydraulic yielding mechanism. This means that the knee should never give way suddenly but would yield allowing time for the patient to recover. If the knee is suddenly shooting/collapsing the patient should be seen by their Prosthetist. This can be caused by an alignment issue and/or a heavy heel strike generating a knee hyperextension moment and turning off the stance resistance/ yield.
Stance, as mentioned above, is activated and deactivated in different ways **(see individual knees): -**

- *position dependent*; yield is activated by full knee extension and loading e.g. Mauch, Mercury, KXO6. Alignment can be critical for these knees. Important to note that for Mauch/ Mercury the knee should be aligned unstable so as to minimise the chance of accidental hyperextension/ switching off of the yield.
- *load activated*: yield activated by loading e.g. 3R80.

  Unlike other hydraulic knees, the Sensor knee is both position and load activated.

Swing control: hydraulic stance control must be deactivated appropriately to allow swing to occur **(see individual knees).**

Gait Training requirements: with yielding knees the main goal is to ensure the patient learns to trust the knee when it yields, especially if they have never used this type of knee before. Teaching the patient for the first time to allow the residuum to flex on slopes and stairs, instead of extend, needs time and patience.

Start in parallel bars and allow patients to feel the resistance that the yield offers i.e. allow the patient to feel that the knee is not going to give way suddenly
This is also nicely demonstrated to the patient when they sit down from standing (see below).

Walking
Position dependent hydraulic yielding knees
To deactivate stance with the KX06, Mercury and Mauch units it is important that the patient is able to step past the prosthetic leg, loading the prosthetic toe thereby creating a knee hyperextension moment. Patients with weak hip extensors or hip flexion contractures that are not accommodated within the socket alignment may not be suitable therefore for this type of knee. It is easier to destabilise the KX06 in TSt due to its polycentric design and the ICOR being proximal when the knee is in extension.
Take particular care if a patient has a heavy heel strike as this could disengage stance by generating a knee hyperextension moment with the above-mentioned units at initial contact and the knee would give way. This would usually only be problematic on stairs, slopes or uneven ground if the alignment of the prosthesis is correct.

Load activated hydraulic yielding knees
To activate stance flexion resistance with the **3R80** and **Sensor knee** the patient has to load the heel at initial contact. Stance will then disengage automatically allowing swing to occur when terminal stance is reached or if foot load is reducing i.e. at PSw. Since terminal stance has to be reached to deactivate stance these knee units would not be suitable for amputees with **fixed flexion contractures that are not accommodated** within the socket alignment or particularly weak hip extensors. These 2 knees should not have stance control disengaged by heavy heel strike.

Turning
With the KX06, Mercury and Mauch units take care that stance is not disengaged unintentionally by creating the knee hyperextension moment on turning. However, if correctly aligned i.e. slightly unstable, this should not happen.

Stand to sit
Can do this normally using the yield for a slow descent or without the yield for a fast descent **(see individual knees).** Sitting down is a good way for the patient to learn to use the yield as mentioned above. Just make sure the chair is stabilised by therapist or against a wall. Encourage the patient to transfer weight onto limb and feel the yield. With these knees (compared to fluidic and MPKs) it is normal for the patient to experience less yield as they get closer to the chair.

Stairs
Begin by using a small step in parallel bars in preparation for stairs.
Practise targeting of the foot half off the step. It is important to establish exact foot position as this will facilitate knee flexion.
Encourage patient to activate the yield (transfer weight onto the prosthesis, allow the knee to bend without leaning backwards or forwards – ‘head up to ceiling’ is a good prompt). It is important that they remember to move their hands at the same time. If they do not do this, then reaching the next step on the prosthetic side is very difficult.

Sometimes, a slight leaning forward to get their shoulders and head above the prosthesis can be a big help. Also, placing the intact foot over the edge of each step can make things easier by minimising the distance they have to reach for the next prosthetic step.
Step past with remaining leg. Patients must learn to do this with all or most of their weight through the prosthesis or yield will not be activated. This is more important with the 3R80 and Sensor knee as the yield is only activated by loading.
Start on bottom step with 2 rails and gradually work back up to do more consecutive steps reducing support as the patient gains in confidence. Physiotherapist can help by placing one hand on the front of prosthetic knee and other hand on the front of pelvis on that side to encourage patient to stay over the knee. It can also be helpful to get patient to think of their body facing forward and imagine keeping their knees together (tennis ball width apart).

Slopes
For slopes start at the end of the slope, ideally with 2 hand rails although all yielding knees function better with more loading so wean off hand support quickly. Position the foot ahead of the sound limb and transfer weight allowing the knee to yield and the foot to become flat on the ground. Gradually work back up the slope to do more consecutive steps and gradually reduce support.

You may need to practise on a slope greater than 10 ° for the yield to be most effective. If the patient has a hydraulic ankle then they may need an even greater slope as the foot will accommodate some of the slope's angle reducing the need to bend the prosthetic knee. Take care on steep slopes, as patient will really need to trust the knee to achieve the required degree of knee flexion.

NB Please read individual sheets to find out what will activate and deactivate stance control, as this varies.

When to liaise with the Prosthetist: -

- Knee gives way during walking

- Patient feels that knee is not supporting their weight/ is not stiff enough on stairs. The yield resistance may need to be increased.
  However, check the following factors first as they may cause the patient to feel as though the knee is not supporting them enough or in the case of the sensor knee, it will feel locked: -
  - Are they loading the knee enough?
  - Do they lack confidence?
  - Are they positioning their body incorrectly?

- Patient feels that knee is giving way/ 'shooting' on stairs.

  With position dependent knees this may happen if the patient generates a knee hyperextension moment with a heavy heel strike and/or pull back in the

socket. A solution with the KX06 is to make it less alignment stable to allow the knee to initiate flexion against the geometry more easily and/or the yield resistance decreased so the knee moves into flexion more easily.

- Difficulty bending the knee on stairs
  Yield resistance may need to be reduced and or body position checked or realigned.

*****Extremely useful to do first session with Prosthetist when setting the yield*****

EXAMPLE: Single Axis Yielding Knee

Make **OTTOBOCK**

Name **3R80 modular knee joint with rotary hydraulic swing control.**

Weight of unit 1240g

Activity Level Moderate – high (Mobis 3-4) transfemoral/hip disarticulation

Suitability
Good residual limb strength
Varying walking speeds.
Max patient weight 150kg
Range knee flex 150°

Distinguishing Features
Load activated stance control (default swing). Stance resistance will then disengage automatically allowing swing to occur when terminal stance is reached or if foot is offloaded.
Single axis knee unit with hydraulic reservoir around pivot point
Rotary hydraulic swing phase control with offset stance axis for hydraulic stance phase control.
Stance flexion for shock absorption at IC
Heavy unit: 1240g – Patients need to be fit and strong. Not suitable for patient weight less than 50kg.
Waterproof
Manual lock

Adjustments
Flexion and extension dampening of swing can be adjusted separately
Load dependent stance phase stability can be adjusted and remains constant throughout full range of knee flexion therefore patient never feels that the knee is “running away” from him/her.
Stance control releases automatically at terminal stance or with off-loading
Stance yield is set on stairs by Prosthetist.

Implications for physio	Load activated yield allows foot over foot descent on stairs, slopes and stumble recovery. Teach Patient to use loading response knee flexion i.e. not pull back into hip extension at IC.
Sitting	For slow descent load and use yield and sit down For fast descent (no yield) offload the limb and sit down
Stairs	*Foot positioned half off step* Need to practice loading and targeting of foot starting on a small step in parallel bars. Teach patient to allow hip to flex activating yield initiating gradual knee flexion (see generic description above for more detail).

EXAMPLE: Single Axis Yielding Knee

Make **ORTHO EUROPE LTD**

Name **Sensor Knee**

Sensor Knee Weight of unit 1141g

Activity Level Mod to High

Provides 3 modes (function): manual lock, stance lock (locked in stance free in swing) and stance yield so that a new amputee can develop from first time patient to high activity all with one knee unit.

Suitability Varying walking speeds

High degree of safety

Moderate to good residual limb strength required to progress through all 3 modes. May not be suitable for the less active, frail amputee.

Max Patient weight 125kg

Range knee flex 120 °

Distinguishing features Hydraulic controlled knee mechanism

Load activated stance control (default swing). Stance resistance will then disengage automatically allowing swing to occur when terminal stance is reached or if foot is offloaded.

To change between modes, the Prosthetist will require to adjust the control settings: -

- Knee lock/yield switch down = stance lock (no loading response knee flexion, knee locked through stance).
- Knee lock/yield switch up = yield and loading response knee flexion. Stance flex stability through movement
- To change function to a manual lock the Prosthetist would put knee lock/yield switch up and adjust the flexion control valve
- During rehabilitation patient can have periods of experimentation and satisfy their changing needs by moving through the modes. Once established, the patient can choose to change between modes to help with certain activities e.g. using locked mode for extended standing.

Hydraulic swing control: swing phase can be optimised by utilising the flexion control valve and the knee terminal impact dampening screw.

Adjustments	Many adjustments can be made depending on the mode selected. Variable stance flexion resistance Adjustable stance resistance from locked to yield (black screw) Adjustable load activation to accommodate weight of patient (silver sensitivity screw) Weight activated knee lock in flexion up to 15-20 °
Implications for physio	Can be used locked (stance and swing) for initial rehab using switch activation as above Can be progressed from locked (in stance and swing) to stance lock (locked in stance, free in swing) to stance yield (yield resistance on through stance activated by loading prosthesis at initial contact and free in swing) To activate yield teach patient to allow hip and prosthetic knee to flex under load. Load toe at pre swing encouraging normal gait in preparation for swing phase.
Sitting	For slow descent using yield – teach patient to load heel and flex hip. For fast descent not using yield – unload limb and sit down as usual.
Turning	As normal – knee will not disengage with a heavy heel strike.
Slopes	Patient can go down slopes with lever up or down. When it's down there is no yield, the knee is straight but safe as long as patient stays on their heel ('step to'). When it is in the up position, yield activates and patient can descend slope step over step.
Stairs	***Foot positioned half off step*** Need to practice loading and targeting of foot starting on a small step in parallel bars. Load heel and teach patient to allow hip to flex activating yield initiating gradual knee flexion (see generic description for more detail).

EXAMPLE: Single Axis Yielding Knee

Make **ÖSSUR**
Name **Mauch**

Weight of unit = **1140g**

Activity Level High level of activity (moderate to extreme)

Suitability

Full hip extension or fully accommodated hip flexion contracture

Patients who have hard heel strike, weak hip extensors or hip flexion contracture *may not* be suitable as they could deactivate the stance mechanism inappropriately (see below)

Good residual limb strength required

Varying walking speeds

Max patient weight 136kg (Mauch Plus 166Kg)

Range of knee flexion 115 °

Distinguishing Features

Position dependent stance control (default stance)

Hydraulic swing control

Stance flex stability from hydraulic Mauch SNS Cylinder

Swing phase control from hydraulic Mauch SNS Cylinder

Selective operating modes

- Swing mode only for activities such as cycling
- Optional Manual lock

To select modes patients must be taught to use U lever in the knee: -

- U lever down is normal position for stance and swing function (normal walking)
- Hyperextend knee then raise the U lever for swing phase only
- Knee not hyper extended, raise lever and knee will lock in any degree of flexion

Adjustments	Independent flexion and extension resistance adjustment. Stance flexion resistance adjustment i.e. greater the resistance the slower the yield.
Implications for physio	Yielding knee offers foot over foot descent on slopes and stairs. Also offers a degree of stumble recovery. Stance control in this unit is automatically “switched on” or activated and needs to be deactivated (default stance). Deactivation of stance is achieved by creating a hyperextension moment at the knee. This can be done during normal walking by making sure that the hip is ahead of the knee and the toe is loaded. Patients therefore need to be able to step past the prosthetic limb to achieve this. A hard heel strike could also deactivate stance. Someone who has previously walked with a hard heel strike with a different knee unit may not be suitable for this type of knee.
Sitting	For slow controlled descent using yield sit down normally as described above. For fast descent place foot slightly behind, load toe and extend knee.
Turning	Care not to deactivate stance – avoid hard heel strike or toe loading with knee.
Stairs	Teach foot half off step and allow residuum to flex and knee to yield. Patient must be reminded if it is their first time using this type of knee that their instinct may be to extend. This would be dangerous as it would deactivate the stance control and the knee could give way

EXAMPLE: Polycentric Yielding Knee

Make
Name

BLATCHFORD
KX06

Weight of unit = 1230g

Activity Level **Medium to high activity transfemoral and hip disarticulation.**

Suitability

Full hip extension or hip flexion contracture accommodated

Patients who have hard heel strike or hip flexion contracture *may not* be suitable as they could deactivate the stance mechanism inappropriately (see below)

Good residual limb strength required

Varying walking speeds

Max Patient weight 150kg (K3 patients), 145Kg (K4 patients)

Range knee flex 160 °

Distinguishing Features

Position dependent stance control (default stance)

Polycentric knee offering greater stability benefitting shorter residual limbs and hip disarticulation patients. Also useful with longer residual limbs/ knee disarticulation because of shorter knee build

Hydraulic swing control

Stance flex stability from hydraulic SNS cylinder

Swing phase control from hydraulic SNS Cylinder

Selective operating modes

- Swing mode only for activities such as cycling
- Optional Manual lock

To select modes Patients must be taught to use U lever in the knee

- U lever down is normal position for stance and swing function (normal walking)
- Hyperextend knee then raise the U lever for swing phase only (knee completely free)
- Knee not hyper extended, raise lever and knee will lock in any degree of flexion but will still extend

Adjustments	Independent flexion and extension resistance adjustment Stance resistance adjustment i.e. greater the resistance the slower the yield
Implications for physio	Yielding knee offers foot over foot descent on slopes and stairs and a degree of stumble recovery Stance control in this unit is automatically “switched on” or “activated” and needs to be deactivated. Deactivation of stance is achieved by creating a hyperextension moment at the knee. This can be done during normal walking by making sure that the hip is ahead of the knee and the toe is loaded. Patients therefore need to be able to step past the prosthetic limb to achieve this. A hard heel strike could also deactivate stance. Someone who has previously walked with a hard heel strike with a different knee unit may not be suitable for this type of knee.
Sitting	For slow controlled descent using yield to sit down normally as described above. For fast descent place foot slightly behind, load toe and extend knee
Turning	Care not to deactivate stance – avoid hard heel strike or toe loading with knee extended
Slopes	If a KX06 doesn’t initiate flexion fast enough the amputee naturally tends to panic and extend their hip back, thus switching off the stability. A solution is to set the stance resistance/yield lower to allow easier flexion it cannot hyperextend because the knee is already flexed.
Stairs	Teach foot half off step and allow residuum to flex and knee to yield. Patient must be reminded if it is their first time using this type of knee that their instinct may be to extend. This would be dangerous as it would deactivate the stance control and the knee could give way.

Polycentric (4 and 5 bar) knees

Alignment

Examples

- **Ottobock** 3R36 (Habermann)
- **Blatchford** S500
- **Össur** NOFM1
- **Ottobock** 3R78
  3R106
  3R60

Description: Free polycentric knee characterised by multiple centres of rotation. The four bar knee has four pivot points and the intersection between the straight lines drawn through the four bars coincides with the Instantaneous Centre of Rotation (ICOR). The position of the ICOR changes with the knee flexion angle. In extension it is proximal and posterior and in flexion it is distal and anterior.

Activity: Low to high activity

Patient requirements: more stable 4 bar knees e.g. 3R36 can be used with lower activity amputees who have reduced hip strength. More responsive 4 bar knees should only be prescribed for moderate to high activity amputees e.g. 3R78, as they do require good hip strength.

Stance control: The 4 bar knee is inherently stable because of its design. The stability of each knee can be adjusted most commonly by changing the position of the knee unit to be more posterior to the weight line. Less commonly, the alignment of the four bars can be adjusted to move the instantaneous centre of rotation (ICOR) more posterior and proximal and therefore more stable when the knee is in full extension, for example, 3R36.
Generally, the more stable the knee is the more difficult it can become for the patient to destabilise it and initiate swing i.e. the less responsive it is. Different models are more or less inherently stable making them more or less responsive.

Swing control: there are various controls of swing – pneumatic, hydraulic (cadence responsive) or constant friction with or without extension assist (not cadence responsive). All polycentric knees shorten in mid swing so aiding clearance of the swing leg.

Gait Training requirements

Walking: -
Stance: teach patient to extend their hip and prosthetic knee from IC. The more responsive the knee the harder the patient will have to work to maintain knee stability particularly on slopes and uneven terrain.
If the patient is struggling to control the knee at IC and LR liaise with the Prosthetist.

