CHARLES UNIVERSITY
Faculty of Physical Education and Sport
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Case Study of Physiotherapy Treatment of a Patient with Bilateral Achilles Tendon Prolongation after Spastic Biparesis of Neuroinfectious Aetiology

Bachelor Thesis

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Declaration

I hereby declare that I composed this bachelor thesis independently and that I have not used any other sources than those listed in the bibliography and identified as references. All methods applied on the patient are based on the knowledge acquired during my three years study of Bachelor degree Physiotherapy program at UK-FTVS in Prague.

I declare that no invasive methods were used during the practical approach and that the patient was fully aware of the procedure given at any time.

In Prague: …………………...   ……………………………….

Author's signature:

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Abstract

Title

Case Study of Physiotherapy Treatment of a Patient with Bilateral Achilles Tendon Prolongation after Spastic Biparesis of Neuroinfectious Aetiology

Aim of the thesis

The first part of the thesis provides an overview of the theoretical background according to the complex course of the patient's diagnosis starting with spasticity in children in relation to neuro-infections including Meningeal Syndrome, then a summary of kinesiology of the ankle, thirdly a general outlook of Achilles tendon prolongation procedures, and lastly detail on related diagnostic and therapeutical methods. The second part includes the practical review of the patient case study with bilateral Achilles tendon prolongation that resulted from no longer reacting to conservative treatment for toe walking after spastic biparesis of neuroinfectious origin.

Method

The protocol is a 3-week therapy course based on the initial kinesiological examination. A variety of therapeutical approaches and training were used in each unit. The therapeutic effect was to concentrate the patient on reaching their current rehabilitative goals.

Result

After a total of 6 sessions the patient was able to master the difficulty in exercises. They paid careful attention to detail during the therapy. This not only showed gradual improvement in strength and balance in the lower extremities but also the quality of functional movement overall including fluency, control, and balance notably in walking.

Conclusion

The patient's physical ability of re-training the decompensation in bipedal mobility formed a groundwork to performing a gait pattern that appears effortless. The mental drive of the patient showed the dedication to the rehabilitation process which reflected on the patient's consistency in cooperation and activities at home or in sports at school.

Keywords

Achilles Tendon Prolongation, Biparesis, Spasticity in Children, Toe Walking

Abstrakt

Název

Kazuistika pacienta fyzioterapeutické péče s oboustranným prodloužením Achillovy šlachy po spastické biparéze neuroinfekční etiologie

Cíl práce

První část práce poskytuje přehled teoretického základu založeného na komplexním průběhu diagnostiky pacienta počínaje spasticitou u dětí ve vztahu k neuroinfekcím včetně meningeálního syndromu, dále shrnutí kineziologie hlezna, za třetí obecný přehled postupů prodlužování Achillovy šlachy a v neposlední řadě informace o souvisejících diagnostických a terapeutických metodách. Druhá část obsahuje praktický přehled kazuistiky pacienta s oboustranným prodloužením Achillovy šlachy, které bylo důsledkem již nereagování na konzervativní léčbu chůze po špičkách po spastické biparéze neuroinfekčního původu.

Metoda

Protokol je 3týdenní terapie na základě vstupního kineziologického vyšetření. V každé jednotce byly použity různé terapeutické přístupy a školení. Terapeutický efekt spočíval v soustředění pacienta na dosažení jeho aktuálních rehabilitačních cílů.

Výsledek

Po celkem 6 sezeních byl pacient schopen zvládnout obtížnost cvičení. Během terapie pečlivě dbal na detaily. To se projevilo nejen postupným zlepšováním síly a rovnováhy v dolních končetinách, ale také v kvalitě funkčního pohybu celkově včetně plynulosti, kontroly a rovnováhy, zejména při chůzi.

Závěr

Fyzická schopnost pacienta během přeučení dekompenzovaného bipedálního pohybu vytvořila základ k dosažení vzorce chůze bez námahy. Duševní pud a motivace pacienta prokázaly oddanost rehabilitačnímu procesu, což se odrazilo na pacientově důslednosti v kooperaci a aktivitách doma nebo ve sportu.

