Walking and Bracing Support Systems

This easy-to-understand explanation of the mechanics of walking and how orthotic support systems can help has been assembled by the Post-Polio Network (NSW) from a collection of excellent documents published by DynamicBracingSolutions Inc on their website <www.dynamicbracingsolutions.net>. DynamicBracingSolutions is based in San Diego, California, USA, and is currently developing a national network of practitioners dedicated to providing their patients with unsurpassed bracing solutions. The company aims to provide solutions to deficiencies in locomotion resulting from neuromuscular disorders on an individual basis. The paper is published here with the kind permission of DynamicBracingSolutions Inc. Requests to reprint the paper should be sent to Marmaduke Loke, CPO at <Solutions@DynamicBracingSolutions.net>.

The paper provides background to the presentation given to members on 16 June by Mark Raabe, Orthotist/Prosthetist, OrthoSynergy Pty Ltd, entitled "Overview of Orthotic Stance Phase Control Systems". You can learn about Mark's presentation on pages 17 and 18.

Walking is moving by taking steps at a pace slower than running. While energy is definitely consumed during this activity, it is minimized by the symmetrical advancement of body parts. This creates an efficient rhythm allowing energy to be carried over from one step sequence to the next when walking on a fairly level surface.

Discounting getting up, stopping, or turning, a lot of our normal walking activity is usually done in a fairly straight line. This means that from one step sequence to the next, there is some energy carried over. This minimizes the amount of energy that we use. Thus, all of our body segments (arms, trunk, legs, head) displace minimally and add to a primary, or net, force. The velocity or speed of our body during walking is sustained, if not constant. This is probably as close as we will ever get to Isaac Newton's concept of momentum as stated in the First Law of Motion whereby a body in motion tends to remain in motion.

It is a normal response for humans to seek out external support systems when the body becomes fatigued. People unconsciously seek a safe structure on which to rest for efficiency when they are placed in demanding or stressful situations. Observing people at gatherings, you may notice some resting against a wall or leaning back on a chair. Others may be leaning on counters or walls without realizing they are doing it. This is especially true during activities involving prolonged standing. When such activities result in discomfort, balance problems or fatigue, the sensory input will cause the individual to react. In these instances, people without physical limitations use support systems such as handrails, armrests and backrests. Support systems are not used exclusively by physically challenged individuals.

When someone has physical limitations and the ability to stand and walk is compromised, the need for support systems becomes more important. Support systems in the form of custom bracing vary according to the design and choice of materials. The objective of such a support system is to provide for stability and mobility simultaneously. The goal is to support involved body parts without undue restriction and allow for efficient ambulation.

Support systems in all orthotic applications need to be placed where they are needed most. It is necessary to differentiate these systems according to each person's needs. Custom braces should not be the same for everyone. The location of support systems combined with high tech materials is critical in achieving efficient ambulation and maximizing potential. Traditional braces for ankle deficiencies relied upon support behind the calf and were made of metal and leather or plastic. In many cases where the knee was involved a long leg brace was used keeping the knee straight during ambulation. As new materials became available, metal and leather were replaced with plastics; unfortunately, the "old theory" remained and designs did not change.

The old theory regarding support systems has become the traditional approach when treating people with physical limitations that affect ambulation. It is necessary to reconsider the biomechanical needs of each individual and design the most appropriate orthosis for that person. New materials alone do not change the functional characteristics of a support system. It is the combination of design and materials based upon specific biomechanical requirements that are essential to restoring balance, security, and the ultimate goal of functional efficiency in ambulation.

Support systems are intended to help the individual. They can often impose limitations on balance, security and efficiency! This is important to understand since the old theories have become entrenched in our thinking as professionals and clients. A support system that is applied below the knee has a profound effect on the knee and hip musculature above as well as the entire body! It is impossible to create a support system below the knee and not affect the rest of the body. Since this is a given, we must address the body as a whole in our choice of design and material when creating support systems. An orthosis should enhance efficiency. It should not add to the effort required to ambulate nor should it increase energy expenditure. The term "support system" is more descriptive than orthosis or brace as it implies a functional process and the use of critical thinking.