Swing: re-educate normal PSw movement i.e. loading of the prosthetic toe with hip extension and anterior pelvic shift to initiate knee flexion. The term “loading the toe”

is used here because it is normal movement but unlike the geometric locking knee (see following section) it is not necessary to load the toe to release stance control. The 4 bar knee will bend as long as the hip is in front of the foot to give a knee flexion moment. If initiation of knee flexion is difficult check for a hip flexion contracture that is not accommodated in the socket which will be limiting the patient's ability to move the pelvis and hip ahead of the foot to destabilise the knee and also check how stable the knee is.

CAUTION: Alignment is extremely critical with a 4 bar knee e.g. an unaccommodated hip flexion contracture will affect stability in early stance because there is no additional mechanism beyond the posterior positioning of the knee's instantaneous centre of rotation to control stance stability. This can also affect transition from stance to swing, making it happen earlier and the knee less stable at TSt also.
Anterior/posterior shift of the socket relative to the knee can be used to increase or decrease stance stability and to make it more or less responsive at the end of stance and more or less stable in early stance.

Stand to sit: may need to place foot posteriorly to get weight through the toes to destabilise the very stable knees, otherwise would be as normal.

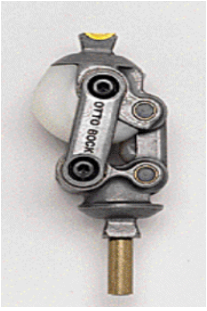
Sit to stand: as normal

Stairs: Step together.

EXAMPLE: Polycentric 4 bar knee

Make **OTTOBOCK**

Name **3R36 modular polycentric knee joint (Habermann knee)**



Weight of unit 445g

Activity Level Suitability

LOW to MODERATE transfemoral and hip disarticulation.
Max weight 100kg (220lbs)
Range knee flex 110°

Distinguishing features

4 bar linkage therefore stance phase stability achieved through polycentric kinematics. Relative positioning of links can be altered by the Prosthetist thereby moving the ICOR and making the joint more or less stable as required.
Swing phase control using axis friction and extension assist (not cadence responsive).

Adjustments

Excessive heel rise is controlled by increasing the compression of the spring and the knee will come through to full extension more quickly.
The ICOR can be adjusted by altering the position of the links in order to change the stance phase stability. Stance phase stability can be further adjusted by altering the position of the socket relative to the knee joint and the weight bearing line. For example, more post placement of the knee will increase stability. Increasing stability of this knee will increase the difficulty of initiating swing knee flexion.
Axis friction can also be adjusted on this unit to fine tune the swing element in conjunction with the extension assist.

Implications for physio

Load toe to initiate prosthetic knee flexion at pre swing with anterior pelvic shift and vertical pelvic drop.
Teach active hip extension to extend prosthetic knee from initial contact.
The patient should feel a reassuring ‘clunk’ at full knee extension at TSw. This is due to the polycentric design of the knee combined with the strong extension assist spring, which means the knee really wants to go back to a fully extended position. This helps as the patient not only knows the knee is extended, but it has a strong extension bias and will not fall back into flexion

	like a single axis joint may do. However, this knee can be difficult to destabilise for initiation of PSw knee flexion particularly if the patient has a hip flexion contracture that is not accommodated and prevents them moving their hip in front of the prosthetic foot to create a knee flexion moment to destabilise the knee.
Sitting	Patient may need to place foot posteriorly to destabilise knee. If this is not necessary then sit down as normal
Stairs	Step together

EXAMPLE OF Polycentric 4 bar knee

Make **BLATCHFORD**

Name **S500**

Weight of unit = 882g

Activity Level	Low to moderate (K2-3).
Suitability	Knee disarticulation or long residual limb.
Distinguishing features	Build Height 20mm. Geometric lock (see following section) at initial contact and stance. Swing control: pneumatic swing phase control (PSPC). The knee has a training lock feature to assist users during rehabilitation in the early stages. High instantaneous centre of rotation means optimum shortening of shin during swing.
Adjustments	Independent flexion/extension control. Adjustable spring extension.
Implications for physio	Good residual limb strength (hip extension) beneficial. Teach hip extension from initial contact through to terminal stance. Teach weight transference through the toes of the prosthetic foot in pre swing to encourage normal movement and knee flexion in preparation for swing phase.
Sitting	May need to place foot posteriorly to destabilise knee. If this is not necessary then sit down as normal.
Stairs	Step together.

EXAMPLE OF Polycentric 4 bar knee

Make	**Össur**
Name	**NOFM1**
	
	Unit weight: 590g – 720g
Activity Level	Low activity transfemoral or knee disarticulation . Single speed walking.
Suitability	High degree of stance stability. Max Patient weight: 136 Kg. Range of knee flexion: 150 °.
Distinguishing features	Polycentric 4 bar knee. Stance control: axial geometry (aligned for stability – see generic description above for more information on polycentric knees). Swing Control: integrated extension spring and adjustable axle friction to dampen extension. Also prosthesis effectively shortens in swing due to polycentric knee design.
Adjustments	Extension assist and friction dampening.
Implications for physio	Patients will require to learn how to walk with a free polycentric knee (see section 2.1.2.)
Sitting	***Stand to sit:*** Teach the patient to use free knee as per instructions above. ***Sit to stand:*** As normal if using free.
Stairs	Step together
Slopes	Step together

EXAMPLE: Polycentric 4 bar knee

Make **OTTOBOCK Healthcare plc**

Name **OTTOBOCK 3R106**

Weight of unit = **755 - 790g**

Activity Level Suitability

Moderate to high transfemoral.

High stance phase stability due to proximal and posterior ICOR position at full extension.

For varying walking speeds due to pneumatic swing phase control

Max. weight 100kgs.

Range knee flex 170 °.

Distinguishing features

High knee flex angle 170 °.

Smooth gait.

Smooth extension stop prevents terminal impact.

Stable in stance and easy to release stance phase stability to initiate swing.

Angled pyramid top for HD no longer available

Adjustments

Flexion and extension resistances are independently adjustable using pneumatic swing phase control adjustment.

Extension assist spring can also be adjusted.

Implications for physio

Teach weight transference through to the toes of the prosthetic foot in pre swing to encourage normal movement and prosthetic knee flexion in preparation for swing phase.

** Do not require to load the prosthetic toes to initiate swing knee flexion – will flex when off loaded or loaded (see glossary for “toe load”).

Limb will shorten in swing due to polycentric design thus aiding clearance.

Sitting

May need to place foot posteriorly to destabilise knee. If this is not necessary then sit down as normal.

Stairs

Step together.

EXAMPLE: Polycentric 5 bar knee

Make **OTTOBOCK**

Name **3R60 EBS (Ergonomically Balanced Stride) polycentric modular knee**

Weight of unit = **845-940g**

Activity Level
MODERATE to high transfemoral
Can be used for high activity but there is a maintenance issue with the bumper and heavy use. EBS must be set correctly to reduce need for bumper replacments
It is not recommended for low activity amputees.
Good for knee disarticulation

Suitability
For varying walking speeds
Adjustable stance stability by adjusting ABS
Needs foot with stiff bumper due to shock absorption of bumper within knee
Max weight 125kg
Range knee flex 175°

Distinguishing features
Polymer bumper gives cushioned loading response stance flexion of up to 15° and affects the positioning of the posterior link. It therefore controls both heel strike cushioning and joint stability due to the displacement of the ICOR.
Hydraulic swing phase control, which is cadence responsive.

Adjustments
Hydraulic unit can be adjusted to increase flexion and/or extension resistance.
Resistance of EBS unit (polymer bumper) can be adjusted to suit activity level/weight of amputee.
Harder bumper can be put in to increase the feel of security from initial contact through loading response to foot flat.

Implications for physio
Patients need to be taught not to ‘fight’/resist loading response knee flexion, that is, to the feel 15° ‘give’ to the mechanical stop. They should use parallel bars to practice initial contact to foot flat to let them feel the bounce and

	when it stops. The amputee will need to load the knee to reach the stop.
Sitting	May need to place foot posteriorly to destabilise knee. If this is not necessary then sit down as normal
Stairs	Step together
Slopes going down	Patient can walk step over step on a shallow slope (10 ° or less) using the loading response knee flexion to allow foot to make contact with the slope - this is the main advantage of this knee over a normal polycentric knee. On steeper slopes patients will have to “step-to” as the loading response knee flexion is insufficient to allow foot to make contact with the slope.

EXAMPLE: POLYCENTRIC 4 BAR KNEE

MAKE **OTTOBOCK**

Name **3R55 modular polycentric knee joint.**

Weight of unit = **720g**

Activity Level HIGH transfemoral.

Suitability
Minimal stance phase stability *because ICOR is kept distal.*
Dynamic swing phase control from hydraulic cylinder.
Max. Weight 125kg.
Max knee flex angle 110°.
Durable.
Can be used for running but Ottobock recommend 3S80.

Distinguishing features
Titanium.
Hydraulic swing phase control.
Polycentric 4 bar linkage. This knee has long linkages which shorten the shin section in swing (more so than smaller 4 bar e.g. 3R36).

Adjustments
Stance phase stability can be altered by changing the position of the knee in relation to the socket, that is, the knee centre can be moved anteriorly (reduces stability) or posteriorly (increases stability) to weight bearing line.
Swing: -

- can adjust friction – CRUDE
- can adjust hydraulic mechanism (flex and ext independently adjustable) - FINE TUNING.

Implications for physio
Need good residual limb strength (hip extension).
Teach hip extension from initial contact through to terminal stance.
Teach weight transference through the toes of the prosthetic foot in PSw to encourage normal movement and knee flexion in preparation for swing phase.

Sitting May need to place foot posteriorly to destabilise knee. If this is not necessary then sit down as normal.

Stairs Step together.

Geometric locking (multibar)

Examples

- **Össur** Total Knee (1900, 2000 and 2100)

  NOH7 (or NKH7 which has low build height)
- **Otto Bock** 3R60

Description: Free polycentric knee (more than 4 bars) that creates a geometric lock in extension for increased stance stability i.e. when the knee swings into extension it will stay in extension until the amputee weight bears through the prosthetic toe.

Activity: Low (Total 1900) / Moderate / High (Total 2000 and 2100, Össur NOH7)

Patient requirements: patients require full range of hip extension or any flexion accommodated in the socket to enable them to load the prosthetic toe at PSw and destabilise the knee. These knees can be used with patients with reduced residuum muscle strength and/or poorer health because of the geometric lock for increased stance stability (no need to augment with hip extension moment at IC) and the effortless release of the lock and initiation of swing knee flexion.

Stance control: Geometric lock in extension.
Mechanical (0 – 15^0) loading response stance knee flexion with Total 2000 and 2100 and OH7, which is a 'give' or 'bounce' with mechanical stop. Can be adjusted by using different bumpers according to the weight and activity level of the patient. Teach patient to feel give and allow knee to flex at IC – can be quite subtle.

Swing control: Polymer friction (not cadence responsive, 1900) or hydraulic (cadence responsive 2000, 2100). Effortless release of geometric lock on loading the prosthetic toe. The patient has to load the toe to release the geometric lock. The high level of stability for stance control does not compromise the initiation of swing but the patient does require full hip extension or hip flexion contracture accommodated to load the toe. The knee will shorten in mid swing.

Gait Training requirements
Walking: -
Stance: Teach mechanical (0 – 15 °) loading response stance knee flexion with mechanical stop if present (see above). Teach patient to feel give and allow knee to flex at IC.

Swing: Load prosthetic toe at PSw to initiate prosthetic knee flexion. This should be effortless if not check for hip flexion contracture and/or liaise with Prosthetist.

Turning: take care not to load the toe as this will deactivate stance.

CAUTION: patients must be advised to be careful that after standing still for a while when they go to walk off they should always lead with their prosthetic limb in case they have been leaning on the prosthetic toes and have released the geometric lock.

Stand to sit: must load the prosthetic toe to release the geometric lock i.e. put prosthetic foot behind.

Stairs: One at a time.

EXAMPLE OF Polycentric Geometric Locking Knee

Make **Össur**

Name **TOTAL KNEE**

1900	**2000**	**2100**
		
675g	**690g**	**900g**

Activity Level

Low (1900) → Mod to high (2000) → Mod to extreme (2100).
Different knees for different levels of activity - hydraulic model (2000, 2100), polymer friction model (1900).

Suitability

Hydraulic for moderate to extreme activity.
Polymer bumper for low.
Max knee flex angle 160°.
Max patient weight 100,100,125kg.

Distinguishing features

Polycentric seven axis knee.
Auto lock at full extension resulting in optimum stance stability.
Effortless release at PSw on loading toe.
Allows loading response knee flexion at IC (up to15° depending on bumper stiffness) which gives a degree of shock absorption and normalises gait up and down shallow ramps.

Adjustments

Colour of bumper will indicate degree of softness.
Extra shims make leg less stable - comes with one shim as standard.

Implications for physio

Teach loading response knee flexion (15º) at initial contact. Patients need to be taught not to 'fight/resist' stance flexion, that is, they should feel the 15 º 'give' to the mechanical stop (geometric lock). They should use parallel bars to practise initial contact to foot flat to let them feel the bounce and when it stops. Bumper can be changed to a softer version to increase loading response knee flexion.

	Teach weight transference through the prosthetic toes at pre swing to release the geometric lock and allow knee flexion for swing phase (have to get a toe load). **CAUTION:** Patient must be aware that if weight is through their toe the knee will be unstable. Patient should take care not to load the toe as this will deactivate stance.
Turning	CAUTION: patients must be advised to be careful that after standing still for a while when they go to walk off they should always lead with their prosthetic limb in case they have been leaning on the prosthetic toes and have released the geometric lock.
Sitting	Must load the prosthetic toe to release the geometric lock i.e. put prosthetic foot behind.
Stairs	Step together

Fluidic Controlled Hydraulic

Description: fluidic controlled knees allow patients to achieve controlled foot over foot descent on stairs and slopes and support stumble recovery (see Appendix 4). The yield is achieved by a high level of resistance to knee flexion during stance which is set by the Prosthetist. This resistance to flexion results in knee stability during use thus preventing the knee 'giving way/ collapsing. These knees differ from the yielding knees described above as they maintain the same level of stance flexion resistance/ yield through full range i.e. they control the increased leverage during knee flexion during weight bearing. Fluidic controlled yielding knees also compensate for the thinning out of the operating hydraulic fluid that occurs through heating during prolonged use of the yield function e.g. when descending a long flight of stairs.

Activity: moderate to high activity levels. The yield is not intended as the main control of stance but as an added feature to allow for the functional activities mentioned above.

Patient requirements: adequate range of movement with flexion contracture accommodated and muscle strength in the residuum to be able to activate and deactivate stance control.

Stance control: will be alignment controlled with the added safety of the hydraulic yielding mechanism. This means that the knee should never give way suddenly but would yield allowing time for patient to recover. If the knee is suddenly shooting/collapsing the patient should be seen by their Prosthetist**.**

Note: the position dependent yielding knees described before may release inadvertently for swing (lose stance knee flexion resistance) on hyperextension that sometimes occurs when patients pull back on their sockets on stairs, slopes or uneven ground prior to attempting to yield (see also comments in 'walking'). This shortfall has been designed out in both the fluidic knee e.g. the VGK and the MPKs e.g. the C-leg.

Swing control: stance control must be deactivated by patient reaching TSt and generating a knee hyperextension moment to allow swing to occur**.** The patient can walk at varying speeds and the fluidic hydraulics limits the swing knee flexion angle to 65 ° helping to ensure a smooth gait.

Gait training requirements: fluidic knees as with yielding knees require the patient to learn to trust the knee when it bends under load (yields), especially if they have never used this type of knee before. Teaching an amputee for the first time to allow the prosthetic knee to bend on slopes and stairs may be learnt more easily with a fluidic knee than the hydraulic knees described previously, because of the sustained and stable knee flexion rate which gives the sense of stability throughout the yielding phase.
Start in parallel bars and allow patients to feel the resistance that the yield offers i.e. allow the patient to feel that the knee is not going to give way suddenly.
This is also nicely demonstrated to the patient when they sit down from standing. Just make sure the chair is stabilised by therapist or against a wall. Encourage the patient to transfer weight onto limb and feel the yield.

Walking
To deactivate stance with a fluidic knee it is important that the patient is able to step past the prosthetic leg, loading the prosthetic toe thereby creating a knee hyperextension moment. Patients with weak hip extensors or hip flexion contractures that are not accommodated within the socket alignment may not be suitable for this type of knee. Take particular care if a patient has a heavy rearward heel strike at IC as this could

potentially disengage stance (if the swing release is set too easy) by generating a knee hyperextension moment and the knee would give way.

Backwards walking: this is stable due to stance control re-engaging at mid-stance.

Turning: a fluidic knee is stable on turning because the combination of forces, alignment and timing required for normal swing release in walking are disturbed

Stand to sit
Patient can do this normally using the yield for a slow descent or without the yield for a fast descent. Sitting down is a good way for the patient to learn to use the yield as mentioned above. A fluidic knee allows a sustained and stable knee flexion rate, which gives stability throughout the full range of knee flexion as the patient sits.