Klíčová slova

Prodloužení Achillovy šlachy, biparéza, spasticita u dětí, chůze po špičkách

Table of Contents

1 INTRODUCTION

Achilles tendon prolongation or Achilles tendon lengthening is a surgical procedure for correcting a tightened or contracted tendon. The Achilles tendon is important in allowing the whole foot to meet in contact the ground. The tendon should not limit the range of motion in the ankle when walking, running, jumping or any movement that involves plantar flexion. When the tendon becomes too tight, it may cause stiffness or pain and difficulties in ambulation such as stumbling or general incoordination which may lead to the manifestation of toe walking or walking on tiptoes. (Jarman, M. 2022)

In children, toe walking is not uncommon especially when the child first learns to walk. After a couple or few years of age most children learn to use the whole foot in normal heel-to-toe gait pattern. The majority cause for toe walkers beyond a couple or few years of age is idiopathic and is harmless to the child. (American Academy of Orthopedic Surgeons. 2017) A recent study showed that statistically various gait characteristics does not always relate directly to the chronological age of the child. (Bach, M. M., Daffertshofer, A., & Dominici, N. 2021). The toe walking child can typically stand with whole foot on the ground but will prefer to be on their toes when walking or running. (American Academy of Orthopedic Surgeons. 2017) In older children the reason may also be due to habit or be idiopathic because of the tendon becoming tighter from shortening or contracture of muscles in the calf over time. There may be many underlying medical causes of a shortened Achilles tendon which can be categorized into congenital, developmental, traumatic and neurological causes. These may include birth defects, developmental delay, or neuromuscular disorders such as cerebral palsy and muscular dystrophy or neuroinfectious cause (meningeal inflammation thus damage to the CNS) such is with the patient in this paper's case study. (Natarajan, R., Ribbans, W.J. 2010)

Before diagnosis of toe walking, it is necessary to make a physical assessment of the child to assess the child's gait, range of motion and muscle tone. It is also important to make an examination for possible neurological pathologies that may likely be contributing to toe walking. Usually, imbalance or neurological findings such as spastic signs require further investigation into the underlying medical condition of the toe walking. (Krochak, R. 2021)

The first-line treatment for children with toe walking is the conservative approach of rehabilitation therapy. These sessions should focus on stretching the tendon and muscles decrease the severity of toe walking. Exercises for stretching are indicated in participation of home exercises. For more severe cases may require bracing for the shortened tendon by an ankle-foot orthosis (AFO). It is a custom brace that is worn during the day and helps to encourage stretching of the tight tendon and flattening of the foot. A more fixed version of prosthetics is serial casting. Leg casts are applied in intervals of one or two weeks for stretching the tendon and changing the position of the foot and ankle. As an adjunctive to children wearing casts is Botulinum Toxin application that has a more targeted effect to the muscle to also stretch the tendon. As a last line of treatment is Achilles tendon prolongation procedure. This is indicated for the child when conservative approach of rehabilitation and bracing is unsuccessful or ineffective. The lengthening of the Achilles tendon provides flattening of the foot for walking by allowing greater range of motion and function of the foot. (American Academy of Orthopedic Surgeons. 2017) In conjunction to the prolongation the child can wear the AFO and as a result due to the surgical procedure the orthosis is more tolerated. (Rutz, E., McCarthy, J., Shore, B. J., et al. 2020)

The main objective of the study is to make a record before and after to analyse the effect of the planned therapy methods on the patient after Achilles tendon prolongation. The case study research took place at MediCentrum, a.s. in the outpatient rehabilitation department in the period of 12.1.2022 to 4.2.2022. Supervision and assistance of the therapeutical procedures were provided by an expert Physiotherapist Bc. Vojtěch Oplt.

2 GENERAL PART

2.1 Spasticity in Children and it's Neuroinfectious origin

Definition of Spasticity

Spasticity can be defined as an increase in "velocity dependent resistance during passive muscle stretch". Another way to define it is when the muscle undergoes inappropriate involuntary activation in association with paralysis of the upper motor neuron. There are numerous functional problems linked with spasticity such as feeding, washing, dressing, dressing, toileting and walking that all tie in together as the activities of daily living (ADL). More serious problems caused by spasticity include pain or spasms in muscle, impaired ability to stand and walk, poor seating position, difficulty with transfers, trouble moving in bed, dystonic posturing muscle, contracture leading to joint deformity, joint subluxation or dislocation, bony deformation and diminished functional independence. Contractures happen when there is decreased motion in the joint because of structural changes in the muscles, tendons and ligaments of the joint. This prevents normal movement of any typical action because there is shortness and stiffness in the soft tissues (muscles, tendons) that are making the joint resistant to stretching. (Shamsoddini, A, 2014)

