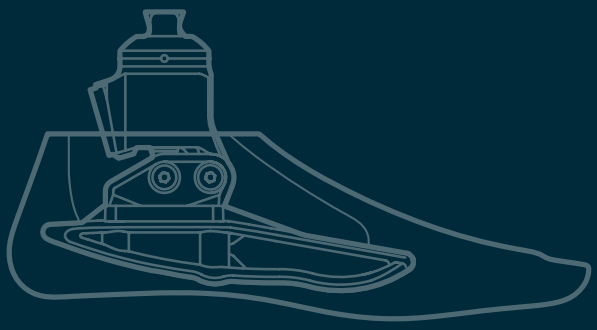


A Study of Avalon^{K2}

Blatchford

Avalon K2



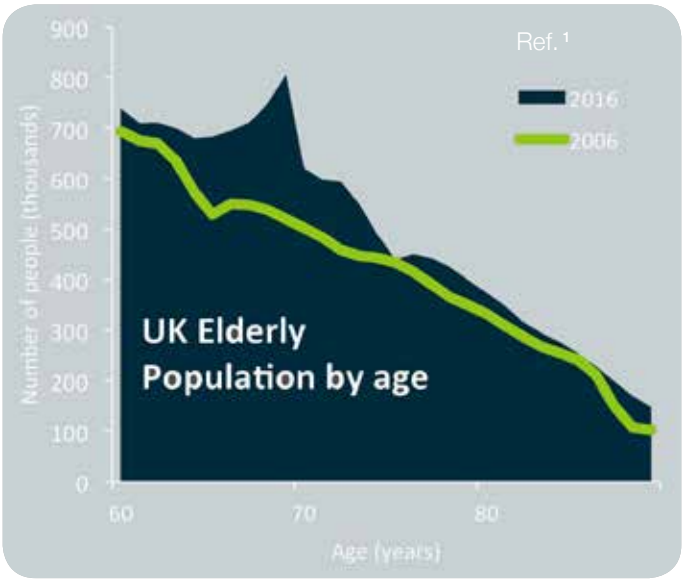
Hydraulic prosthetic feet can improve mobility and independence for limited community ambulators.

The main driving forc
lower limb prosthetic
the 21st century is b
reproducing the biome
performance of natura
in this is recognisin
demographics of the a
population have difer
requirements, and tha
principles behind dif
accommodate for this.

Amputee Demographics

The global trends of increasi
incidence of chronic disease i
known. Over 60s make up approx
population – approximately 1 in 4 of c
for National Statistics reports
by 21% in the last 10 years.[1] This trend is consistent with that
in the United States where ove
20.3% of the population.[2] Globally
almost 1 in 10 people are ove
estimated to become 1 in 5 peop

The prevalence of diabetes an
increases with age[3,4] and vascular diseas
over 80% of lower limb amputations[5,6] are in people over 50
limb amputations[5] and 185,000 in the UK alone,[7] with
of which 75% occur in over 60s[5,6]



The Biomechanics of Elderly Gait

It is well documented that there are a number of biomechanical
diferences between the gait of
young people.[8] Older pe
tend to walk more,[9,10]
contributing to a s
stride length.[9-11] The
afect the ranges o
the joints, predomi
plantarfexion of t
extension.[9-12] Lower
limb muscle weakness is common
amongst elderly p
therefore the powe
by the ankle in l
significantly reduce

All of these difer
the motion of the
of-mass in relation to its base of
support at the grou
be considered duri
foot design. Elde

10% Reduction in walking speed [10]

11% Shorter stride length [10]

17% Less ankle power generated in late stance [11]

are often described as being 'steady on their feet' to someone who has the "ability to traverse low-level environmental barriers such as curbs, stairs, or uneven surfaces"[10, 14, 15]. Despite this much greater variability in the gait patterns of older people that can provide consistency and predictability of function is even greater importance in order to ensure safety.