Stairs
Begin by using a small step in parallel bars in preparation for stairs.
Practice targeting of the foot half off the step. It is important to establish exact foot position as this will facilitate knee flexion.
Encourage patient to activate the yield (transfer weight onto the prosthesis; allow the knee to bend without leaning backwards or forwards).
Step past with remaining leg. Patients must learn to do this with all or most of their weight through the prosthesis or yield will not be activated.
Start on bottom step with 2 rails and gradually work back up to do more consecutive steps reducing support as the patient gains in confidence.

Slopes
For slopes start at the end of the slope, ideally with 2 hand rails. Position the foot ahead of the sound limb and transfer weight allowing the knee to yield and the foot become flat on ground. Gradually work back up the slope to do more consecutive steps and gradually reduce support.

You may need to practice on a slope greater than 10 ° for the yield to be most effective. Care on steep slopes, as patient will really need to trust the knee allowing a greater degree of knee flexion.

When to liaise with the Prosthetist: -

- Knee shoots/ gives way at any time
- Patient feels that knee is “giving way” on stairs*:* yield may need to be increased
- Difficulty bending the knee on stairs: yield resistance may need to be reduced

*****Extremely useful to do first session with Prosthetist when setting the yield*****

EXAMPLE: Fluidic Knee

Make **Orthomobility**

Name **VGK (Very Good Knee)**

Weight of unit = 1500**g**

Activity Level Suitability

K2 – K4

Full hip extension or fully accommodated hip flexion contracture

Good residual limb strength required

Varying walking speeds

Max Patient weight 125kg

Range of knee flexion 160 °

Distinguishing Features

Position dependent stance control (default stance)

Stumble recovery support

Temperature compensated yielding

Fluidic swing control

Stance flex stability from hydraulic cylinder

Water proof (5m submersible)

Adjusts to varied weights but can only accommodate additional 15Kg if patient is already at maximum body weight of 125Kg.

Selective operating modes

- cycling (switch at back)
- optional manual stance lock

To select modes patient must be taught to use lever on posterior-distal aspect of knee

- Lever to right = cycling
- Lever to middle = lock
- Lever to left: yielding/stair (normal activity)

Adjustments	Yield resistance (stance flexion). Sensitivity of stance control release for swing is manually adjusted by pre-loading a biasing PU-spring in the distal knee. Independent adjustment of swing/heel rise using 'heel rise slider' 'Heel rise slider' is found in the posterior proximal aspect of knee and should sit centrally. When moved to right less resistance/more heel rise, when moved to left more resistance/less heel rise. There is a 'tall person valve' which should only be used with extra long shanks. Terminal swing dampening auto adjusts.
Implications for physio	VGK offers foot over foot descent on slopes and stairs It also offers a degree of stumble recovery from yield resistance Stance control in this unit is automatically "switched on" or activated and needs to be deactivated (default stance). Deactivation of stance control is achieved by knee extension together with toe load creating a hyperextension moment at the distal knee. This can be done during normal walking by making sure that the hip is ahead of the knee and the toe is loaded. Patients therefore need to be able to step past the prosthetic limb to achieve this. **A hard heel strike that generates a knee hyperextension moment has a potential to deactivate stance if immediately followed by knee flexion e.g. on uneven ground, slopes or stairs**. Someone who has previously walked with a hard heel strike with a different knee unit may not be suitable for this type of knee. However, if the knee is set up with correct alignment the patient would be expected to adjust to a more natural gait (soft heel strike) once the benefits of stability have been discovered.

Sitting	For slow controlled descent using yield sit down normally as described above (see Section 2.1.1.3) For fast descent place foot slightly behind, load toe and extend knee or unload
Turning	Teach as per normal, knee should remain stable as long as patient does not deactivate stance i.e. avoid hard heel strike or toe loading
Stairs	Teach foot half off step and allow residuum to flex and knee to yield. Patient must be reminded if it is their first time using this type of knee that their instinct may be to extend and this may deactivate yield. If there is insufficient yield resistance on the stairs, liaise with the Prosthetist who will ensure that the yield resistance is set correctly and that the distal knee has no free/slack movement due to insufficient tension on the PU-spring as this will deactivate yield.

Microprocessor controlled knees

Introduction to microprocessor knees

In recent years microprocessor controlled knees (MPKs) have gained increasing popularity following huge developments in this area.

There are now a variety of options available which allow you to accommodate the individual needs of patients following an amputation at knee disarticulation or above. It is important to assess individual aims and requirements for the user such as their hobbies or employment. Each knee has its own distinguishing features which may influence the final prescription.

Microprocessor controlled knees feature sensors, a microprocessor, software, a resistance system and a battery.

The internal computer (microprocessor) monitors each phase of the gait cycle using a series of sensors. The continuous monitoring and control of fluid and/or pneumatics allows the knee to make adjustments in resistance enabling the user to walk more efficiently at various speeds and improves safety descending ramps and stairs. Microprocessor knees have shown to reduce falls with the assistance of stumble recovery technology which allows patients to walk with improved confidence and less concentration.

When fitting a microprocessor controlled knee, joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimal use of the knee. Further physiotherapy is required and gait training is essential, particularly if the patient has been using a mechanical knee joint with different control patterns. Patients may have to unlearn compensatory movements to achieve an improved gait pattern.

As with mechanical knee joints it should be noted that microprocessor knees are sensitive to change in heel height and patients should not change their shoes without discussion with their Prosthetist.

Also of note, should the battery run out of charge in the micro processor knee the default setting can vary depending on knee, this should be discussed with the patient.

Ongoing adjustments of settings will be required as the patient becomes more accustomed to using the knee joint.

Patient requirements

- K-Level: K2-4
- Optimum socket fit to maintain comfort and accommodate increased weight of knee unit
- The user must demonstrate adequate cognitive ability to follow instructions to use the device correctly, potential to adapt their walking pattern to accommodate new functions of the knee and ensure regular charging of the unit.
- Able to commit to prosthetic rehabilitation
- Adequate strength and balance to activate the knee unit
- Sufficient cardiovascular abilities to meet the fitness demands of using a free knee

A microprocessor knee “hints and tips” section has been included at the back of this chapter and will give general advice and problem solving ideas when treating common challenges faced by the patient when they have changed over to their microprocessor knee.

Ottobock Kenevo

Activity level	Mobis 1/2	
Weight limit	125kg	
Weight of unit	915g	
Knee flexion angle	124°	
Warranty	3 or 6 years (24 month servicing)	
Default	Stance	

Battery

To check the charging status: turn the knee joint upside down and keep at rest for 2s (5 beeps = >80% - 1 beep <35%) * charger must be unplugged

Charging Time	Capacity
6-7 hours	24 hours
2 hours	12 hours
45 mins	6 hours

*Warning vibrations/ beeps for low battery power
*Safety mode activates when there is insufficient charge in the battery. In Modes A,B and B+ the knee joint will activate a high level of resistance which is over the default resistance set for the user in K-Soft.
In Mode C the level of resistance will remain at the default level, set within K-soft.

On/off:

Remaining time until POWER OFF	Approx 10 hours	Approx 5 hours	0 min
Vibrations	x3	x5	x10 (and beeping)
Knee function	Normal function		Safety mode

Distinguishing features

- Microprocessor controlled hydraulic stance and swing
- Electronic Axon tube (can use Genium tube if torsion required)
- Foot selection restricted- Mobis2/K2 feet
- Backward walking possible
- Varied cadence with maximum gait speed 3.5kph/2mph

	Mode A	Mode B	Mode B+	Mode C
Stance	Locked	Locked	Locked with 10° stance flexion	High resistance/Yield
Swing	Locked	Free	Free	Free
Stumble	No	Yes	Yes	Yes

recovery				
Intuitive stance	No	No	No	Yes
Sitting function	Yes (all modes)			
Wheelchair Lock	Yes (optional, all modes)			

- Sitting function: hydraulic resistance, requires 10-70% body weight, resistance increases as knee angle increases. Patients can sit with knee extended, and knee will relax into flexion after 0.5s

- Wheelchair lock: optional function whereby the knee can be locked in flexed position when sitting (45° – extended knee) activation and deactivation by lifting the shank

Adjustments

- Requires K Soft software and bionic link
- Modes can be changed by the Prosthetist via K-Soft or via Therapist App (On-line certification required)

Physiotherapy

Kenevo Mode A

Notes

Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see introduction). Therapists should be aware that if the patient is moving from a SAKL knee onto a Kenevo, their movement patterns should be monitored to ensure that the “sitting down” position is not activated inappropriately as this can result in the knee unlocking unexpectedly.

Mode A

Locked knee during swing phase with ability to sit down with progressive stance flexion resistance.

Training

The knee will be in a high resistance (like locked in a SAKL) state except for sitting, so the patient should continue with gait training as for a SAKL knee joint.

Donning whilst sitting

To flex the knee prior to donning, the patient holds socket horizontal to allow knee to automatically bend then donn prosthesis as normal. As the patient stands up the knee joint will automatically lock in extension so the patient can complete donning safely.

Sitting

Initially, try not to over complicate sitting, the user should simply be able to “sit down”. However, if the patient is having problems the following can be tried.

The patient should have the prosthesis a little bit in front, load 15-70% (50% through each leg is optimal unless patient has particular medical issues preventing them from doing so) of bodyweight through the knee and then sit as normal. At the last 30° of flexion, the Kenevo has a softer motion to allow a more controlled sit down.

	Advise the patient to “push their bottom out” as they sit for the knee to yield and allow them to sit down – “nose over the toes” and reaching for the ipsilateral hand rest first can all help. If the patient is struggling with the sitting function then ensure there is sufficient load on the prosthesis, that the prosthesis is not too close to the chair and that the movement is fluid. Resting the chair against a wall so that the chair cannot tilt during training can help increase confidence. Ensure the patient does not try to force the knee into flexion, as the knee will resist the motion to protect the user.
Automatic unlock in sitting	If the patient has been unable to unlock the leg on sitting and the leg is extended in front of them, after 0.5s the knee unlocks automatically – the hip flexion angle must be at least 60°. If the joint does not unlock then the prosthetic leg can be lifted until the flexion angle is reached and the joint unlocks.
Sit to stand	The prosthesis should be a little bit ahead. The knee can lock midway (see supported standing up/sitting down below) if the patient is struggling to get up.
Supported standing up/sitting down	This function can be useful for transfer purposes, repositioning during sit to stand etc. To practise this function the patient should start to sit down or stand up and pause midway, they should feel the knee lock in less than 2 seconds. Continue with the planned motion for it to unlock.
Wheelchair function	The knee joint will lock at 45° if held in the same 45° position for 2 seconds. It can then be unlocked by extending the knee joint via the contralateral limb or hand, by pushing on the toes, tapping against a wall or by standing. NB: Please note this feature can be switched off in all modes
Gait	As per training for a SAKL knee
Walking backwards	Patient can walk backwards; patient should ensure they do not flex their trunk to initiate the sitting function.
Stairs going up	Step to pattern
Stairs going down	Step to pattern
Slope going up	As per SAKL knee
Slopes going down	The patient can step alternate steps on shallower slopes but on steeper slopes will need to use a step to pattern or side step.

Kenevo Mode B

Notes	Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see introduction). Therapists should be aware that if the patient is moving from a SAKL knee onto a Kenevo, their movement patterns should be monitored to ensure that the “sitting down” position is not activated inappropriately as this can result in the knee unlocking unexpectedly.
Mode B	Acts as a free knee without loading response stance flexion or yield (stance flexion resistance)
Training	In this mode the knee joint will demonstrate swing flexion and provide a controlled extension resistance to prevent terminal impact. In this mode, swing flexion has one resistance, which limits the cadence range to 2mph/3.5kph or 117m in a 2 minute walk test. Patients who walk faster than the above will experience excessive heel rise and a slowed swing extension and this would be a contraindication to the use of Kenevo. The patient may describe this as “waiting on the leg to come through”.
Donning whilst sitting	As per mode A
Sitting	As for mode A
Automatic unlock in sitting	As per mode A
Sit to stand	As per mode A
Supported standing up/sitting down	As per mode A
Wheelchair function	As per mode A
Gait	Aim for a normal walking pattern but the patient will have no loading response stance flexion in this mode. For the knee to release into swing phase, the patient should ensure the sound foot passes the prosthetic foot (forward inclination of the shank) and they are off loading the prosthesis.
Walking	Patient can walk backwards; patient should ensure they do not flex their trunk to initiate the sitting function.

backwards	
Stairs going up	Step to pattern
Stairs going down	Step to pattern
Slope going up	As per normal walking pattern
Slopes going down	The patient can step alternate steps on shallower slopes but on steeper slopes will need to use a step to pattern or side step.

Kenevo Mode B+

Notes	Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see introduction). Therapists should be aware that if the patient is moving from a SAKL knee onto a Kenevo, their movement patterns should be monitored to ensure that the “sitting down” position is not activated inappropriately as this can result in the knee unlocking unexpectedly.
Mode B+	Acts as a free knee with loading response stance flexion.
Training	This mode is a free knee with 10° of loading response stance flexion but **NO** yield. The patient can find this difficult to adapt to, especially if their previous prosthetic knee has not had this function. The patient will often describe it as they feel their knee is “giving”. Training is required to help the patient adjust and accept this new sensation when mobilising. In this mode, swing flexion has one resistance, which limits the cadence range to 2mph/3.5kph or 117m in a 2 minute walk test. Patients who walk faster than the above will experience excessive heel rise and a slowed swing extension and this would be a contraindication to the use of Kenevo. The patient may describe this as “waiting on the leg to come through”.
Loading response stance flexion	The patient should practise standing in the parallel bars and loading the heel to feel the cushioned bounce/bend at the knee.
Donning whilst sitting	As per mode A
Sitting	As for mode A
Automatic	As per mode A

unlock in sitting	
Sit to stand	As per mode A
Supported standing up/sitting down	As per mode A
Wheelchair function	As per mode A
Gait	The patient should aim for a normal walking pattern but will have loading response stance flexion in this mode. For knee to release for swing phase ensure the sound foot passes the prosthetic foot (forward inclination of the shank) and they are off loading the prosthesis.
Walking backwards	It is possible but the patient should ensure they do not flex into sitting down position.
Stairs going up	Step to pattern
Stairs going down	Step to pattern
Slope going up	As per normal walking pattern
Slopes going down	Stance flexion at loading response will allow foot over foot walking down shallow slopes but this will not be possible for steeper slopes and the patient will need to use a step to pattern or side step. The patient must have confidence to load the knee or flexion will not activate.
Stop and rest on slope	The patient can stand on the slope with their prosthetic knee in 10° of stance flexion – this is useful for patients to practise and can feel more secure if stopping on a slope. This can be a training tool prior to walking down a slope.

Kenevo Mode C

Notes	Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see introduction).
Mode C	In this mode, the patient has a free knee with loading response stance flexion **and** yield (stance flexion resistance).

Training	Acts as free knee with yielding function. The patient can often find it difficult to adapt to the sensation of loading response, especially if their previous prosthetic knee has not had this function. The patient will often describe it as they feel their knee is “giving”. Training is required to help the patient adjust and accept this new sensation when mobilising. In this mode, swing flexion has one resistance, which limits the cadence range to 2mph/3.5kph or 117m in a 2 minute walk test. Patients who walk faster than the above will experience excessive heel rise and a slowed swing extension and this would be a contraindication to the use of Kenevo. The patient may describe this as “waiting on the leg to come through”.
Loading response stance flexion	Unlimited and is controlled by the patient like a yielding knee.
Donning	As normal free knee donning
Sitting	As per normal, like a yielding knee, aiming for 50% weight through each leg. Patients may find mode C is easier than previous modes as they are not overcoming the lock function in that of the previous modes.
Automatic unlock in sitting	Not applicable
Sit to stand	As per mode A
Supported standing up/sitting down	As per mode A
Wheelchair function	As per mode A
Gait	The patient should aim for a normal walking pattern and will have loading response stance flexion. For the knee to release for swing phase the patient should ensure the sound foot passes the prosthetic foot (forward inclination of the shank) and they are off loading the prosthesis.
Walking backwards	The patient can walk backwards. Let it move into the yield (stance flexion resistance) and encourage soft knees at end of stance. .
Stairs going	Step to pattern

up	
Stairs going down	Patient can walk down step over step with the foot 1/2- 2/3 overhanging each step and engage the yield (stance flexion resistance). Caution: When the patient is initially training on how to go down stairs and steeper slopes it can be useful to turn off the intuitive stance feature because if the patient hesitates (which can be common in the early stages of training) then the knee can lock and prevent a smooth and continuous motion.
Slope going up	As per normal walking pattern
Slopes going down	The patient can step with alternate steps and engage the yield function of the knee. The loading response stance flexion may be enough to absorb the slope and allow the patient to walk down foot over foot when it is shallower but the yield can be used to allow step over step on steeper slopes. Patient must have confidence to load the knee or flexion will not activate and the confidence to do this successfully can be difficult in patients who have not had a knee that has allowed them to do so previously. Caution: When the patient is initially training on how to go down stairs and steeper slopes it can be useful to turn off the intuitive stance feature because if the patient hesitates (which can be common in the early stages of training) then the knee can lock and prevent a smooth and continuous motion.
Stop and rest on slope	Patients can stand on a slope using the stance function at any position between 5-65°. Stance function activates when holding the knee joint in the same position for about 1 second. This is useful for the patient to practise and they can feel more secure if stopping on a slope. It can also be used as a training tool prior to walking down a slope.
Intuitive stance function	Available*. When training, the patient should lean against a secure surface, flex knee with it loaded and it will lock in position. To deactivate, unload the leg, extend the knee or yield. Only 20% of the patients body weight is required to activate this feature, the flexion angle range is between 5-65 degrees. This is a particularly beneficial feature for bilateral amputee patients to offload pressure in their lower back. *K-Soft software allows an option to deactivate Intuitive Stance function

Ottobock C-Leg 3

Activity level	Mobis 1/2	
Weight limit	125kg	
Weight of unit	915g	
Knee flexion angle	124°	
Warranty	3 or 5 years (24 month servicing)	
Default	Stance	

Battery

Charging Time	Capacity
4.5 hours	approx 30-45 hours (full battery)
1.5 hours	approx 15 hours
20 mins	approx 5 hours

*Warning vibrations/ beeps for low battery power
*Empty battery mode, the knee either sets “high flexion damping” (standard setting) or “low damping”, for suitable patients. This is set by the Prosthetist and should be discussed with the patient.