In order to achieve an efficient gait that is balanced and secure, the knee and hip joints need to be free to move through swing phase yet allow for stability in stance. As stated earlier, the location of support in a standard AFO (ankle-foot-orthosis or short leg brace) is behind the calf. In order to feel this support, it is necessary for the individual to lean back into the plastic shell or calf band. An efficient gait is fluid and motion is always forward. Many people wearing such conventional devices are leaning and often use muscle power to maintain the leg back in the brace. The need to push back while moving forward is counter-productive. Compensations then need to be made because of the orthosis; consequently, balance and efficiency are adversely affected. Complete extension of the knee or hyperextension (recurvatum) is not part of a normal gait cycle. The knee maintains varying degrees of flexion throughout. These compensations cause increased energy expenditure, fatigue, balance problems and insecurity. The overall inefficiency is being caused by the brace! The mechanics are all wrong!

The use of free dorsiflexion in a support system would seem to be consistent with the concept of moving forward throughout the gait cycle. This design has gained popularity without addressing security issues or efficiency. Video documentation has shown the shortcomings of this design. The support system behind the knee in combination with free dorsiflexion creates a "drop off" at the knee, which prevents full weight bearing on the affected side during stance; in other words, it is an ineffective approach that increases difficulties with balance, security and efficiency.

The issue of security takes precedence over balance and efficiency. Humans need to be safe and feel secure. Compensations for security reasons are made at the expense of balance and efficiency. Habits develop that become normal to the individual over time. This leads to a further deterioration of function. It is a vicious cycle that needs to be broken. Old movement patterns have to be replaced by new or more natural patterns in order to reach one's potential. An appropriate support system will allow the body to assume more normal patterns required for balance, security and efficient gait; however, retraining is necessary to overcome the compensations established over time.

Security issues are concerns about safety. They involve activities or movements that elicit fear. We don't want to get hurt. In the case of physically challenged individuals, the fear is usually of falling. Security issues are based on actual events and justifiable concerns. An example of a security issue for anyone is walking on ice. One discovers quickly that they must alter their walking strategy. It may be based on a previous experience or the mere fact of losing control without actually falling. One soon learns to alter their walking strategies. Most people will crouch down a little and spread their feet out. This lowers the center of gravity and increases the foundation. The concentration required for movement is intense and becomes the primary focus of attention. Shorter steps or even shuffling the feet without lifting them is safer. Arms are spread out to help with balance. All these compensations are made to reduce the security risk. If these strategies don't work, it may be necessary to get down on all fours and crawl to safety.

It is human nature to make compensations for security reasons. Security issues in post-polio can become a routine part of daily life. This may happen gradually over time with aging or early effects of post-polio syndrome or are a way of life since the initial onset from the polio virus. Each falling episode has a cumulative effect. Ultimately ambulation becomes a conscious effort. Normal ambulation is an unconscious activity. Security issues can make ambulation a conscious activity. This creates compensations, balance problems and a lack of efficiency. Until the security issues have been solved, compensations will be made. In the case of a typical individual on ice, the security issues are eliminated upon reaching dry ground. For the individual with post-polio, security issues become ingrained in the subconscious mind; in other words, the compensations become normal in spite of the lack of efficiency. Understanding that they exist, recognizing and understanding their purpose and providing a solution can return security and efficiency to near normal levels.

Security issues causing compensations in post-polio are learned activities. They ultimately become habits. Each person demonstrates unique characteristics and degree of severity. The most common examples of security issues in gait are decreased standing and walking balance, tripping over the feet, ankles rolling over and, for some, knees buckling.

Difficulty with balance is one of the most common security issues in post-polio. This is caused by a combination of weak or no muscle power and progressive deformities. The foot and ankle complex as well as the knee are the most common structures affected by progressive deformities. Balance is normally maintained by a complex array of neurosensors, muscles, and proper structural alignment. This is called proprioception. Proprioception can be defined as the awareness of the body in space or the awareness of the position of a body part without visual cues. As the body leans too far, sensors send messages to activate muscles to oppose that movement and return to the original upright position. In post-polio, the sensors are usually working that provide proprioception but the muscles may not be working properly. Instead of small activation of a few muscles to maintain standing in one place, the individual with post-polio often recruits other muscle groups to compensate to right themselves. Rather than subtle isolated muscle contractions to maintain balance, the recruited muscles are usually at a mechanical disadvantage and must activate longer and stronger to accomplish a similar task. This is often at the price of efficiency and over taxing the system.