Domestic Independence

Older people tend to spend less time outside and more time around the home. This means for those with lower mobility capabilities, functional domestic tasks, such as rising from a chair, become imperative to maintaining independence and quality of life. In fact, the transition from a seated position to standing has been described as "the most mechanically demanding functional task routinely undertaken during daily activities"[17].

Older people can adapt their movement strategy to account for their abilities. When rising from a chair, if they bring their feet to a more posterior position they reduce the distance between their body's centre-of-mass and their base of support. Consequently, there is less demand on the lower limb muscles and joints, allowing them to generate enough force to stand[18]. Several studies have identified foot placement as a critical factor in the sit-to-stand movement[19-21]. Consideration of foot placement and the ankle range of motion in prosthetic design enables a more optimised body posture and movement that requires less effort[22].



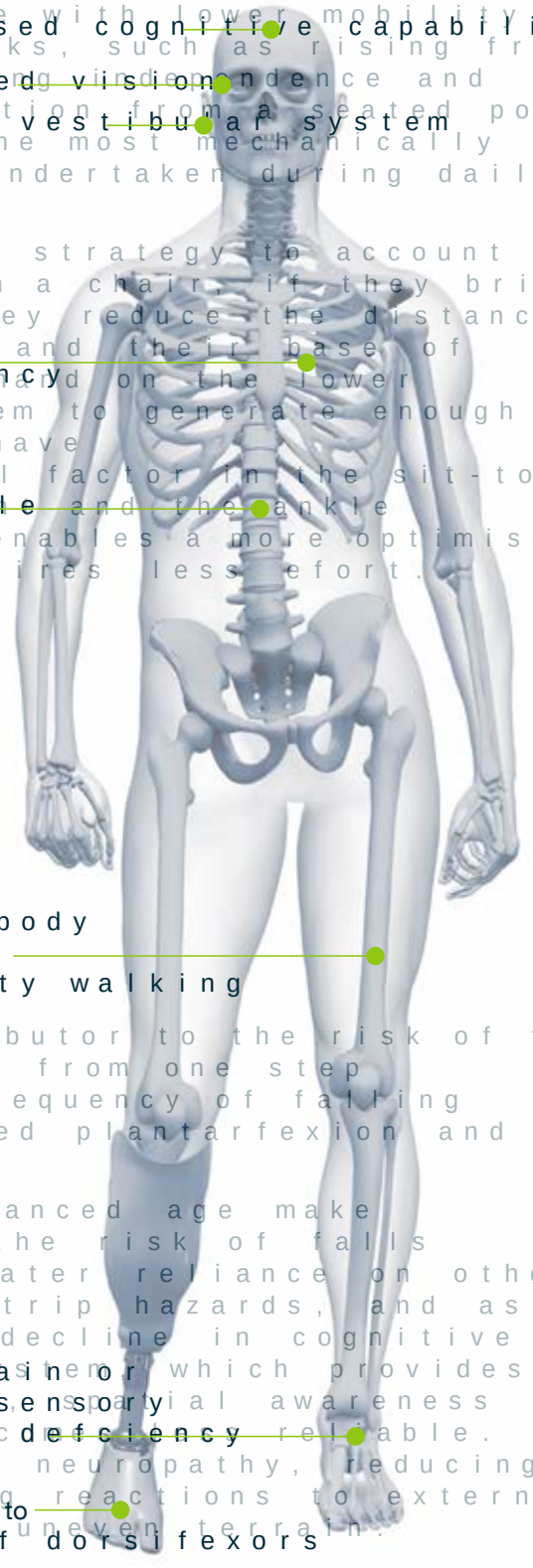
Placing the base of support in a more posterior position **reduces** peak hip moment by up to **33%**[19]

The Risk of Falling

Gait patterns are a significant contributor to the risk of falling in the elderly[23-27]. Their increased variability from one step to the next has been linked to the frequency of falling[10, 28-29], as has shorter stride length, reduced plantarflexion and reduced hip extension[27].