On/Off: Unable to turn off

Remaining time until POWER OFF	60 min	30 min	0 min
Vibrations	3	5	10
Knee function	No stance extension damping		Empty battery mode

Distinguishing features

- Microprocessor controlled hydraulic stance and swing
- Electronic tube (torsion tube available)
- Foot selection restricted to Ottobock recommended feet
- Continuous adaptive walking speeds
- Requires user to load toe >70% body weight to release for swing at terminal stance
- Manual stance function – activated via motion pattern
- 2 additional activity modes
- Charging extension cable can be used if foam required

Adjustments

- Programming requires C Soft software, Bluetooth adapter and BionicLink
- User can use remote control or body movements (bounce on toe 3 or 4 times) to activate additional modes

Physiotherapy

C-Leg 3

Notes	Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see microprocessor knee introduction).
Sitting	When sitting down, the patient should aim to put 50% body weight through each leg. When working on sit to stand or stand to sit, the patient can use the chair arm rests for support but advise them to take as little weight through the arms as possible, therefore loading the prosthesis more. Stand to sit is beneficial for the patient to get used to flexing the prosthesis under load which is useful for slopes and stairs practise. Resting the chair against the wall so that it cannot tilt back can help increase confidence in the early stages.
When seated	Not available.
Loading response stance flexion	Available – Please note that patients sometimes do not like the feeling of stance flexion and may try to fight this sensation; see physiotherapy hints and tips.
Gait	At terminal stance, the patient requires a fully extended knee and to transfer 70% of their body weight onto their prosthetic toes to allow the knee to release for swing. The patient can walk at varying speeds and the knee controls the knee flexion angle to allow a smooth motion. The patient may complain of the knee “sticking” or “going stiff” at times, this is often because they are not achieving the toe load and therefore the knee will not move into swing mode. This is a safety feature but it can be frustrating for the patient during gait training.
Walking backwards	This can be achieved but requires care to avoid toe load.
Stairs going up	Step to pattern.
Stairs going down	The patient can walk down step over step with the foot 1/2- 2/3 overhanging each step and engage the yield (stance flexion resistance).
Slope going up	As per normal walking pattern.
Slopes going	The patient can walk step over step. Patients should load their heel

down	and engage the yield. Decrease support as able; start with rails, then 1 rail then no rail. Patients changing from a knee with no yield or stance flexion can find this a very difficult task and generally takes the longest of all aspects of the knee to train.
Manual stance function	Manual stance – the patient bends beyond the angle they wish and extends back to the desired knee flexion and holds statically for 2 seconds then the knee will lock in this position until the patient actively extends the leg or allows it to yield.
Modes	2nd mode is only possible for the “free” or bike mode – 3 x bounces on the toe and holding the leg back. 3rd mode is activated by 3 x bounces on the heel and then holding the leg back. Note: Generally, it has been hard to activate the modes using the above method.
Running mode	Not available

Ottobock C-Leg 4

Activity level	Mobis 2-4	
Weight limit	136kg	
Weight of unit	1235g	
Knee flexion angle	130°	
Warranty	3 or 6 years (24 month servicing)	
Default	Stance	

Battery

To check the charging status: turn the knee joint upside down and keep at rest for 2s (5 beeps = >80% - 1 beep <35%) * charger must be unplugged
Charging status can also be checked using Data station, Cockpit App or remote
Do not move knee immediately after charging as knee performs self test, a beep and vibration will indicate the knee is ready for operation
Can turn knee off by plugging and unplugging charger 3 times

Charging Time	Capacity
4.5 hours	approx 30-45 hours (full battery)
1.5 hours	approx 15 hours
20 mins	approx 5 hours

*Warning vibrations/ beeps for low battery power
*Empty battery mode, the knee either sets “high flexion damping” (standard setting) or “low damping”, for suitable patients. This “safety mode” is set by the Prosthetist and should be discussed with the patient.

On/Off:

Remaining time until POWER OFF	10 hours	5 hours	0 hours
Vibrations	3	5	10
Knee function	Normal function		Empty battery mode

Distinguishing features

- Microprocessor controlled hydraulic stance and swing
- No electronic tube required
- Foot selection restricted, unless NHS provision
- Continuous adaptive walking speeds
- Stance release; forward inclination and movement of shank and defined knee extension moment
- Able to walk backwards with no restriction
- Intuitive or manual stance function
- Sitting function; low flexion and extension resistance
- 2 additional activity modes
- Activity monitor – has to be activated by the Prosthetist

- IP67. Fully submersible and functional for up to 30 minutes in a depth of 1m and protected against the “ingress of solid particles”- deemed as weatherproof NOT waterproof
- Charging extension cable can be used if foam required
- Power save feature active when patient is sitting or limb is fully extended and not in use
- Functional Cosmesis available for a more durable foam cover that does not interfere with swing function

Adjustments

- Requires C Soft Plus software and BionicLink
- Knee delivered in Safety mode- will not release for swing until patient data has been entered and calibrated
- Cockpit app (available in IOS or android phone) or remote control allows user to switch modes, make limited changes to adjustments, and check battery level
- User can also use body movements (bounce on toe 3 or 4 times) to activate additional modes if preselected in adjustment software by Prosthetist
- Can switch knee joint off by inserting and removing the charger 3 times, a tone sequence will then be heard before knee switches off **This is for practitioner only**

Physiotherapy

C-Leg 4

Notes	Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see microprocessor knee introduction).
Sitting	When sitting down, the patient should aim to put 50% body weight through each leg. When working on sit to stand or stand to sit, the patient can use the chair arm rests for support but advise them to take as little weight through the arms as possible, therefore loading the prosthesis more. Stand to sit is beneficial for the patient to get used to flexing the prosthesis under load which is useful for slopes and stairs practise. Resting the chair against the wall so that it cannot tilt back can help increase confidence in the early stages.
When seated	Yield (stance flexion resistance) disengages which allows the patient to move their leg freely when in sitting e.g. sitting in a restricted space like the bus
Loading response stance flexion	Available – Please note that the patient sometimes does not like the feeling of stance flexion and may try to fight this sensation; see physiotherapy hints and tips
Gait	The knee releases into swing phase when there is forward inclination, forward movement of the shin tube and a knee

extension moment – i.e. at terminal stance. This is independent of body weight and ground condition. The knee recognises pressure along the foot to release into swing phase therefore no toe load is required. Note: Unlike C-leg 3 which requires 70% toe load. The knee has a target angle of 65 ° (this can be altered by the Prosthetist depending on individual residual limb length) during swing phase flexion and therefore if the patient is aggressively accelerating the knee will not go past this angle.

The patient at times may complain of the knee “sticking” or “going stiff” this is often due to the knee going into its intuitive stance feature. Other occasions this may occur are due to the knee not achieving sufficient forward inclination of the shin, a knee extension moment or forward rotation of the shank (e.g. if the patient has a short prosthetic step or insufficient socket flexion) therefore, the knee will not move into swing phase. This is a safety feature but can be frustrating for the patient during early gait training.

Due to the adaptive swing phase control, the patient can vary their walking speed or change to different weights of shoes and the resistance will feel the same. The patient needs to be aware that this will not accommodate for changes in heel height and that this should be discussed with their Prosthetist to ensure the alignment is not affected.

Walking backwards

The patient can walk backwards. Let the knee move into the yield (stance flexion resistance) and encourage soft knees at end of stance.

Stairs going up

Step to pattern

Stairs going down

The patient can walk down step over step with the foot 1/2- 2/3 overhanging each step and engage the yield (stance flexion resistance).

Slope going up

As per normal walking pattern

Slopes going down

The patient can walk step over step – weight on heel and ride the yield. If a patient is changing from a knee with no yield or stance flexion they can find this a very difficult task and generally, this takes the longest of all aspects of the knee to train. Decrease upper limb support at able.

Caution: When the patient is initially training on how to go down stairs and steeper slopes it can be useful to turn off the intuitive stance feature because if the patient hesitates (which can be common in the early stages of training) then the knee can lock and prevent a smooth and continuous motion.

Intuitive stance

The patient should lean against a secure surface, flex knee whilst loading at least 20% of their body weight and it will lock in position. To deactivate, the patient would unload the leg, extend the knee or

function	yield. The C-Leg 4 has no restriction to where intuitive stance can be activated but this will become more difficult as the patient reaches a deeper angle e.g. deep squat position. It is a beneficial feature for bilateral amputee patients to offload pressure in their lower back.
Modes	2 additional modes, these can be activated using the method below, cockpit app with android phones or via the remote control. 2nd mode is only possible for the “free” or bike mode – 3 x bounces on the toe and holding the leg back 3rd mode is activated by 3 x bounces on the heel and then holding the leg back. Note: Generally, it has been hard to activate the modes using the above “bouncing” technique and the App or remote control has been more reliable.
Running mode	Not available

Ottobock Genium and Genium X3

	Genium	X3	
Activity level	Mobis 2-4	Mobis 3-4	
Weight limit	150kg	125Kkg	
Weight of unit	1400g	1750g	
Knee flexion angle	135° (flexion stops available)	135° (flexion stops available)	
Protection	IP67 (Weatherproof)	IP68 (Water and dust proof)	
Warranty	3 or 6 years (24 month servicing)	3 or 6 years (24 month servicing)	
Default	Stance	Stance	

Battery

Approximately 5 days of battery life with average usage

To check the battery status: turn the knee joint upside down and keep at rest for 2s (5 beeps = >80% - 1 beep <35%) * charger must be unplugged
Charging status can also be checked using Cockpit App, remote or LED lights on charger
Do not move knee immediately after disconnecting the charger as knee performs self test, a beep and vibration will indicate the knee is ready for operation

Charging Time	Capacity
6.5 hours	5 days 120 hours
2 hours	2 days + 48 hours
45 mins	1 day + 24 hours

*Warning vibrations/ beeps for low battery power
*Empty battery/safety mode. If the knee becomes fully discharged or enters an error state, Safety Mode is activated. This is a high resistant state that provides stance resistance but stance release will not occur. During gait the patient will feel like their knee is locked. The resistance can be adjusted by the Prosthetist and it is recommended that the patient has experienced this before leaving the clinic.

Remaining time until POWER OFF	24 hours	6 hours	0 hours
Beeps/Vibrations	3	5	10
Knee function	Normal function		Empty battery/safety mode

Distinguishing features

- Microprocessor controlled hydraulic stance and swing
- Electronic tube (torsion tube available, no water proof tube available for X3)
- Foot selection restricted to Ottobock recommended feet
- Continuous adaptive walking speeds
- Stance release: Knee monitors ground reaction force and will release for swing when centre of pressure is on toe
- Able to walk backwards

- Intuitive stance (takes longer to initiate therefore less likely to be accidentally engaged by newer patients or bilateral amputees)
- Stumble recovery
- Stair and obstacle function
- Sitting function; low flexion and extension resistance
- OPG: can be activated/deactivated
  - Pre flex (knee remains in 4° flex at terminal swing = shock absorption and easier initiation of stance flexion)
  - Adaptive yield
  - Adaptive extension resistance
  - Stance release on ramps
  - Adaptive swing phase control
  - Stance extension control
  - Adapts to different shoe weight
- Activity monitor – has to be activated
- 5 additional activity modes
- Walk2Run
- Cockpit App 2.0 for iOS and Android
- Protector and Functional Cosmesis available for a more durable foam cover that does not interfere with swing function

- X3: IP68- Waterproof and submersible up to 3m for 1 hour - Requires waterproof components
  - Sand proof and dust proof
  - Running mode
  - Robust chasi

Adjustments

- Requires X Soft software and BionicLink (For bi-lateral patients 2 knees can be connected to one laptop with 2 bionic links)
- Bluetooth is always active on Genium and X3
- Knee delivered in Safety mode- will not release for swing until patient data has been entered
- Stance and swing parameters can be adjusted as well as additional functions
- Cockpit app or remote control allows user to switch modes, make limited changes to adjustments, and check battery level
- User can use body movements (bounce on toe 3 or 4 times) or remote to activate modes 2 and 3 additional modes and otherwise remote control or cock pit app
- User can use app or remote to put knee in to deep sleep mode
- Knee can be turned off in X-Soft Data Station “maintenance” tab.

Physiotherapy

Genium and Genium X3

Notes

Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see introduction).

During early stance phase (loading response) OPG and pre-flexion encourage stance flexion to occur. This is to encourage a more

physiological gait pattern with benefits of shock absorption, reduction in forces in the lower back and socket along with improved control when ascending or descending slopes and stairs.

When using the pre flexion, patients transferring from a previous knee, especially a polycentric, may find this feature difficult to adapt to because of the lack of full extension at initial contact/loading response. With the recent update, pre-flexion can now be deactivated if the patient is struggling to adapt and then turned on again as the patient progresses and gains confidence with the knee. However, it is recommended that the patient perseveres and tries to get used to pre-flexion; discussing with a more established Genium user can be helpful.

The knee has adaptive yielding control and therefore can adapt to different weights e.g. carrying a child, washing etc. It can also adapt to the change of weight in shoes (please note that if they are using different shoes although the weight will be accommodated, they may still need wedges to ensure the same heel toe angle for optimum alignment).

Sitting

When sitting down, the patient should aim to put 50% body weight through each leg. Depending on patient preference, increasing or constant resistance can be selected using Data Station

When working on sit to stand or stand to sit, the patient can use the chair arm rests for support but advise them to take as little weight through the arms as possible, therefore loading the prosthesis more.

Stand to sit is beneficial for the patient to get used to flexing the prosthesis under load which is useful for slopes and stairs practise. Resting the chair against the wall so that it cannot tilt back can help increase confidence in the early stages.

When seated

When in sitting for longer than 2 seconds the knee resistance reduces to a minimum allowing a more natural seated position.

Loading response stance flexion

Automatic if OPG switched on. Available without OPG but more difficult for patient to achieve.

Gait

The knee transfers from the stance to swing phase independent of body weight or walking aids. The dynamic stability control constantly monitors the gait cycle to ensure that stance release is accurate on every step. The patient should feel the knee adjust as they change walking speed so practicing changes in walking pace is beneficial. The knee adjusts to different shoe weights.

Walking backwards

The patient can walk backwards and has the added support of the dynamic stability control feature. Let the knee move into the yield (stance flexion resistance) and encourage soft knees at end of stance.

Stairs going up

Has a stair ascent function. Step over step on the way up is possible but it is difficult to manage without a rail. Feedback regarding bilateral amputees is that it takes a lot of work to manage and only the very determined ones continue to do so in day to day life. Good hip strength, balance and a well fitting socket are required to initiate.

The patient should be advised to “flick a sheet of paper back from under their foot” (load the leg and in full extension, ensure upright posture), “kick your own bottom” or “wipe your feet on a mat” followed by hip flexion to trigger the motion. When the prosthetic foot is fully on the step, the patient should load the foot and actively extend their stump to push up the stairs – their pelvis moving forwards and upwards. Therapy assistance to guide the knee and hip extension can be beneficial.

The patient should carry out the following steps:

1. Load the prosthesis with knee fully extended
2. Flick/pull the foot
3. place on the step
4. load the flexed knee
5. extend the knee, hip and trunk (lean into it, engage gluteals and back extensors and propel from other foot)

Stepping over an obstacle

Same method as triggering stair up function – noted above

Stairs going down

The patient can walk down step over step with the foot 1/2-2/3 overhanging each step. The Genium will adapt to changes in load (adaptive yield) therefore making it easier for patients to carry items up and down the stairs.