There are a great many deformities and functional deficits, but there are a limited number of major compensations with many subtle compensatory movements that are possible. There are only so many ways that the body can make gross movement compensations in order to balance and walk in an upright position. All of them require excessive energy use. Some of them may result in secondary deformities if not addressed. All or any of them identify the way you walk as abnormal.

Normal ambulation involves the coordinated effort of the entire body. This involves the head, trunk and arms as well as the legs. Ambulation has been described as a *series of falls* following a *period of recovery*. This is a learned activity and requires confidence. It is efficient and appears to be one continuous motion. In actuality, it is a complex series of movement patterns. Under routine circumstances, ambulation is automatic and does not require conscious thought.

In the presence of special conditions, it may be necessary to actively think about the act of walking. A person on the high wire uses compensations involving the whole body in order to maintain balance and security. The arms may be extended out to the side as a counterbalance to the decreased base of support. Walking on ice is another activity that requires compensations to ensure balance and security. The toddler learning to walk has a very wide base of support and uses gross body movements or compensations to avoid falling down. There is a learning curve that must be mastered before ambulation can become an unconscious activity. These counterbalances and gross body movements ultimately give way to effortless and efficient gait as the individual matures. Compensations are normal responses to activities that affect balance and security.

Individuals with physical limitations must use compensations on a routine basis. These compensations are evident in movement patterns that can identify an individual from a distance. Muscle weakness with associated muscle imbalance, joint deformities and limited range of motion or surgical fusions are common causes resulting in a loss of balance. Compensations become an unconscious habit over time. The repetitive nature of these movement patterns decreases efficiency and places a tremendous burden on the body.

Compensations vary in complexity according to the degree of deficiency and loss of balance. They range from a single arm movement in one plane to many movement patterns involving multiple planes of motion. Instead of all the body parts working in harmony, they move contrary to the intended direction. The symmetry of gait is lost. Efficient gait requires the body to continuously move forward with minimal deviation. Compensations involving the trunk, pelvis, arms and legs cause gait deviations. The deviation of these body segments can be forward or backward, up or down, side to side, rotational or any combination thereof. The analysis of the complexities of compensations, their underlying causes and how to eliminate them is a demanding task.

Among the more common compensations are the following:

- Truncal deviations in which the trunk shifts to one side or to the other or moves forwards or backwards. This balancing strategy is horizontal in nature as about 70% of the body's weight shifts.
- Excessive hip flexion in which the hip muscles lift the entire leg against gravity, usually to compensate for a drop foot or an ankle contracture. This functional strategy is vertical in nature as about 15% of the body's weight is lifted against gravity.
- Circumduction or a swinging of a leg to one side to advance the leg and clear the ground. This functional strategy is also vertical in nature, lifting about 15% of the body's weight. Frequently, however, it is combined with the following strategy.
- Circumduction of a leg accompanied by a shifting of the trunk to the other side. This is a classic seesaw application as the shifting trunk makes possible for the outward swinging of the leg on the other side when the hip muscles are weak.
- Hip hiking or lifting the pelvis on one side. This is a vertical strategy frequently used to assist the leg in clearing the ground.
- Vaulting or raising almost all of one’s body weight vertically against gravity. This is an exhausting strategy frequently used to also help in clearing the ground on the other side. It is also sometimes used to regulate timing. By raising the body’s weight

during vaulting, the velocity or speed of the body decreases. This is sometimes necessary to allow the other leg to catch up.