Other common characteristics of advanced age make elderly people more susceptible to the risk of falls[29]. As vision deteriorates, there is a greater reliance on other sensory inputs to detect potential trip hazards, and as the central nervous system ages, a decline in cognitive ability can occur. The vestibular system, which provides sensory information regarding movement, spatial awareness and balance, begins to weaken and become unreliable. Poor circulation leads to peripheral neuropathy, reducing sensation at the extremities, slowing reactions to external stimuli, such as changes in slope or uneven terrain.

Studies looking at amputee falls have found that those who have had a lower limb amputation are more likely to fall[30-31]. Of those who fell, 50% sustained a tissue injury, requiring medical treatment[32]. Other effects of falls include head injuries[33, 34] and a loss of confidence[35, 36], that can in turn severely affect the quality of life[37].



The Cost of Falls

As well as physical consequences, falls can impact on many areas of life. 60% of amputees who fall say it affects their daily life and 36% report a loss of confidence[32].

Falls can also cause a financial burden, both on the individual and their family if extra social care is required, and to the economy as a whole. In 2000, in the United States, medical costs for falls totalled $19.2 billion[37]. Reducing the risk of falls and the need for institutional care has the potential for a significant health-economic effect due to reduced healthcare costs.



60%

of amputees say that their daily lives are affected by falls[32]

Vascular Health

The majority of elderly amputees have a vascular aetiology relating to atherosclerosis, resulting poor circulation and diabetes. The skin and soft tissue of the residuum are vulnerable to irritation and damage. Any resulting wounds are slow to heal and vulnerable to infection. An infected wound can necessitate further amputation[39].

Musculoskeletal Concerns

Amputees walk with more reliance on their sound limb and asymmetry of gait and stance[38], leading to an increased likelihood of developing osteoarthritis in the sound limb[38 – 40]. The prevalence of osteoarthritis is two to three times higher in the sound limb[38], and there is an increased chance of developing back pain[41]. Many amputees report moderate to extreme pain in the sound limb many years after amputation[42].

Advanced Technology Can Advance Functional Ability

It is common for health services to prescribe inexpensive devices with restricted functionality to limited community walkers. Prosthetic interventions that are specifically designed for the biomechanical requirements of the older user could help reduce the risk of falls, maintain greater mobility and independence, improve quality of life and help reduce the long term burden on health care services.

Hydraulic Ankle Technology

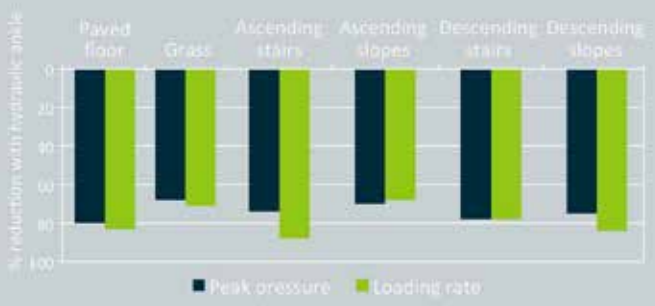
Conventional prostheses are usually fitted to a rigid shin or 'pylon' and rely on the deflection of deformable plastic of polymeric foot components to provide dorsiflexion and plantarflexion behaviour of the ankle. Models of the biological foot have shown that this type of behaviour is present at normal walking speeds, however, at slower speeds, the ankle becomes a net elastic moderator[43]. The viscoelastic behaviour of hydraulic ankles is better replicated by the biological ankle[44].

Hydraulic ankle technology has a number of benefits to elderly amputees. When the foot contacts the ground, the ankle is unloaded and rotates plantarflexion, and the body weight is transferred onto the contralateral limb. When loaded with body weight, the ankle joint remains in a dorsiflexed position during swing phase[44]. This helps to reduce the chance of catching the toe of the prosthesis on an object and a trip occurring.