The patient and therapist can use the phone app to make small adjustments to yield without requiring the help of the Prosthetist to find their optimum level on the stairs.

Caution: When the patient is initially training on how to go down stairs and steeper slopes it can be useful to turn off the intuitive stance function because if the patient hesitates (which can be common in the early stages of training) then the knee can lock and prevent a smooth and continuous motion.

Slope going up

As per normal walking pattern

Slopes going down

The patient can walk step over step – adaptive yield supports this by altering the level of resistance depending on the steepness of the slope; it also allows the knee to go into swing flexion on slopes, even with a flexed knee. Decrease upper limb/ therapy support as able.

Caution: When the patient is initially training on how to go down stairs and steeper slopes it can be useful to turn off the intuitive stance feature because if the patient hesitates (which can be common in the early stages of training) then the knee can lock and

prevent a smooth and continuous motion.

The patient and therapist can use the cockpit phone app to make small alterations to yield without requiring the help of the Prosthetist to find their optimum comfort level on the slope.

Intuitive stance function

The patient should lean against a secure surface, flex knee whilst loading at least 20% of their body weight and it will lock in position. To deactivate, the patient would unload the leg, extend the knee or yield. The knee has no restriction to where intuitive stance can be activated but this will become more difficult as the patient reaches a deeper angle e.g. deep squat position. It is a beneficial feature for bilateral amputee patients to offload pressure in their lower back.

Deliberate stance function: Has to be enabled in X-soft. Similar to Intuitive Stance with the same operating range but the knee joint must remain still for slightly longer before the lock is activated. To deactivate the user must extend or off-load the knee joint. Deliberate stance is a more robust stance flexion lock, which will not disengage during small movements of the knee joint. This can be of real benefit to bilateral users to allow off-loading of the prosthesis or to any user who requires increased stability.

Modes

Option of 5 modes, these can be set up via x-soft with the Prosthetist. The first two modes can be activated by bouncing on the forefoot up to 4 times in 1 second (unload the prosthesis and wait for the confirmation beeps) or with the remote control/cockpit app. To switch back, the patient uses the same method. The remaining 3 modes can only be activated by the remote control/ cockpit app; generally patients have found the remote control/cockpit app to be a more reliable method. If the patient is struggling, there are YouTube videos available via the Ottobock channel.

Walk2Run mode

Genium automatically detects a change in pace, switches off the pre flexion and increases the swing angle to accommodate for this. There have been reports of the toe catching at times on first instance.

A running mode can be added the X3.

Hints: During running, imagine bringing your heels up to the buttocks. Focus on equal movement patterns and excessive “jumping” on the prosthesis is not necessary.

Össur Rheo and Rheo3*

Activity level	K3	
Weight limit	136kg	
Weight of unit	1630g	
Knee flexion angle	120°	
Warranty	3 or 5 years (40 month servicing)	
Default	Swing Enhanced stability control can be activated on Ossur Logic to change knee to default stance	

* Rheo 3 – only additional features are weatherproofing and has a manual lock

Battery
To charge – knee can be switched on or off

Charging Time	Capacity
3 hours	approx 48-72 hours (full battery)
1.5 hours	48 hours
45 minutes	24 hours

- Repeating warning pulse and beeps for low battery power
- Battery check via LED light on interface panel on posterior knee
- Caution empty battery mode results in free knee joint. Patient has option of using manual if this occurs knee lock

Battery Check	Green	Orange (Low)	Red (Empty)
Beeps	N/A	Every 15s	Continuous for 5s before shut down
Knee Function	Normal	Normal	Empty battery mode

Distinguishing features

- Microprocessor controlled Magneto-Rheological fluid stance and swing
- Continuous adaptive walking speeds
- No restrictions on foot prescription
- Activity monitor records number of steps and walking speeds
- No additional modes
- Knee can be turned off when not in use using button on posterior control panel
- Extension hold function
- Default swing or default stance
- Ossur logic App includes functional training exercises for clinicians and users

* Rheo 3 is weatherproof and has a manual lock

Adjustments

- Programming requires Rheologic software for windows devices or Össur Logic on IOS (Apple) devices

Physiotherapy

Rheo Knee

Notes

Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see introduction).

Rheo Knee has software that allows the knee units to learn as it goes (matrix learns the patients parameters and then fine tunes itself). If the patient takes the leg away for a couple of weeks they should find that the knee adapts to their walking speed to allow a smoother gait pattern. At times, the patient may still find they need to have changes made to the yield resistance as their confidence increases with the knee.

Rheo Knee and Rheo Knee XC are the only knees that are default swing when the weight is off the leg – the patient should note if the battery goes flat then the knee will become free with no resistance but there is now the option of a manual lock.

Rheo Knee uses proportional resistance, so it is load activated. The more it is loaded, the harder it is to flex the knee. The lighter load on the knee, the easier it is to flex the knee. It is key that the patient understands this. To build confidence in how the knee works, you can demonstrate loading of the knee in the parallel bars. The patient should lightly load the leg and the therapist can then pull the knee joint, the patient should feel it begin to yield. Repeat this with full load on the leg, this time it will be very difficult for the knee to flex. It is also a good to get the patient to try to flex the knee themselves in light/full loading of the knee.

Sitting

Exercises are available for user training on the Össur Logic App, along with demonstration videos on YouTube.

When sitting down/standing up, the patient should aim to put 50% body weight through each leg. The patient can use the arm rests for support but advise them to take as little weight through the arms as possible, to allow loading of the prosthesis. Resting the chair against the wall so that it cannot tilt back can help increase confidence in the early stages.

Stand to sit is beneficial for the patient to get used to flexing the prosthesis under load which is useful for slopes and stairs practice. To facilitate even loading, using hand resistance from the therapist on the prosthetic limb side, or squeezing a pillow/balloon between the knees, or a theraband around the knees.

For sit to stand practice, begin with asking the patient to push down under their heels (use a stress ball/foam pad/therapists' fingers as a prompt). Asking where they feel the muscles working and assessing if there are any trunk compensations/ repeating on sound leg, can help use more of the Rheo Knee when standing up to offload the sound leg.

When seated	The knee is free when weight offloaded so the knee can be manoeuvred in small spaces.
Loading response stance flexion	Unavailable. However, if a patient is struggling to transition from their previous knee prescription there is now the option to set the knee from default swing to default stance. This is done using the Enhanced Stability setting on the Össur Logic App by switching it from “Dynamic to “Stable”. This means at initial contact the resistance will be maximum to prevent any unwanted flexion and if the patient does not demonstrate forward progression over their foot, the knee will remain stiff.
Gait	The knee is a load activated knee, therefore when the patient offloads the weight the knee will release into swing. However, from a gait training perspective, the patient should still aim to have forward progression along the foot (heel to toe). The patient should feel the knee adjust quickly as they change walking speed so practicing changes in walking pace is beneficial. The knee also adapts if the patient is carrying a heavier load.
Walking backwards	Figure of 8 walking is beneficial to demonstrate the free knee movement when turning in tight spaces, instead of a stiff knee. This can also be turned off via the Össur Logic App under ‘Enhanced Stability’ setting for Swing Initiation Sensitivity to "Stable". The patient can walk backwards. Let the knee move into the yield (stance flexion resistance) and encourage soft knees at end of stance.
Stairs going up	Step to pattern. Encourage the patient to provide a slight hip extension to allow the knee to flex and clear the edge of the step. It is also useful to check what the sound knee and trunk is doing when stepping up this way. Prompts to prevent the sound knee hyper extending and trunk facing the floor can be helpful.
Stairs going down	The patient can walk down step over step with the foot 1/2- 2/3 overhanging each step and engage the yield (‘stance flexion resistance stairs and ramps’ setting). The knee will adapt to carrying various loads. It is important that the patient has time to practice in Physiotherapy before settings are adjusted by their Prosthetist. This ensures they have the correct technique. Exercise available for user to train with on the Össur Logic App as well as a demonstration video also available on YouTube.
Slope going up	As per normal walking pattern. Small steps to allow roll over onto the toe to get the most energy return from the prosthetic foot.
Slopes going down	The patient can walk step over step – weight on heel and ride the yield. As Rheo Knee is load activated, increasing arm support will decrease the yield resistance felt in the knee therefore aim for the knee to be as

	loaded as possible. Decrease upper limb support as able. Small steps and support in front of the knee from the therapist can be used while the patient gains confidence down slopes. If a patient is changing from a knee with no yield or stance flexion they can find this a very difficult task and generally this takes the longest of all aspects of the knee to train. A useful exercise to gain confidence with the yield prior to the ramp, is the Caveman within the parallel bars. This is slightly squatting (like trying to sit down), and whilst staying low, taking small steps to feel comfortable with the yield and loading of the knee.
Intuitive stance function	Not available but load activated yield
Modes	No automatic recognition available on Rheo Knee. The power can be turned off to allow it to be used to cycle without resistance. The user must remember to turn it back on once finished cycling as it will be completely free.
Running mode	Not available
Extension hold	The patient can activate this by extending the knee and pulling backwards. It can be quite a subtle movement. The knee locks out in full extension for up to 5 seconds to assist getting on/off bike, in/out car and obstacle avoidance. If 5 seconds feels too long, the patient can load put through the knee and it will deactivate e.g. pressure against the foot well when getting in/out car or pushing the knee down. Caution: The patient can accidentally engage this feature, but this can be switched off as a feature if the patient is not finding it beneficial.
Manual extension lock	To lock, the button on side of the knee is pushed across when knee is in full extension. To unlock, push back in opposite direction. Useful for tasks where the patient wishes to increase stability or for increased safety if the battery has gone flat and the knee has become a free knee.

Össur Rheo XC

Activity level	K3-4	
Weight limit	110-136kg	
Weight of unit	1630g	
Knee flexion angle	120°	
Warranty	3 or 5 years (40 month servicing)	
Default	Swing Enhanced stability control can be activated on Ossur Logic to change knee to default stance	

Battery

To charge – knee can be switched on or off

Charging Time	Capacity
3 hours	approx 48-72 hours (full battery)
1.5 hours	48 hours
45 minutes	24 hours

*Repeating warning pulse and beeps for low battery power
* Battery check via LED light on interface panel
* Empty battery mode results in free knee joint, option of using manual knee lock

Battery Check	Green	Orange (Low)	Red (Empty)
Beeps	N/A	Every 15 s	continuous for 5 s before shut down
Knee Function	normal	Normal	Empty battery mode

Distinguishing features

- Microprocessor controlled Magneto-Rheological fluid stance and swing
- Continuous adaptive walking speeds
- No restrictions on foot prescription
- Automatic cycle recognition
- Automatic running recognition
- Activity monitor records number of steps and walking speeds
- Weatherproof
- Knee can be turned off when not in use
- Extension hold function
- Default swing or stance
- Ossur logic App includes functional training exercises for clinicians and users

Adjustments

- Programming requires Rheologic software for windows devices or Össur Logic on iOS (Apple) devices
- Cycling mode activated after completion of 2 crank rotations, 1 long beep indicates cycling function. When stepping off the bike, the knee resistance cuts in at 15 ° or less to return to walking mode, this is confirmed with 1 short beep.

- The patient can use Össur Logic in the default user mode to monitor battery status, step count and functional training exercises.

Physiotherapy

Rheo Knee XC

Notes

Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see introduction).

Rheo Knee XC has software that allows the knee units to learn as it goes (matrix learns the patients parameters and then fine tunes itself). If the patient takes the leg away for a couple of weeks they should find that the knee adapts to their walking speed to allow a smoother gait pattern. At times, the patient may still find they need to have changes made to the yield resistance as their confidence with the knee increases.

Rheo Knee and Rheo Knee XC are the only knees that are default swing when the weight is off the leg – the patient should note if the battery goes flat then the knee will become free with no resistance but there is now the option of a manual lock.

Rheo Knee XC uses Proportional Resistance, so is load activated. The more it is loaded, the harder it is to flex the knee. The lighter load on the knee, the easier it is to flex the knee. It is key the patient understands this. To build confidence in how the knee works, you can demonstrate loading of the knee in the parallel bars. The patient should lightly load the leg and the therapist can then pull the knee joint, the patient should feel it begin to yield. Repeat this with full load on the leg, this time it will be very difficult for the knee to flex. It is also a good to get the patient to try to flex the knee themselves in light/full loading of the knee.

Exercises are available for user training on the Össur Logic App, along with demonstration videos on YouTube.

Sitting

When sitting down/standing up, the patient should aim to put 50% body weight through each leg. The patient can use the arm rests for support but advise them to take as little weight through the arms as possible, to allow loading of the prosthesis. Resting the chair against the wall so that it cannot tilt back can help increase confidence in the early stages.

Stand to sit is beneficial for the patient to get used to flexing the prosthesis under load which is useful for slopes and stairs practice. To facilitate even loading, using hand resistance from the therapist on the prosthetic limb side, or squeezing a pillow/balloon between the knees, or a theraband around the knees. Practising the sitting movement until where the user loses even loading and moves off the Rheo Knee, can

help progress to loading it throughout the entire movement.

For sit to stand practice, begin with asking the patient to push down under their heels (use a stress ball/foam pad/therapists' fingers as a prompt). Asking where they feel the muscles working and assessing if there are any trunk compensations/ repeating on sound leg, can help use more of the Rheo Knee when standing up to offload the sound leg.

When seated

The knee is free when weight offloaded so the knee can be manoeuvred in small spaces.

Loading response stance flexion

Unavailable. However, if a patient is struggling to transition from their previous knee prescription there is now the option to set the knee from default swing to default stance. This is done using the Enhanced Stability setting on the Össur Logic App by switching it from "Dynamic to "Stable". This means at initial contact the resistance will be maximum to prevent any unwanted flexion and if the patient does not demonstrate forward progression over their foot, the knee will remain stiff.

Gait

The knee is a load activated knee, therefore when the patient offloads the weight the knee will release into swing. However, from a gait training perspective, the patient should still aim to have forward progression along the foot (heel to toe). The patient should feel the knee adjust quickly as they change walking speed so practicing changes in walking pace is beneficial. The knee also adapts if the patient is carrying a heavier load.

Figure of 8 walking is beneficial to demonstrate the free knee movement when turning in tight spaces, instead of a stiff knee. This can also be turned off via the Össur Logic App under 'Enhanced Stability' setting for Swing Initiation Sensitivity to "Stable".

Walking backwards

The patient can walk backwards. Let the knee move into the yield (stance flexion resistance) and encourage soft knees at end of stance.

Stairs going up

Begin by teaching the step by step stair ascent pattern. Encourage the patient to provide a slight hip extension to allow the knee to flex and clear the edge of the step. This can prevent the back twisting/hip circumduction when climbing stairs. Prompts to prevent the sound knee hyperextending and trunk facing the floor is important to progress to step over step stair ascent. The patient may need to practice this prior to moving on with the technique.

Step over step stair ascent is possible with Rheo Knee XC. There is a Training video on YouTube and Step over step stair ascent guide is also available. Breaking the full movement up into individual movements can help progress to the full step over step stair ascent. It

can be useful to have Extension Hold function switched on for training as it can activate when the patient is not using correct technique.

Good hip strength is required to initiate the movement. The patient should feel the prosthetic limb move into “stair ascent” function when they are carrying out the motion correctly. Exercises prior to teaching step over step stair ascent should include; pelvic tilts, standing hip extension/flexion, accelerating from hip extension into flexion and step ups (bilaterally).

For the knee to recognise step by step stair ascent, it needs 3 triggers. 1) A slight hip extension, 2) An acceleration into flexion, 3) A height change. Advising the patient to “flick a sheet of paper back from under their foot” or “wipe your feet on a mat” and bring hip forward can assist with the motion required but Össur report that not as much hip extension is required to initiate the stair ascent function; it is more about the acceleration into hip flexion and the height change. The movement should be that taught for step by step stair ascent, a small hip extension to allow the knee to flex.

The patient can start with either their prosthetic side or their intact side.

Leading with <u>prosthetic side first</u> (easier way to commence training), the patient should:
1. Initiate hip flexion on the amputated side,
2. Position the prosthetic foot flat on the step (controlled hip flexion movement is more important than speed)
3. Move their pelvis over the prosthesis with a >25° knee flexion angle
4. Contract the stump muscles and move amputated side into extension, keeping the upper body straight and move in a forwards direction (a handrail can be used to assist with this).
5. Position the intact side onto the next step (their amputated side should be in swing phase) – they patient may need minor hip extension but it is more important, that after the hip extension that they come into hip flexion “*bringing knee to nose*” and step the amputated side onto the next step.