It is important to understand these compensations from the point of view of the client as well as the clinician. Humans are very adaptable. When compensations become habit, security is achieved at the expense of efficiency. The patterns of movement utilized in this effort become as unconscious as "normal ambulation". All compensations detract from the net force of moving the body forward. Inertia (momentum) is lost and rhythm and symmetry is disrupted. It is like driving while alternately hitting the gas pedal and the brakes. Smooth acceleration to a "cruising speed" is replaced by a series of starts and stops. In ambulation, the most energy is expended in acceleration and deceleration. The pre-set cadence that each individual is endowed with is altered which decreases the efficiency of the gait cycle even more.

Approximately 70% of the body mass is concentrated in the upper body consisting of the head and trunk. The remaining 30% is distributed between the lower extremities. In single leg support, 15% of the body mass is supporting the remaining 85%! In normal ambulation, this can only be efficient through balance and inertia as the body moves forward. Compensations that deviate from this forward progression of the body increase effort and energy expenditure to extraordinary levels. As the trunk leans to the side and back while the pelvis rotates in the process, 70% of the body mass is going in the wrong direction! The supporting limb may also be supporting the body mass for longer periods of time as asymmetry increases. In cases of one-sided involvement, it is no wonder that the "good leg" presents more problems in terms of pain and orthopedic problems. If both legs are involved, the effort will ultimately lead to a sedentary lifestyle.

With the proper assessment and appropriate orthotic support system, balance can be re-established and eliminate the need for compensations. The elimination of the habit resulting from these compensations will require conscious effort on the part of the individual to benefit from the orthosis. Fixed deformities, contractures or weakness of the hip musculature will require continued compensations but these can be minimized.

Should an orthotic brace or a prosthesis address the compensations as well as the deformities? Yes. If the design and training do not incorporate features for the compensations, it will not be possible to balance properly while walking nor will it be possible to sustain the velocity or the rate at which you are walking. Also it will not be possible to attain a normal way of walking.

Tripping or the loss of balance heightens the awareness of security issues and the fear of falling. The most common compensation is to lift the whole leg high enough to clear the foot that is dropping. As weakness progresses, the leg must be lifted higher. This compensation is called high steppage gait. One must lift 15% of one's body weight straight up against gravity on each step. This involves increased energy expenditure and creates balance problems.

The ankle rolling over also affects balance and the fear of falling to one's side unexpectedly. This is caused by deformities from an imbalance of muscles. Certain nerves are affected more than others, thus affecting the precious balance of muscle strength.

People with post-polio tend to have structural deviations caused by muscle imbalance and/or lack of proper support under load bearing applications. Some polio survivors have a discrepancy that causes excessively high arches called pes cavus. As the deformity increases, the ankle is very susceptible to rolling over to the outside. Falls, ankle sprains, and even fractures are all quite possible and common. The compensations are spreading the feet, slowing down, shorter steps, quicker steps and no longer shifting one's body weight over the feet. Ultimately, balance becomes impossible.

The buckling of the knees is very common, the resulting security issue dramatically increases the chances of falling. To prevent the likelihood of knees buckling, one will start snapping their knees backwards on each step. This creates hyperextension at the knee (also called recurvatum). This repetitive compensation in time stretches the structures on the back of the knees. The structures involve ligaments, tendons, joint capsules, nerves and blood vessels. The recurvatum is classified as mild, moderate and severe and will progress if not prevented. Pain can also be associated with recurvatum. To be secure, one rapidly moves 15% of their body weight 180 degrees away from the intended forward direction. A secondary compensation often associated with recurvatum is the forward movement of the upper body over the weight bearing leg during stance. Before a step can be taken on the other side, the trunk must move backward and to the opposite side. Since the trunk comprises 70% of the body weight, this constant and repetitive movement increases effort and energy expenditure tremendously! The body is literally moving in opposite directions at the same time! This is extremely inefficient.

In order to be effective, bracing solutions must recognize and address all security issues. This includes structural and functional deficits in addition to the compensations and their causes that are unique to the individual with post-polio. Deviations and habits caused by security issues must be solved in order to achieve balance and efficiency.

Remodeling tight structures will improve security, balance and efficiency as well as improve weight distribution on one's feet. As anatomical positioning improves, security and balance improve. This allows for the restoration of proper movement patterns that ultimately leads to optimal efficiency and a return of a normal gait.