The damped motion of the ankle joint also helps to absorb energy and reduces the loading on the residual limb and socket. One study measured reductions in peak pressure by up to 81% and in the rate of loading by up to 87% during a number of different activities[45]. Hydraulic prosthetic ankles seek to mimic the behaviour of a hydraulically-damped, articulated ankle joint and the deformable foot.

81% reduction in peak pressure when using hydraulic feet on a hard floor[45]

Peak pressure and **loading rate** on residuum compared to sound limb[45]

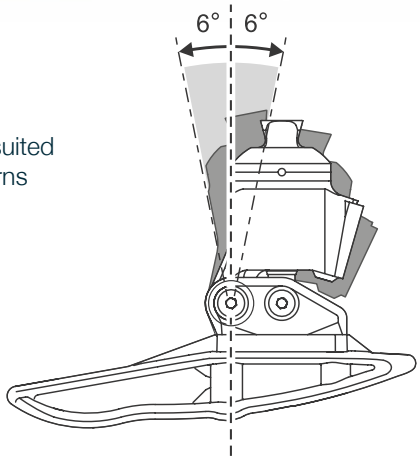


When using hydraulic feet to climb stairs[45] loading rate reduces by 87%

The Avalon^{K2} HC

Avalon^{K2} was designed specifically for Level 2 users. It enhances walking by hydraulically adjusting to include dorsiflexion movement also enhances when sitting down, standing up and coming down. Avalon^{K2} self-aligns to secure alignment to encourage good posture and joint symmetry. Attached to the unwanted moments on the knee joint of transtibial users. The ankle dorsiflexes during swing phase. Modelling for safety and efficiency provides Activity Level 2 biomechanics.





Ankle range of motion suited to elderly walking patterns

Features:

- Waterproof K2 hydraulic ankle foot
- Optimised keel for ease of rollover
- Single valve adjustment for simultaneous plantarflexion and dorsiflexion
- Plantarflexion compliance when descending slopes
- Sandal toe allows different footwear styles

The most energy efficient "rollover" shape has been identified as 30% of the walker's leg length[46,47]. Evidence suggests that when walking at different speeds and changing inclines, people will adapt other gait kinetics in order to maintain this consistent rollover shape[48]. For a person of typical adult height between 1.5m and 1.8m, this equates to approximately 245-290mm. The geometry for the Avalon^{K2} keel has been measured to produce a rollover shape of ~250mm[49], of which this rollover is consistent, regardless of footwear[49].

Another design consideration of Avalon^{K2} was the action of standing from a chair. The keel and shape, along with the 6° of dorsiflexion permitted by the hydraulic ankle, help move the base of support closer to the body's centre-of-mass. Having the feet in a more posterior position reduces joint moments[18–21], making it easier for the user to perform the movement.

Clinical Evidence for Avalon^{K2}

Improved Symmetry

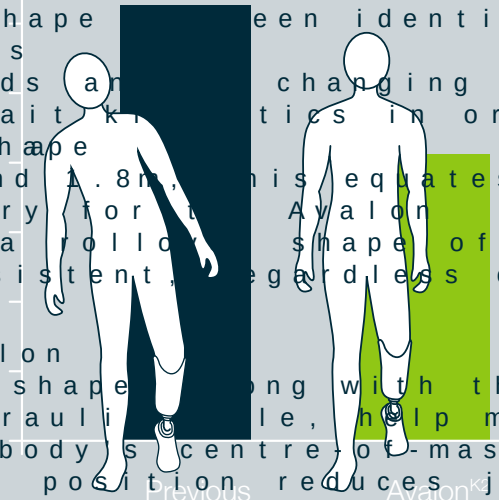
One study sought to measure Avalon^{K2} compared to non-hydraulic d Activity Level 2 amputees[50].

A mixed group comprising u above and below knee amp in the study. Their gait habitual foot whilst wall speed. Afterwards, these provided with Avalon^{K2} hydraulic feet four weeks to acclimatise. After the acclimatisation period, their gait was ass

The result of this study wa for which weight was borne on focus on asymmetry between the amputees, stance phase duratio side because their residuum ma may have a lack of prosthesis c of stability provided by the p detrimental consequences for s

Three quarters of the amputees between the two limbs giving a greatest improvement observed knee amputee, who saw an 86% r When weight bearing is more ev improvements in gait stability factors act to reduce the risk of developing back pain. When sound limb for weight bearing, health problems such as osteoa back pain are reduced.