Leading with <u>intact side first</u> the patient should:
1. Place the intact side on the first step (the patient can use the second step to encourage more hip extension as this will make acceleration into hip flexion easier. However, if doing this, the patient needs to ensure their trunk is not facing down to the step, and that they stay upright).
2. Roll over the prosthetic forefoot and initiate a smooth and quick hip flexion “*bringing knee to nose*” and bring their prosthetic foot onto the step,
3. Contract their stump muscles and move the amputated side into extension, keeping their upper body straight and move in a forwards direction (a handrail can be used to assist with this).
4. position their intact side onto the next step
5. the amputated side should be in swing phase – they may need minor hip extension but it is more important, that after the hip

extension they come into hip flexion “bringing knee to nose” and step their amputated side onto the next step

Advising the patient to “flick a sheet of paper back from under their foot” or “wipe your feet on a mat” and bring hip forward can assist with the motion required but Össur report that not as much hip extension is required to initiate the stair ascent function; it is more about the hip flexion.

Exercises available for the patient to train with on the Össur Logic App as well as a demonstration video available on YouTube.

Stairs going down

The patient can walk down step over step with the foot 1/2- 2/3 overhanging each step and engage the yield (‘stance flexion resistance stairs and ramps’ setting). The knee will adapt to carrying various loads.

It is important that the patient has time to practice in Physiotherapy before settings are adjusted by their Prosthetist. This ensures they have the correct technique.

Slopes going up

As per normal walking pattern. Small steps to allow roll over onto the toe to get the most energy return from the prosthetic foot.

Slopes going down

The patient can walk step over step – weight on heel and ride the yield. As Rheo Knee XC is weight activated, increasing arm support will decrease the yield resistance felt in the knee therefore aim for the knee to be as loaded as much as possible. Decrease upper limb support as able.

Small steps and support in front of the knee from the therapist can be used while the patient gains confidence down slopes. If a patient is changing from a knee with no yield or stance flexion, they can find this a very difficult task and generally this takes the longest of all aspects of the knee to train.

A useful exercise to gain confidence with the yield prior to the ramp, is the Caveman within the parallel bars. This is slightly squatting (like trying to sit down), and whilst staying low, taking small steps to feel comfortable with the yield and loading of the knee.

Intuitive stance function

Not available but weight activated yield

Automatic recognition features	*Automatic stair ascent recognition* - see Stairs going up section for details. *Automatic Speed Recognition* for jogging/running up to 16 km/h. Only patients under 110kg should use this feature. The knee detects a change in pace and adjusts flexion resistance to accommodate for this. It will also deactivate upstairs ascent recognition, so the patient does not accidently activate this mid stride. *Automatic Cycling Recognition*: The knee automatically detects that the patient is cycling after two rotations of the pedals with minimal load on the knee. There is one long beep to confirm cycling function. When stepping off the bike, the knee resistance automatically cuts in at 15° or less to return to normal knee function, this is confirmed with 1 short beep.
Running mode	Automatic speed recognition available – see Automatic Recognition features section.
Extension hold	The patient can activate this by extending the knee and pulling backwards. It can be quite a subtle movement but can happen when patient had not wanted to initiate it. The knee locks out in full extension for up to 5 seconds to assist getting on/off bike, in/out car and obstacle avoidance. If 5 seconds feels too long, the patient can load through the knee and it will deactivate e.g. pressure against the car's foot well when getting in/out car or pushing the knee down. Caution: The patient can accidentally engage this feature if they rapidly extend e.g. utilising stair ascent function but this can be switched off as a feature if the patient is not finding it beneficial.
Manual extension lock	To lock, the button on side of the knee is pushed across when knee is in full extension. To unlock, push back in opposite direction. Useful for tasks where the patient wishes to increase stability or for increased safety if the battery has gone flat and the knee has become a free knee.

Additional resources

Össur Logic connection guide
Exercise sheet (app exercises)
All Exercises on the Össur logic App for Rheo Knee

Blatchford Orion 3

Activity level	K2 – 4 (For K2-K3 Activities)	
Weight limit	125kg	
Weight of unit	1500g	
Knee flexion angle	130 °	
Warranty	5 years (20 month servicing)	
Default	Stance	

Battery

To charge - knee extended and ensure knee is switched on
Once charged – keep knee stationary for 10secs to allow knee boot up sequence

Charging Time	Capacity
8 hours	approx 72 hours (full battery)

*Warning beeps for low battery power
* Battery check via LED light on back of knee by pressing and holding (-) button until 1 short beep is heard
* Battery life can be extended using the “off” switch when limb is not in use
* Empty battery mode, the knee is set to “high flexion damping”

Battery Check	Green	Yellow (Low)	Red (Empty)
Beeps	N/A	8 short	5 long
Knee Function	normal	normal	Empty battery mode

Distinguishing features

- Microprocessor controlled knee with microprocessor controlled hydraulic stance and hydropneumatic swing
- 5 adaptive walking speeds
- 2 additional activity modes; fixed angle flexion lock (0-45° which is patient adjustable) and cycling
- Stop and Lock (Intuitive stance)
- Weatherproof
- No restriction in foot prescription

Adjustments

- Programming requires Orion3 software
- User can use (-) button on knee unit to activate additional modes (**fixed angle flexion lock**: (-) x3 = 3 beeps, **free swing:** (-) x 4 = 4 beeps)

Physiotherapy

Orion 3

Notes	Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see introduction).
Sitting	When sitting down, the patient should aim to put 50% body weight through each leg. The yield resistance increases during sitting in the Orion 3 to allow a consistent rate of flexion. When working on sit to stand or stand to sit, the patient can use the chair arm rests for support but advise them to take as little weight through the arms as possible, therefore loading the prosthesis more. Stand to sit is beneficial for the patient to get used to flexing the prosthesis under load which is useful for slopes and stairs practise. Resting the chair against the wall so that it cannot tilt back can help increase confidence in the early stages.
When seated	Yield (stance flexion resistance) disengages which allows the patient to move their leg freely when in sitting e.g. sitting in a restricted space like the bus.
Loading response stance flexion	Not available (liaise with manufacturer if deemed essential)
Gait	The knee recognises bending moment in the shin to release into swing but training should involve normal progression of the foot as that for normal walking. The patient should feel the knee adjust as they change walking speed so practicing changes in walking pace is beneficial.
Walking backwards	The patient can walk backwards. Let the knee move into the yield (stance flexion resistance) and encourage soft knees at end of stance.
Stairs going up	Step to pattern
Stairs going down	The patient can walk down step over step with the foot 1/2- 2/3 overhanging each step and engage the yield (stance flexion resistance).
Slope going up	As per normal walking pattern, if using a hydraulic foot with this knee then it should absorb some of the incline making this activity easier.
Slopes going down	The patient can walk step over step. The hydraulic ankle can absorb the incline on smaller slopes (approx. 15° angle) so patients may not need to utilise the yield of the knee as often.

Decrease support as able; start with rails, then 1 rail then no rail. If a patient is changing from a knee with no yield or stance flexion they can find this a very difficult task and generally, this takes the longest of all aspects of the knee to train. The patient can walk step over step – weight on heel and ride the yield. Decrease support as able.

Caution: When the patient is initially training on how to go down stairs and steeper slopes it can be useful to turn off the stop and lock (intuitive stance) feature because if the patient hesitates (which can be common in the early stages of training) then the knee can lock and prevent a smooth and continuous motion.

Stop and lock

(Intuitive stance function)

Available, it activates a lock in the knee using a sensor. To practise, the patient should lean against a secure surface and flex knee to desired angle and it will lock in position up to 49°. To deactivate, unload the leg, extend the knee or walk off. This is a particularly beneficial feature for bilateral amputee patients to offload pressure in their lower back.

The knee only requires being stationary for the feature to activate and this includes an extended position. Stop and lock works until 49°of knee flexion.

Modes

2 additional modes.

- Free swing (cycle) mode: (-) button x 4 = 4 beeps
- Fixed flexion angle flexion lock: (-) button x3 = 3 beeps

To exit the modes – press and hold the (-) button until the first of two longer beeps are heard.

Running mode

Not available

Blatchford Linx

Activity level	K3 - 4	
Weight limit	125kg	
Weight of unit	2600g	
Knee flexion angle	130 °	
Warranty	3 or 5 years (20 month servicing)	
Default	Stance	

Battery

To charge - knee extended and ensure knee is switched on
Once charged – keep knee stationary for 10s to allow motors to reset

Charging Time	Capacity
8 hours	approx 72 hours (full battery)

*Warning beeps for low battery power
* Battery check via LED light on back of knee by pressing and holding (-) button until 1 short beep is heard
* Empty battery mode, the knee either set “high flexion damping” (standard setting)
Can extend battery life using physical switch when limb not in use

Battery Check	Green	Yellow (Low)	Red (Empty)
Beeps	N/A	8 short	5 long
Knee Function	normal	normal	Empty battery mode

Distinguishing features

- Fully integrated microprocessor controlled knee and foot system with microprocessor controlled hydraulic stance and hydro-pneumatic swing
- 5 adaptive walking speeds
- Independent ramp descent brake mode at both Knee and Ankle for intermediate ramps
- Up Ramp assistance from foot
- 2 additional activity modes; fixed angle flexion lock (0-45° which is patient adjustable) and free swing
- Stop and Lock (Intuitive stance) - Knee and foot
- Weatherproof

Adjustments

- Programming requires Linx software

- Linx software is also used to adjust plantar flexion and dorsiflexion resistance in the foot
- User can use (-) button on knee unit to activate additional modes (**fixed angle flexion lock**: (-) x3 = 3 beeps, **free swing:** (-) x 4 = 4 beeps)

Physiotherapy

Linx

Notes	Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see introduction). The Linx has the benefit that the knee and foot communicate with each other allowing the knee to adapt to different environments. The benefit of the hydraulic foot allows slopes to be absorbed without the engagement of the knee. If yield is required, yield resistance (stance flexion resistance) can adapt to different environments.
Sitting	When sitting down, the patient should aim to put 50% body weight through each leg. When working on sit to stand or stand to sit, the patient can use the chair arm rests for support but advise them to take as little weight through the arms as possible, therefore loading the prosthesis more. Stand to sit is beneficial for the patient to get used to flexing the prosthesis under load which is useful for slopes and stairs practise. Resting the chair against the wall so that it cannot tilt back can help increase confidence in the early stages.
When seated	Yield (stance flexion resistance) disengages which allows the patient to move their leg freely when in sitting e.g. sitting in a restricted space like the bus.
Loading response stance flexion	Not available (liaise with manufacturer if deemed essential)
Gait	The knee recognises pressure along the foot (bending moments occurring in the shin) to release into swing. The patient should feel the knee adjust as they change walking speed so practicing changes in walking pace is beneficial.
Walking backwards	The patient can walk backwards. Let the knee move into the yield (stance flexion resistance) and encourage soft knees at end of stance.
Stairs going up	Step to pattern

Stairs going down	The patient can walk down step over step with the foot 1/2- 2/3 overhanging each step and engage the yield (stance flexion resistance). Caution: When the patient is initially training on how to go down stairs and steeper slopes it can be useful to turn off the stop and lock (intuitive stance) feature because if the patient hesitates (which can be common in the early stages of training) then the knee can lock and prevent a smooth and continuous motion
Slope going up	As per normal walking pattern. The built in Active Up-ramp mode should make this activity easier.
Slopes going down	The patient can walk step over step. Both the knee and ankle have a Down Ramp mode which can make this activity more fluid, it can allow the patient to walk normally rather than a yielding walk. The hydraulic ankle can absorb the incline on smaller slopes (approximately 15 degree angle) so patients may not need to utilise the yield of the knee as often. Upper limb support should be decreased as able. If the patient is changing from a knee with no yield or stance flexion this can be the most difficult task to relearn due to the amount of trust required in the knee and generally takes the longest of all aspects of the knee to train. Caution: When the patient is initially training on how to go down stairs and steeper slopes it can be useful to turn off the stop and lock (intuitive stance) feature because if the patient hesitates (which can be common in the early stages of training) then the knee can lock and prevent a smooth and continuous motion.
Stop and lock (Intuitive stance function)	Available, it activates a lock in both the knee and the foot using a sensor on the foot, this feature will activate when the patient is standing stationary. To practise, the patient should lean against a secure surface and flex knee to desired angle and it will lock in position up to 49 °. To deactivate, unload the leg, extend the knee or walk off. This is a particularly beneficial feature for bilateral amputee patients to offload pressure in their lower back.
Modes	2 additional modes. • Free swing (cycle) mode: (-) button x 4 = 4 beeps • Fixed flexion angle flexion lock: (-) button x3 = 3 beeps To exit the modes – press and hold the (-) button until the first of two longer beeps are heard.
Running mode	Not available

Steeper Plié 3

Activity level	K2-K4	
Weight limit	100-125kg	
Weight of unit	1235g	
Knee flexion angle	117-125°	
Warranty	5 years (12 monthly services)	
Default	Stance	

Battery

Batteries should be charged daily
2 batteries provided as standard, additional batteries can be purchased
Car charger supplied as standard

Charging Time	Capacity
2.5- 3 hours	24 hours (full battery)
1 hour	6 hours

- No significant low battery warnings

Distinguishing features

- Microprocessor controlled hydraulic stance and safe transition into swing
- Continuous adaptive walking speeds
- Interchangeable batteries (can take spares to change if battery goes flat)
- Fully submersible and functional for up to 30 minutes in a depth of 1m and protected against the “ingress of solid particles” IP67
- Activity monitor – can generate cadence report at set up and will record steps achieved by the patient
- Ability to run

Adjustments

- Programming requires Plié Control 6 software
- Manually adjustable stance flexion and swing extension via an Allen key
- Manual adjustment of swing flexion, using hand pump to increase/decrease pneumatic pressure (should be checked monthly as routine)

* manual setting can be adjusted by the patient for particular activities such as cycling

Physiotherapy

Plié 3

Notes

Joint sessions with the Prosthetist and Physiotherapist are invaluable to ensure patient safety and optimum use of the knee (see introduction).

The Plié offers patients more control over their knee settings that can be adapted using 3 methods:

1. Hydraulic cylinder with pneumatic element – with the use of a pump the flexion resistance and extension assist function can be increased
2. Yield – can be increased or decreased using an Allen key
3. Extension hydraulic resistance – this can be increased or decreased using an Allen key e.g. it could be increased to prevent terminal impact when running

Sitting

When sitting down, the patient should aim to put 50% body weight through each leg.

When working on sit to stand or stand to sit, the patient can use the chair arm rests for support but advise them to take as little weight through the arms as possible, therefore loading the prosthesis more.

Stand to sit is beneficial for the patient to get used to flexing the prosthesis under load which is useful for slopes and stairs practise. Resting the chair against the wall so that it cannot tilt back can help increase confidence in the early stages.

When seated

Yield does not automatically decrease so knee may have more resistance when moving it into small spaces.

Loading response stance flexion

Not available

Gait

For swing to release during the gait cycle; the patient requires a fully extended knee and two triggers; Toe Transition (TT) at approximately 75% of max toe load and Swing Transition (ST) sometime after max toe load as the patient offload's their weight. It is beneficial to practise various walking speeds as the knee can transition smoothly between these.

If the patient complains of the knee "sticking" or "going stiff" this can be because they are not achieving the toe load or because another element of the gait has triggered stumble recovery unnecessarily preventing the knee from initiating swing mode. This is a safety feature that can be frustrating for the patient during gait training but the manufacturer's report that with the new set up, the likelihood of this happening is greatly reduced. It is more likely to occur at very slow or fast walking and usually means that the set up of the knee is not managing to capture the range of speeds and activities that the

	patient is now achieving. If the above is happening during slow walking; observe the patient and if there is no knee flexion then the Prosthetist could reduce toe transition (TT) slightly or if flexion does occur but blocks, the issue could be involving a “Timing parameter”. If it occurs when the patient is fast walking the “Torque Parameters” may need to be adjusted.
Walking backwards	The patient can walk backwards by walking on the heel which maintains the stumble recovery yield.
Stairs going up	Step to pattern
Stairs going down	The patient can walk down step over step with the foot 1/2- 2/3 overhanging each step and engage the yield (stance flexion resistance).
Slope going up	As per normal walking pattern
Slopes going down	The patient can walk step over step. On smaller slopes encourage normal walking and allow normal transition into swing phase; Steeper group recommend the use of the Kinterra foot which can help absorb the slope angle and make this easier for the patient. On steeper slopes, weight on heel and ride the yield. Decrease upper limb support as able.
Intuitive stance function	Not available
Modes	No definitive modes but the patient has more control over their own settings than with some of the other microprocessor knees with 3 functions: • Air pressure flexion control – using pump • Yield control – can be turned on/off using an Allan key • Extension resistance – this can be increased for less terminal impact when running
Running mode	Available. If the patient states they wish to run, the knee parameters can be set to accommodate for this. Additionally, the patient has the option of increasing the pneumatic pressure to reduce heel rise and to ensure high extension assist and rapid extension.