Human locomotion is not a two dimensional activity. We describe three planes of motion (triplanar) necessary for normal ambulation. In actuality, the body moves in an infinite and constantly changing number of planes. For educational purposes we will discuss three: forward and backward; side-to-side; rotation. Combinations of these planes of motion make up the movement patterns for all of our activities. The relationship and alignment of our body segments continuously change over a period of microseconds for efficient ambulation and other activities. Education is an important part of the treatment plan. Understanding the forces applied by an appropriate force system and how the body interacts will allow for the gradual replacement of old habits with better mechanics and efficiency.

Walking should result in as little energy consumption as the neuromuscular condition permits in an individual. Orthotic brace and prosthetic design and training should minimize any increase in the amount of energy consumed. Good design should have as a goal the conserving of energy and, where possible, the storing and release of energy to prevent excessive and early fatigue. This is not only desirable for polio survivors but for any patient displaying deformities or mechanical deviations.

Ignoring certain aspects of walking such as starting, stopping, or changing direction or speed, walking is cyclical. The most commonly accepted basic cycle is from the moment one heel strikes the ground until the same heel strikes the ground again. The amount of time that this cycle takes is easily measured clinically with computer assistance. This allows for a comparison of what the left leg is doing compared to the right leg.

The gait cycle has a stance and a swing phase for each limb. There is a normal time relationship of 60% stance phase and 40% swing phase that each limb cycles through with each step. This 60:40 ratio is affected by gait deviations. To achieve a sustainable velocity is critical for a normal gait appearance. Thus, the stance-to-swing ratios serve as a good clinical tool to measure success.

Orthoses are now judged similar to prosthetic knee joints. How well they control the lower limb in swing phase and stance phase of the gait cycle determine their success. The new designs have made the biggest impact on stance phase control capabilities. The stance phase of walking is where all the potential destructive forces of load bearing takes place. As weight is borne on the load bearing column, the limb and/or orthosis must generate enough force to counteract the forces tending to buckle the limb and to enable a fluid progression. These moments are normally counteracted by muscle action. In the absence of normal muscle function, the orthoses must provide the needed functions or disabilities may result in an aberration from normal gait. The combination of triplanar and balance control, better floor reaction designs, and energy response capability all enhance the stance phase control of the new designs.

The swing phase aspect of the gait cycle is the easiest to orthotically control. It requires minimal effort to support the extremity in the swing phase of the gait cycle. The new designs are enhancing the swing phase, as well as capitalizing on the advent of energy response designs. The energy released by the orthosis at terminal stance propels the leg up and forward. The velocity of the swinging limb is increased which helps the body to move forward and re-establish the normal swing-to-stance phase ratios. This allows the energy from one step to be transferred to the next step, thus taking advantage of inertia and momentum.

Is normal walking possible with an orthosis or a prosthesis? In absolute terms, probably not. In relative terms, a normal walking appearance is often realizable.

Being fitted with a lower limb orthosis (brace) or prosthesis (artificial limb) does not at all guarantee that you will walk normally. It should, however, improve your walking. The design, fit, and alignment of the device as well as the subsequent training all contribute to the static balancing necessary to potentially achieve a normal gait.

The intended result of an orthosis or prosthesis is to prevent or correct deformity, transfer weight, improve balance, and increase the speed of walking.

Having said this, orthotic design and technology has not kept pace with the benefits realized in prosthetics. Carbon graphite foot/ankle systems enable amputees to walk with a normal gait and even to run. These systems incorporate the use of energy storing principles. Loading of the prosthetic foot stores energy due to the materials used and the forces applied during ambulation. This replaces the action of missing muscles. As more pressure is placed on the component, it deflects or yields to the weight of the force applied. In this way movement is allowed while stability is maintained. The precise combination of energy storing and energy dissipation simulates normal gait characteristics.