34% reduction in asymmetry when using Avalon^{K2}, compared to a non-hydraulic foot[50]



User Satisfaction

21.9% increase in gait satisfaction with Avalon$^{K2\ 51}$

Patient feedback **previous foot** and **Avalon**$^{K2\ 51}$ u



In another [5 1] i1n4v eAscttiigvaittyo nLevel 2 Multifex wearers were surveyed Evaluation Questionnaire (PEQ) Avalon$^{K\ 2}$. The group consisted of 1 including one bilateral, and t group evaluated their Multifex programme, they$^{K\ 2}$ t**h**e**n** **w**o**r**e**A**v**a**l**o** before completing the same Ques validated instrument asks the their prosthesis through six di mobility capabilities and utili

When evaluating the results, th six question categories wer^{K2}e co The mean improvement across al and included a 17.3% improveme improvement in prosthesis satis in gait satisfaction. When bro transtibial amputees had a mea categories of 16.6%. For trans category mean improvement was 6

Amputees' perceptions of their element in prosthetic d[5 2]esaigmi.xtl of Activity Level 2 and 3 ampu

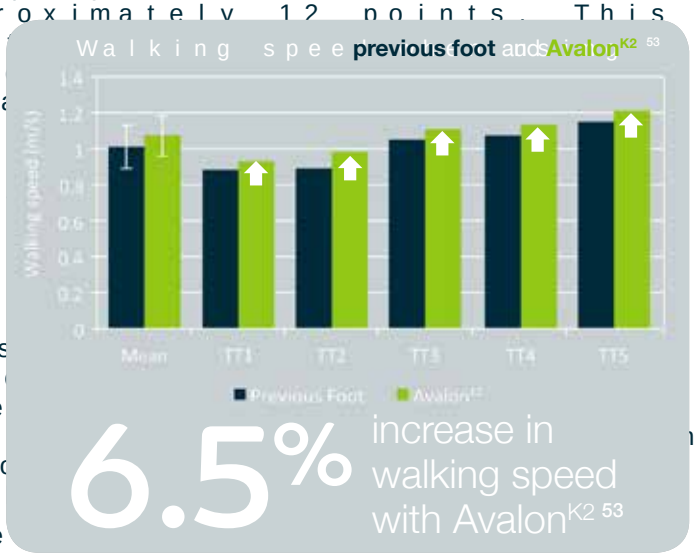


abilities with hydraulic feet, a comparative walking speed test was conducted between the previously prescribed feet. They were asked to rate their ability to walk on different surfaces and inclines, get in and out of chairs of different heights, manage curbs and stairs and using the bathroom. Bilateral amputees and unilateral amputees with contralateral joint pain benefitted from the hydraulic feet, with the average score increasing by approximately 12 points out of 100. This emphasises the suitability of the foot for Level 2 amputees, providing the ability to perform activities of daily life and ma

Increased Walking Speed

For lower mobility amputees, to walk in two minutes is a s the outcome of a prosthetic i researchers performed such tes knee amputees[53]. Each performed the Navigator foot[K2] and Navigator Avalon[K2] keel design and shape as Avalon articulating, hydraulic ankle differences could be attributed As part of the same study, bio investigated using 3D gait ana

All amputees taking part with





C k j _ h q o ň k

The clinical needs of must drive prosthetic engineering principle and the technical spe performance must cate demographic of ampute

For limited community change in practice fo prosthetic feet could long term outcomes. M technology su[K2], cha as Ava foot specifcally desi the older user's requ not only be benefcial health of the user, but could also be a more sound investment in terms of healthcare economics, the costs associated with fall related injuries and tissue h

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