WestMARC hints and tips

Microprocessor controlled knees

Prosthetic hints and tips

General

- Bench alignment is key; ensure hip flexion contractures are accommodated, both in terms of angle and translation. This will allow for easier set up and alignment of knees.
- Ensure tablets and laptops are always charged as they will be required to programme the knee.
- Ensure knee joint is charged and check Bluetooth connection before fitting appointment. This will save clinical time if problems are identified with Bluetooth connection beforehand.
- Have a system in place to record serial number of knee unit as this will be required when returning for repair and/or servicing.
- Have a reminder system in place to ensure servicing dates of the knee unit are not missed as this may affect warranty.
- Keep a copy of returns number when returning knee for repair or servicing as this will be required to track the knee unit, no patient data is used.
- Cosmetic foams have proved to be unsuccessful with knee units and can impact on function.

Ottobock knees

- C-leg 4 and Genium are now delivered in Safety Mode. The knee will not release for swing until patient information has been added to Data Station and C-leg 4 needs to be calibrated
- Do not undo telescopic shin tubes with patient standing
- If there is space above the knee and no cosmesis being used it is useful to fit a turn table. This allows the knee (C Leg 4, Kenevo and Genium) to be turned upside down to turn on Bluetooth and check the battery status.
- Ensure shin tubes for knees (C leg 3, Kenevo and Genium) are inserted facing correct direction before proceeding with fitting as will not function correctly.

- Remember to use knee extender when bench aligning C Leg 4 and remember to remove before dynamic alignment.

- Keep a record of knee centre to black ring for Genium and Kenevo knee joint as this measurement will be required when arranging loaner units for service/repair.

- Collision check in alignment tab for Genium. This is a wizard which walks the user through a check to determine if the socket collides with the hydraulic cylinder. It will recommend the addition of a flexion stop or to change the size of flexion stop if one is already installed. This has been introduced to prevent damage to the cylinder over extended periods of contact.

Össur knees

- Most patient request that the extension hold function is switched off as it can engage unexpectedly during ambulation.

- If problems identified with function of Rheo try re calibrating first as this removes possible false load from the sensors.

- Patient must be able to walk at a moderate speed to get the 20 steps required for programming so if not recording, encourage patient to speed up until it can be measured.

- It should be noted that knee can be switched on/off. Patient should check knee is switched on to ensure normal function

Orion 3

- Cannot connect to software with knee charging

- It should be noted that knee can be switched on/off. Patient should check knee is switched on to ensure normal function

Microprocessor controlled knees

Physiotherapy hints and tips

General

Pre changeover:

- Prior to change over to a MPK knee, physiotherapy sessions are beneficial to decrease flexion contractures, improve core and general muscle strength and highlight gait habits that would benefit from correction.

- Loading the knee is imperative for optimum knee function – improving this with their current prescription prior to changing over to their MPK is useful to optimise their trial time.

- If the patient only has a 4 week trial, ensure they have a comfortable, well fitting socket prior to changing over the knee so that socket fit issues do not dominate therapy gait training time.

- If a patient has a large flexion contracture this can result in a bulky socket which can be cosmetically unacceptable for the patient and should be discussed with them prior to changeover.

- Be aware of the maximum knee flexion angle particularly if the patient requires to kneel a lot throughout the day e.g. nursery nurse, joiner etc. as patients need to be careful that the controls don't hit against the rest of the leg and also that the length of the unit can still allow them to do this task.

Post changeover

- Loading response stance flexion of the MPK can be difficult for established patients who have not had this feature on their previous knee. Gait training is required so the patient can learn to trust and use this feature.

- If adding cosmetic foam, the knee may require reprogramming.

- Long term limb wearers can find the transition onto an MPK very difficult despite the added stability and functions of MPKs – some patients are happy continuing with the familiar and may reject the components. It can also be a lot to change at one time if they are moving to a new socket, knee and foot.

- Patients who have used a yielding knee prior to changing to an MPK generally find this transition easier and may not take long to optimise use of the features.

- Musculoskeletal problems can flare up as the body adapts to a new walking style or if the patient has increased their walking distance.

Kenevo

- If coming off a SAKL – review patients movement patterns to ensure that it does not engage sit down mode – e.g. flexing at the trunk to reach for something.

Walking

- Practise walking and getting the yield to engage – this gives the patient an opportunity to feel that movement while walking on the flat which helps transition to coming down a slope.

Stairs

- In the early stages, the intuitive stance/stop and lock may hinder the therapy session as hesitation from the patient can cause it to lock. This can be switched off for the session. Remember to turn it back on if patient uses the feature regularly.

- If the steps are too wide or the patient is short in height, they may find it useful to place each foot half on, half off so they are keeping consistent step lengths and it is also not as long a loading phase on the prosthetic side.

- Start on the bottom step until patient has an understanding of the stance flexion resistance and engaging the yield.

- The therapists can place their hand on the prosthetic knee and the other hand on their hip to give the patient confidence that the knee will not “shoot” away from them while they adjust to this new technique.

- Ensure the patient’s weight is through the midline or slightly forward because if they lean back this can make the knee think the patient is sitting down.

- Starting on the stairs before moving to the slopes can be helpful for patients to get used to the yield function in a more controlled environment.

Slopes

- The most difficult part to retrain (when using a slope with no rails).

- Loading response knee flexion may accommodate smaller gradients therefore no need to engage yield function.

- If the patient has a hydraulic ankle, smaller slopes maybe absorbed by the ankle with no need to engage the yield of the MPK.

- Increasing the yield (more than initially advised – even just a small amount) in the initial stages can be hugely beneficial for some patients as it allows them to learn to trust the knee and “feel the yield”. The patient will want to feel the knee “holding” them when on slopes and stairs and only when they can feel this sensation will they learn to load it fully and trust the knee to carry out the technique correctly.

  Note: this may make it more difficult for stand to sit as the yield will be higher when using some of the MPKs. The manufacturers have commented that they do not think this is beneficial and that too high a yield resistance can inhibit their walking ability on a slope. However clinically, when patients are moving from a knee with no previous yield function the majority really need to feel the knee “hold them” before they will learn to trust it fully. This can easily be backed off as they progress and become more confident – even within 1 session. Generally, the patient will instantly report if they feel an improvement which can guide whether this increase is required.

- Loading the knee is imperative for optimum knee function. If the patient is offloading the knee it will not respond as effectively.

- It is best for the patient to train on a slope with rails and with a slope steep enough to allow the yield to engage.

- Therapy resistance supporting the patient can be beneficial. The patient and therapist can go “palm to palm” to encourage a step through pattern, to help with feeling the yield and encourage normal walking or with the therapist supporting the patient’s pelvis from the front.

- The intuitive stance/stop and lock may hinder the therapy session as hesitation from the patient can cause it to lock – this can be switched off for the session. Remember to turn it back on if patient uses the feature regularly.

Stand to sit

- Initially, the therapist should have the chair against a wall to give the patient confidence that the chair will not tip back.

- The therapist can place their hand on the amputated side of the patient’s hip and asking them to keep contact with your hand as they sit, this can encourage improved loading on that side

- When the patient is gaining confidence with stand to sit, the intuitive stance/stop and lock may hinder the therapy session as hesitation from the patient can cause it to lock – this can be switched off for the session. Remember to turn it back on if patient uses the feature regularly.

- If the patient is struggling, ensure they are not leaning back on their heel and their foot is flat when possible.

Hip disarticulation

- All MPK users with a hip disarticulation have had marked decrease in knee flexion angle at swing phase.

- It can be a difficult transition for patients when moving from current prescription to new socket, hip, knee and foot, especially if the alignment of the hip joint is different from their previous type.

Bilateral above knee training

Prosthetic Rehabilitation of Bilateral Transfemoral Amputees - WestMARC protocol

A. **On referral call in for physiotherapy and OT assessment**

- Review patient's medical history and risk factors
- Assess strength and ROM
- Assess bed mobility
- Assess transfers including bed to wheelchair and wheelchair to floor
- Complete BLARt (Blatchford Leicester Allman Russell tool) Score[8]: a score greater than 22 suggests patient will not walk with prostheses. See Appendix 5.
- Complete ACE 111 test: a score of less than 82 indicates a degree of cognitive impairment and patient may have difficulties learning to don/doff and walk with a prosthesis
- Find out patient's reasons and goals for limb fitting- ensure realistic and achievable
- Review patient's home situation- external/internal environment, access and family/carer support
- From these findings, discuss outcome with patient and how to proceed e.g. work on home exercise programme then contact the department when achieving.

B. Joint discussion with patient and MDT

- Inform patient of results of assessment
- Ensure clear, honest and documented discussion of the challenges and risks of walking with 2 above knee prostheses: huge effort required to walk, difficulty donning limbs, risk of falls and subsequent serious injury, stress on cardiovascular system, joints and muscles due to extreme effort involved
- Discuss their goals and ensure realistic. Make sure patient understands that the goal of limb fitting is for independence in all ADL activities, including outdoor walking unaided or 1 stick, with 2 stubbies before they would even be considered for articulating knees. They should understand that progressing to 2 articulated prosthetic knees is rarely achieved.
- Inform patient regarding procedure and pathway as follows below.

C. **Discuss case at Tuesday MDT** to secure agreement to proceed to physiotherapy

D. On agreement with MDT **start physiotherapy**

Appointments should be spaced with the emphasis on the patient working on exercises at home as multiple physiotherapy appointments will be required once patient fitted with stubbies.

The patient must achieve the following prior to being fitted with stubbies: -

- Hip flexion contractures no more than 15 degrees
- Good gluteal activation and strength

- Independent bed mobility
- Good sitting balance
- Transfers independently and safely from wheelchair to floor using blocks (no more that 3 stages)
- Able to wheel themselves the full length of the corridor from the Gym to reception with no breaks (60m).

E. Fit with stubbies (using Sidekicks) if patient has achieved goals listed above.

- Maximum of 15 degrees hip flexion contracture prior to casting. This position needs to be monitored and maintained. If hip flexion contracture increases to above 15 degrees, fitting should be suspended until position has improved. This may require further physio input here.
- **Prosthetist**: fit with socks and a belt unless there are other exceptional circumstances, for example, extensive scar tissue.
- **Prosthetist:** use Sidekicks, trial set available in department.
- **Physio:** see 'Stubbies Hints and Tips'

F. Progression to articulated microprocessor knees (MPKs)

The most realistic definitive prostheses for the majority of this group of patients will usually be short stubbies.

If a patient is managing short stubbies independently, height can be increased with or without the inclusion of a SAKL. This may allow increased function due the increase in height, but will be at a higher energy cost.

In order to consider progression to microprocessor knees, a patient needs to demonstrate the following: -

- Has demonstrated full time use of tall stubbies (at least the minimum height of an MPK) ie choosing to wear them for extended periods of time and to carry out appropriate ADLs
- Confident outdoor walker – manage slopes, stairs with a rail, kerbs
- Able to walk in from transport and down to gym independently with 1 stick or no aid.
- Can manage added weight of MPK ie add weights to stubbies to give patient an idea of weight difference of MPK and to check suspension is optimal.
- Maintain a maximum of 15 degree hip flexion contracture

G. Discuss at MDT meeting

- Secure agreement that patient is suitable to put forward to national MDT for provision of bilateral MPKs.

H. Discuss at national MDT

- Secure agreement that patient is suitable to be provided with bilateral MPKs.

I. Rehabilitation with bilateral MPKs

- See section on 'bilateral MPK users hints and tips'

Stubbies

- Start small – commence on stubbies low to the ground and “grow” the patient as able.
- Ask the patient to find the most “comfortable” height for them to carry out ADL’s with their stubbies – for some, this may be lower than their final stubbie height before they progress to microprocessor knees (MPK). They may wish to return to this lower height as it is more energy efficient and functional.
- Aim for joint sessions with the Prosthetist in the early stage.
- Aim to get to a height that makes it easy to get on and off a wheelchair as soon as possible.
- Add in knee joints as able so patient can sit comfortably at a table or desk.
- Having check sockets that the patient could trial for a couple of weeks in the “real” environment would be optimal before proceeding to definitive sockets.
- Avoid walking aids where possible – this may not be feasible for every patient.
- Challenge in all activities: walking in squares – forward, backwards, side to side, changing direction, different walking speeds, walking while pressure applied.
- Walking on mats or crash mats can be very challenging to the stubbie user and also provides a soft landing when working on falls techniques. Activities such as throwing and catching a ball whilst trying to stand on the mat, using a table tennis bat and ping pong etc. Standing on either side of a BosuBall is a nice advancement from this.
- Take the patient out onto various surfaces and challenge their walking distance.
- When walking down steep slopes and stairs the patient may find it beneficial to come down backwards.
- A patient found the kerb easier to do if he stepped off with half his foot already off the kerb.
- Use of torque absorbers can be beneficial for skin grafted patients to decease shear forces. However, it should be noted that these can decrease purchase and can make it harder to stand still so patients should be assessed for these.
- Ferrier couplings from Ortho Europe can be used to change the same sockets from full length legs to stubbies – alignment permitting.

Bilateral Microprocessor knees

- Aim for joint sessions with the Prosthetist in the early stages.

- Having check sockets that the patient could trial for a couple of weeks in the “real” environment would be optimal before proceeding to definitive sockets.

- Avoid walking aids where possible - this may not be feasible for every patient.

- Ensure correct alignment and ensure flexion contractures have been accommodated to allow the MPKs to work as efficiently as possible. Liaise with the Prosthetist promptly if an issue with alignment is suspected. Ongoing discussion is helpful to try and decipher what is an alignment issue and what is a gait deviation.

- It can be beneficial to have the patient standing with their “rested hip position” while balancing on one stubbie in the parallel bars. Some of our patients have appeared to have no flexion contracture in lying but when they stood at rest they have adopted a more flexed posture which can had an impact on their alignment.

- The patient should not have to “fight” to stand upright or if they complain of their legs wanting to “collapse”, “give” or “fold” under them, request an alignment review. Similar, if they complain of this on the slopes.

- Use of torque absorbers can be beneficial for skin grafted patients to decease shear forces.

Donning/doffing

- Can be done by sliding on when sitting.

- Can be put on whilst kneeling on the floor then standing up.

Falls recovery

- Learning to fall and losing the fear of falling is important for patients. Learning to fall from a stubbie height and gradually building up helps with this. However, this activity needs to be treated with caution depending on the patient’s medical conditions and risk factors e.g. osteoporosis.

- Commando roll: Learn how to fall. This method decreases the weight going through their wrists with the aim of the patient trying to land on the lateral aspect of their trunk. The momentum of rolling onto their back can allow enough momentum so the patient can get back on their feet. Unfortunately, the patient will not always get enough warning to allow this to occur.

- Falls recovery: As per normal, getting onto knees then onto one knee (like they are proposing). Stand back up by extending one leg out to the side and pushing up through that extended foot and standing up. This works best when there’s a solid object against the outside of the extended foot. A wall is ideal but in some cases the therapist’s foot can be placed to give some support. Additionally, they can use a chair or similar for support to help with their upper limbs.

- Caterpillar crawl back up from the floor, here are some steps to work towards this:

1. When starting: commence by kneeling on the floor – find the balance point to lean back and trust putting weight on the back of the legs (2 point kneeling in full knee flexion)
2. Use a gym ball for them to support their weight and push back onto or use wall bars if a more stable surface is required.
3. Progress to one hand on the ball/bar and one of the floor and push up to find balance point
4. Bring one foot out to the side (your less dominant side) and then push up
5. Alternatively bring both legs out to the side and then push up
6. Practise walking forwards and backwards in this position
7. Some patients may always require the support of something stable to assist them up from a fall

Stand to sit and sit to stand

- Practise from varied height plinth.
- "Nose over toes" as they attempt to stand.
- Good gluteal strength.
- If struggling to go forwards to stand, the patient should twist to their stronger side as they stand and straighten their legs so that they have the support of the chair to assist them. The patient could also twist to stand if they sit at an angle, they push up through one hand and stabilise as they get into an upright position facing the chair they have been sat in.
- If the patient finds it useful, they can stand and walk away as they get up to provide more momentum when moving forward and help them gain their balance rather than from a stationary position.

Walking

- Practise walking and getting the yield to engage – this gives the patient an opportunity to feel that movement while walking on the flat which helps transition to coming down a slope.
- Using theraband, wrapped around the patient's waist like a chariot can be used to help engage the gluteals when walking. This is a useful tool to progress onto slopes with, to help get them to drive up the slope.
- The above exercise can be reversed and the patient can resist the therapist with the theraband to get the patient engaging the yield by trying to slow the therapist down.

Stairs

- In the early stages, the intuitive stance/stop and lock may hinder the therapy session as hesitation from the patient can cause it to lock. This can be switched off for the session. Remember to turn it back on if patient uses the feature regularly.
- If the steps are too wide or the patient is short in height, they may find it useful to place each foot half on, half off so they are keeping consistent step lengths and it is also not as long a loading phase on the prosthetic side.

- Start on the bottom step until patient has an understanding of the stance flexion resistance and engaging the yield.