The majority of people with AFO's have learned to walk with conventional designs. Some did well while others realized little benefit. Regardless of past experience, the potential exists for improvement. The knowledge and skills for sophisticated lower limb orthotic support systems utilizing new theories, designs, materials and movement strategies have been developed. Outcomes once thought unattainable are now being realized. More secure and efficient ambulation is possible.

The orthotist of the future will need to employ more sophisticated elements to stay abreast of the advancements. People in need of bracing solutions will greatly benefit. Outcomes now thought life changing, will become the standard. The future client will have fewer falls, better balance and more security. A more natural gait appearance is the result with improved velocity, more endurance, and enhanced functional gains. All these elements are the quintessential result of improving efficiency of human locomotion.

In giving his permission for publication of the preceding article, Marmaduke Loke gave some further insight into his work which I thought should be shared with readers. He wrote:

I am most interested in this subject of Stance Phase Control orthoses. I have been practicing true Stance Phase Control in all my lower limb orthoses (braces) since the early 1990s, long before the latest fad of new Stance Phase knee joints became available. They may or may not provide dependable stance phase control. Most of the SPC knee joints of today are first generation and hopefully more improvements will be made in the next generations.

The great news is people are now starting to think and consider the benefits of stance phase in bracing. Conventional bracing systems that are available world wide are primarily single plane (sagittal) verses triplanar control devices. They are primarily swing phase control braces. The swing phase of gait, when the foot is in the air, is by far the easiest to accomplish. Most Stance Phase Control knee joints are attached to conventional or modified conventional designs.

True Stance Phase Control is much more than preventing the knee from buckling. Stance Phase control must include how the whole limb and foot is controlled from the ground up and how they improve pathomechanics to a more natural biomechanics. Stance phase requires control and realignment of each bony segment (26 in the foot) of the lower limb to be supported to optimize balance and security under full load bearing on an affected limb. It must apply corrective forces for each bony structural deviation in each dimension, yet be designed for restoring more natural and efficient biomechanics. Another term for this is Triplanar Control. The design must take in consideration each millisecond of the gait cycle in each dimension, not just one aspect of the gait cycle. There are many aspects of the gait cycle.

I agree true definitions should be made for better clarification. Many terms are utilized too broadly and too comprehensively. The new theories, technologies, and methodologies developed by DynamicBracingSolutions are based on very complex principles.

We are outcome driven and independent research is validating our outcomes. One such study has documented a reversal of disuse atrophy in several polio survivors by two physicians and two Physical Therapists that are polio specialists.

Queen's Birthday Honours - 11 June 2007

We were very pleased to see that Paul Galy, David Windsor Shoemaker, Bondi NSW, was awarded a *Medal of the Order of Australia* in the recent Queen's Birthday Honours. His citation read: "*For service to the community as a medical grade footwear practitioner and manufacturer*." The many Network members who have had their footwear made by Paul over the years will attest that this honour was richly deserved. Well done, Paul!

Can You Help to Promote the Network ?

We are most grateful to everyone who has been able to distribute our pamphlets widely throughout their local communities. If any member can help to get the message out about the late effects of polio and the Network by putting more pamphlets on display in, for example, pharmacies, doctors' surgeries or waiting rooms, clinics, shopping centre notice boards, libraries and community health centres, please contact the Office during business hours, or Alice after hours by phone (02) 9747 4694 or email <ea@post-polionetwork.org.au>, and some will be posted out to you.

Overview of Orthotic Stance Phase Control Systems

In June, a Network Seminar was held for the first time in the Sutherland area. This enabled members in the area to attend a Seminar close to home, and those further afield to experience a new venue. A good number braved the wild rainy weather to hear guest speaker Mark Raabe, Orthotist/Prosthetist, OrthoSynergy Pty Ltd, give an interesting presentation on the range of orthotic stance phase control systems now available in Australia. As noted in the article on pages 9-16, such systems provide a more normal gait pattern and reduce the effort required for people with lower limb weakness and paralysis to walk.

This was Mark's second presentation to Network members – he last spoke to us in March 2003 on the topic *Advances in Orthotic Management* and we were looking forward to hearing an update. (Mark's previous presentation was reported on in *Network News*, Issue 58, May 2003.)

Mark Raabe graduated in 1984 from the Lincoln Institute of Health Sciences, Melbourne with a Dip App Sci P&O. His employment history reveals over twenty years experience in all aspects of prosthetic and orthotic prescription and manufacture:

1985 – 1987 : REIS Orthopaedics (Sydney) – Prosthetics & Orthotics

1987 – 1988 : RALAC Melbourne – Prosthetics

1988 – 1989 : Orthopaedic Techniques (Melbourne) – Prosthetics

1989 – 2000 : Otto Bock (Sydney) – Technical coordinator – National Sales Manager

2000 – present : OrthoSynergy (Sydney) – own Orthotic Company

Mark has been consulted by a number of Network members and is well placed to appreciate our individual and unique polio-related issues. His presentation covered the following Orthotic Stance Phase Control systems:

Microprocessor "E" Knee

Horton Stance Control Knee Joint

UTX Free Walk

FullStride

Swing Phase Lock Knee

Load response Knee

Electronic lock knee

Ultraflex knee

Unilateral upright systems

Blue Rocker

Mark explained that historically there have been two orthotic knee joint options: locked and free motion. A new generation of orthotic knee joints was introduced in 2002. These joints provide stance phase control (knee stability) allowing knee flexion during swing. However, these new devices do not suit everyone and care must be taken when prescribing them to ensure a good outcome for the wearer.

Stance phase control knee joints can be classified into three styles: mechanical, spatial and electro-mechanical.

Mechanical Joints

- The **Load Response Knee** and the **G-Knee** are known as hybrid types. The Load Response model provides resisted knee flexion up to a maximum of 18 degrees, together with cushioning at initial impact. The G-Knee is an extension assist joint utilising a gas strut. Differing strength gas struts are available. It is possible to lock the knee joint. Mark stressed that the G-Knee does not resist knee flexion and this must be taken into account when assessing whether it is suitable for a particular person.

- If a client has poor hip extensors which prevent him/her from stabilising the knee joint then the mechanical hybrid knee joints are not suitable. Quadriceps weakness will not preclude the prescription of one of these joints, however, provided that the hip extensors are able to stabilise the knee.

- The **UTX® Free Walk** is an example of a mechanical stance phase control (SPC) joint. The tubular stainless steel design weighs approximately 900 grams. There are two models: Swing and Stabil. With the Swing model, the knee joint is unlocked by ankle dorsiflexion. These joints have a safe design because a series of events is required to unlock the joint. The Stabil model locks and unlocks by control of the user.

- The **FULLSTRIDE™** joint is another example of a mechanical SPC joint. It features a cable actuated knee joint which uses existing componentry. It is a low cost/risk design because it allows clinicians to experiment with Stance Phase Control.

- The last example of a mechanical SPC joint that Mark demonstrated was a **HORTON SCOKJ™**. This is a multifunction, weight-activated joint (dual mould orthosis design). The joint is not widely used in Australia.

Further information on the range of Horton stance phase control knee systems can be found online at <www.stancecontrol.com>.

Spatial Joint

- Mark then demonstrated the **BASKO SPL™** pendulum activated knee joint. Here, a medial joint provides variable swing phase control. This model is a multifunction joint via satellite control – the SPL is provided with a control element that is connected to the hinge by a cable; apart from mounting on the brace, this satellite can also be slid over the waistband with the advantage that for knee joint control one does not have to reach for the knee.

Electro-Mechanical Joint

- The final stance phase control knee joint that Mark showed us was the **E-KNEE™**. This is an electro-mechanical model which is footplate activated. The electro-magnet pulls gear faces apart – when the power is on, the knee is free; when the power off, the joint locks (the leg can still be extended though).

Mark showed some short videos during his presentation which demonstrated how clients' gait, and therefore their safety while walking, could be improved by the prescription of an appropriate orthotic, individually tailored for their particular disability. Some of the improvements seen were quite dramatic.

After a question and answer session, Committee Member Bill McKee thanked Mark for giving up his Saturday to share his knowledge and expertise with members, and presented him with a pen hand-crafted from Australian wood as a memento of the occasion.