- The patient, if appropriate, can practise trying to stop still coming down a step. This helps build confidence when stepping down multiple stairs with control when there is no rail – the steps generally need to be slightly wider.

- When ascending without a rail, a useful skill is to 'side step' up each stair, bringing both feet to rest on each step. It is important to come to a total stop to regain control and foot position before stepping up again.

- The therapists can place their hand on the prosthetic knee and the other hand on their hip to give the patient confidence that the knee will not "shoot" away from them while they adjust to this new technique.

- Ensure the patient's weight is through the midline or slightly forward because if they lean back this can make the knee think the patient is sitting down.

- Starting on the stairs before moving to the slopes can be helpful for patients to get used to the yield function in a more controlled environment.
-

Slopes

- The patient should ascend with purpose.

- Use rails in the early stages where possible.

- Keep a vertical position where possible. When descending a slope the patient should be aware of their head position (looking at their feet can affect the weight distribution).

- Walk backwards or sideways going down if required.

- Teach the patients to yield then turn and pivot onto the side that they need to turn – like an emergency stop on a slope. The leg that turns and lands should be straight. This gives them a method to control momentum if they are picking up too much speed on the way down a slope.

- The patient should practise standing on a slope and maintaining balance, this can be very challenging for the patient.

- If the patient is struggling with slopes, a possible review of the type of heel wedge they have may be beneficial depending on the type of foot they are using.

- On shallow slopes the patient can be more likely to use loading response stance flexion (if available to them) or a hydraulic ankle rather than yield depending on their prescription.

- Altering yield amount while on the slopes is also useful so the patient can find the optimum and allow them to descend slopes as safe as possible.

- As the patients confidence increases, holding a stick horizontally or a tea tray can help the patient's posture and control.

Stairs going up (Ensure MPK has stair ascent ability)

- See individual knees for specifics on stair ascent.
- Patient will likely have a preferred leg for stair ascent.
- Some patients find it easier to "straight leg" it up the stairs.
- Worst case scenario the patient can "crawl" with straight legs on all fours up the stairs if unable to use a rail or push their way up backwards in a seated position.
- Good gluteal strength.
- Well fitting socket required.
- Patient will require at least 1 rail.

Kerbs

- The patient can go sideways or backwards if struggling to do by stepping on/off forwards.
- Can be done as yielding the knee by having the foot half-two thirds overhanging the kerb.

References

1. Perry J (2010) 'Gait Analysis – normal and pathological function, 2nd Edition.' Thorofare, NJ, Slack.

2. Applied Motor Control 2000 Gait Relationships http://www.appliedmotorcontrol.com/12.htm Accessed 21st April 2004

3. Saunders JB, Inman VT, Erberhart HD (1953) 'The major determinants of normal and pathological gait.' J of Bone and Joint Surgery, 35A (3), 543 – 558.

4. Michaud SB, Chard SA and Childress D (2000) 'A preliminary investigation of pelvic obliquity patterns during gait in persons with transtibial and transfemoral amputation.' J of Rehabil, Research and Development, 37 (1).

5. Michael JW (1994) 'Prosthetic Knee Mechanisms.' Phys Med Rehabil: state of the art reviews.', 8 (1), 147 – 164.

6. Kirtely C (2006) 'Clinical gait analysis: theory and practise' Elsevier Churchill Livingston

7. Sutherland DH (1984) 'Gait disorders in childhood and adolescence' Lippincott Williams and Wilkins.

8. Bowrey S, Naylor H, Russell P and Thompson J (2018) 'Development of a scoring tool (BLARt score) to predict functional outcome in lower limb amputees'. Disabil Rehabil, 41(19), 2324-2332

Appendices

APPENDIX 1: Expert advisors

Carolyn Hirons, Clinical Specialist Physiotherapist, Pace rehabilitation

Kate Sherman, Clinical Specialist Physiotherapist, Headley Court

Alastair Ward, Prosthetist, Blatchford

Emma Gillespie, Prosthetist, Ottobock

Alan Gordon, Prosthetist, Ottobock

Alan McDougall, Prosthetist, Ottobock

Jacob Boender, Prosthetist, Orthomobility

Ollie Smith, Prosthetist, Össur

Katy Farr, Prosthetist, Össur

Rachel Humpherson, Physiotherapist, Össur

Tim Verrall, Clinical Support Prosthetist, Steeper

Dawn Henderson, Sales manager, Prosthetist, Steeper

Nigel Davis, Product Specialist, Ortho Europe

Ken Hurst, Prosthetist, Ortho Europe

Lucy Duffy-Wyatt, Marketing Manager, Ortho Europe

Scott Meenagh, Bilateral transfemoral prosthetic limb user, WestMARC

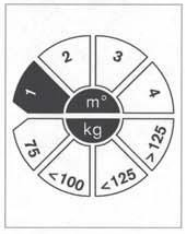
Dr Anthony McGarry, Senior Teaching Fellow, Biomedical Engineering, University of Strathclyde

APPENDIX 2: Activity Levels

Ottobock Mobility System

The Otto Bock Mobility System: Mobility Grade and Goal of Therapy

Indoor Walker



The patient has the ability or the potential touse the prosthesis for transfer purposes and to move at minimal speed on level floors. The amount of time and the distance that he/she can walk are **seriously** limited due to his/her condition.

Therapy Goals: Restoration of the patient's ability to stand and provide limited mobility indoors.

Restricted Outdoor Walker

The patient has the ability or the potential to move slowly with the prosthesis and can negotiate low environmental obstacles like curbs, single stairs or uneven ground. The amount of time and the distance that he/she can walk are limited due to his/her condition.

Therapy Goals: Restoration of the patient's ability to stand and move both indoors and with limited mobility outdoors.

Unrestricted Outdoor Walker

The patient has the ability or the potential to move with the prosthesis with variable cadence and can simultaneously negotiate most environmental barriers. He/she also has the ability to move about open areas and can undertake occupational, therapeutic and other activities that do not expose the prosthesis to above-average mechanical demands. This also includes those patients who have an increased need for security due to secondary conditions (additional handicaps, special living circumstances) in connection with medium to high mobility activities. In comparison to healthy individuals, the amount of time and the distance that he/she can walk are limited only in non-essential ways.

Therapy Goals: Restoration of the patient's ability to walk and move without any limitations indoors and with only non-essential limitations outdoors.

Unrestricted Outdoor Walker with Especially Rigorous Demands

The patient has the ability to move with the prosthesis in a manner similar to the Unrestricted Outdoor Walker. The amount of time and the distance that he/she can walk are unlimited. Moreover, due to the high functional demands, the prosthesis can sustain a high degree of shock, tension and torsion.

Therapy Goals: Restoration of the patient´s ability to stand, walk and move both indoors and outdoors without any limitations.

Blatchford Activity Guide

Activity Guides

Prescription Activity Guide

Trans-tibial

Trans-femoral

Suitable prescription | Structurally safe but may not be optimum prescription | Not recommended

Indoor walker

Limited outdoor walker

Active walker

Very active, sports participant

Maximum Amputee Weight

Notes:

1. The weight limit on the complete prosthesis is determined by its lowest rated component.
2. The weight limit applies to all products unless stated otherwise.
3. Before assembly always refer to the appropriate Technical Information.

Example

30mm 100 kg 220 lbs

35mm 100 kg 220 lbs | 120 kg 264 lbs

Overview of Activity Levels

Note -
Activity Level indicators for K3/K4 feet are provided in the foot section.

K0
The amputee does not have the ability to move independently and uses a prosthesis for cosmetic purposes only

K1 - Indoor walker

Limited to indoor walking the amputee is able to walk on level surfaces at slow cadence.

K2 - Limited outdoor

Within a limited outdoor range, the amputee has the ability walk at low to medium speed and can manage small obstacles such as curbs, steps and uneven surfaces.

K3 - Active walker

Daily activities including walking with rapid and variable cadence over uneven terrain and negotiating most environmental obstacles encountered.

K4 - Very active, sports participant

Daily activities that exceed basic walking including rigorous, high impact, high-energy activities like athletics, children's games and rugged work.

ENDOLITE

Össur Impact Levels

LOW

Daily activities involving gentle, steady walking with the use of a walking aid.

Example: Moving around at home, modest walking in the community.

MODERATE

Daily activities involving average walking with the ability to vary speed or walking pattern.

Example: Going to the shops, confident outdoor walking.

HIGH

Daily activities involving fast walking, jogging and climbing stairs.

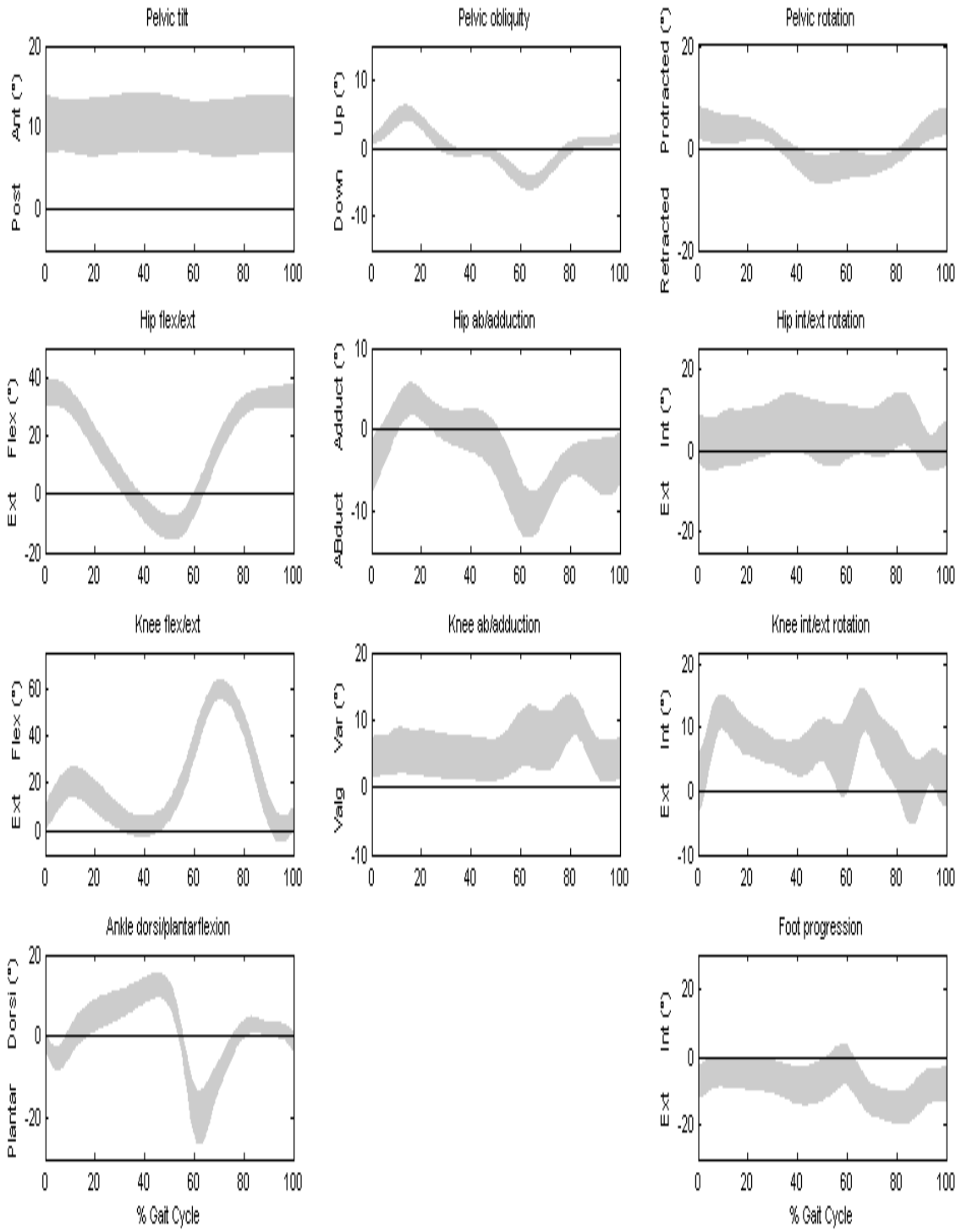
Example: Heavy-lifting, manual labour, recreational sports.

EXTREME

Activities involving running, track and field, sprinting, and long-distance running.

Example: Track and field sports.

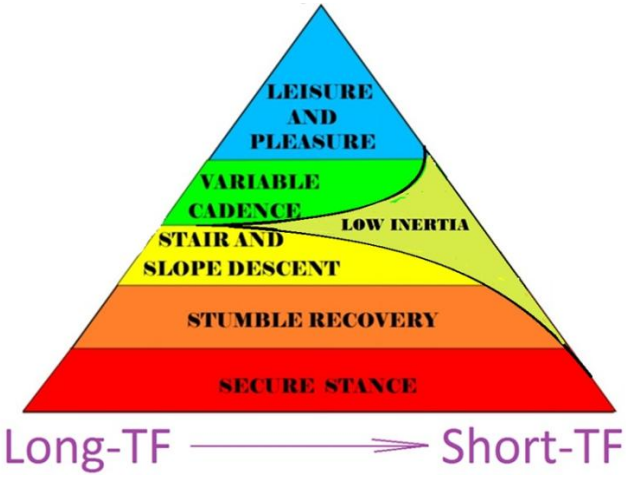
APPENDIX 3: Normal adult gait kinematics



APPENDIX 4: Orthomobility Knee Function Chart

When deciding on a knee joint the patient's needs must be considered first.

This is well mapped out through Orthomobility's hierarchy of needs:



These needs must be met by the artificial knee joint. From this basic evaluation it naturally follows that a knee without stumble recovery is DANGEROUS. People and amputees do trip and must be offered a stumble recovery by whatever means.

Such means typically needs a method for the knee to 'know' when a stumble occurs and to provide the correct response.

This is CONTROL.

How to offer such control? One established means is through the use of a microprocessor, the other is through the use of fluidics.

APPENDIX 5: Blatchford Leicester Allman Russell tool

BLARt Score for Amputee Outcomes (Blatchford Leicester Allman Russell tool)

Gender		
Male	0	
Female	1	
Age		
Under 60	0	
60-64	1	
65-74	2	
75-80	5	
81+	6	
BMI		
Average (18.5 – 25)	0	
Above average (25-30)	1	
Obese (>30)	3	
Below average (<18.5)	2	
Cause of Amputation		
Trauma	0	
Congenital	0	
Cancer	1	
Orthopaedic	2	
Vascular	3	
Level of Amputation		
Above/through knee	3	
Below knee	1	
Hip disarticulation	5	
Bilateral	4-6	

Cognitive Capacity		
Confused	5	
Limited carry over	3	
Alert/aware	0	
Pre-amp Mobility		
Wheelchair bound for 12 mths +	5	
Wheelchair bound for < 12 mths	4	
Indoor mobility only	3	
Outdoor mobility with aids	2	
Unaided outdoor mobility	1	
Walking 3m+	0	
Special Risks		
CVA / Neurological	3	
On dialysis	4	
Severe respiratory problems	5	
Contralateral limb issues	2-4	
Recent MI/Angina	2	

Score for special risks should be a total of all relevant conditions.

BLARt Score	

- ≤13 - 85% Likelihood of walking with a prosthesis (with or without walking aids)
- 14-21 – 21% Likelihood of walking with a prosthesis (with a walking aid)
- ≥ 22 – Will not use a prosthesis

Guidance Notes for use of BLARt

(Gender; Age and BMI) is basic demographic information.

Cause of Amputation	
Trauma	Amputation is due to an accident that has led immediately to amputation within one hospital admission.
Orthopaedic	Any amputation due to osteomyelitis; non union fracture; deformity; soft tissue infection.
Vascular	Amputation following either acute (DVT; thrombus) or chronic vascular insufficiency.
Cancer	Cause of amputation is due to any cancer, whether bone or soft tissue tumour.
Level of Amputation	
Bilateral	Both amputations to be done on the same hospital admission within initial rehabilitation period.
Range of score dependent on levels	4=bilateral below knee amputations 5= below knee/above knee 6=bilateral above knee
Cognitive Capacity	
Limited carry over	Orientated to time and place but are unable to remember details of previous conversations.
Confused	Long term dementia or Alzheimer's, do not score for patients who have acute confusion due to sepsis.
Pre-amp Mobility	
This is to score mobility prior to any recent sudden decline.	
Special Risks	
CVA/Neurological	Only score IF there is any motor deficit.
On dialysis	Long term dialysis patients only.
Severe respiratory problems	Only score if patient is short of breath at rest ; when having a conversation or on home oxygen.
Contralateral limb issues	2=limb becomes painful when mobilising (leg ulcers;claudication) 3=e.g. partial foot amputations where patient can walk but is unsteady 4=e.g. previous amputation

Follow Blatchford:
@BlatchfordGrp
/BlatchfordGrp
blatchford.co.uk
0114 268 7900
sales@blatchford.co.uk

M00497 Iss2 11/17

blatchford