2.1.1 Aetiology

Spasticity can be described as a pathology located in the cortex, brainstem or spinal cord that is either localized or diffuse. Cerebral palsy is the common cause of spasticity in children. Two thirds of all children with cerebral palsy are affected by spasticity. Traumatic brain injury, stroke, multiple sclerosis, spinal cord trauma, anoxic insults, or disease are other causes of spasticity. The actual clinical manifestations of the spasticity depend on the localization of the lesion that causes the spasticity. Important is to distinguish if the spasticity is related to cerebral palsy if it is a result of spinal cord injury or whether it is localized or diffuse.
(Yasser, A., Tamer, R. 2012)

Spinal cord injury may be caused by compression of a tumour, by inflammatory or demyelination disease or degenerative disorders or an insult to descending pathways by trauma. Localized cerebral injury include tumour, abscess, cyst, arteriovenous malformations, haemorrhage or trauma. Diffuse cerebral injury includes metabolic or toxic encephalopathies or anoxia. (Yasser, A., Tamer, R. 2012)

There is an annual incidence of 30 – 40 per million individual new cases of spinal cord injuries in the US. Every year there are 3 – 5 % of those cases in children younger than 15 years old. (Price, C. 1994) In the general population there is a 4:1 of male to females however the ration is estimated around 1.5:1 in younger age groups. (Zidek, K. 2003) The causal focus of spasticity due to spinal cord injury in the next part will be centred around inflammation of the meninges hence the affection of the CNS (brain, brainstem and spinal cord) = Meningeal syndrome.

2.1.2 Pathophysiology: Meningeal Syndrome

Meningeal syndrome is the pathological irritation of meninges that results in a complex of subjective and objective symptoms. (Dostál, V, et al. 2004) The most common contributary factors are neuro-infection, subarachnoid haemorrhage, tumours − especially meningeal carcinomatosis (diffuse tumour infiltration of meninges) or lesion of the brain tissue. (Ambler, Z., 2006) The following part will focus on Meningeal Syndrome of viral and non-viral neuroinfectious cause; specifically viral meningitis (infectious pathogen) and aseptic meningitis (that is infectious but can also be non-infectious).

Viral Meningitis

The viral pathogen can enter the CNS in 2 ways: haematogenously (most common) and neurogenically (typical of herpesviruses). (Wan, C. 2018)

In the spring, young patients are affected by the mumps virus. Parotitis can complicate meningitis and can possibly lead to residual hearing loss. Mononucleosis is caused by EBV and affects adolescents. It can be complicated by serous meningitis when there is monocytosis in the blood which leads to increased fatigue that lasts several months. (Seidl, Z. & Obenberger. J. 2004*)*

Enterovirus infections (caused by ECHO viruses) are common in adolescents in the summer and autumn. They are spread faecal-orally and mainly infect the paediatric population up to one year of age. The infection is more common in lower social groups.
(Seidl, Z. & Obenberger. J. 2004*)*

Coxsackie viruses cause C-viruses with severe muscle pain. HSV 2 is responsible for 5% of viral meningitis, a quarter of these patients have a primary genital infection. Lymphocytic

choriomeningitis spreads by air from rodent faeces. In HIV infection of high-risk groups, the antibodies appear 1-3 months after the onset of the disease. (Seidl, Z. & Obenberger. J. 2004*)*
There are unknown long-term effects in children with viral meningitis. Some studies show that the infection can attribute to deafness, neuromuscular impairments (i.e., mild paresis or loss of coordination) and learning disabilities. Researchers have seen that many of these cases cause encephalitis or encephalomyelitis due to involvement of the CNS parenchyma. (Wan, C. 2018)

Aseptic Meningitis

Aseptic meningitis is categorised into non-infectious (divided into three main groups: systemic diseases, drug-induced and neoplastic meningitis) and infectious. (Tattevin, P., 2019) The following will discuss the latter, the infectious category. The process of the infection is caused by colonization and penetration of an unknown organism (fungi, bacteria, virus – most common) into the nasopharyngeal or oropharyngeal. In the bloodstream these organisms survive and multiply which are then able to evade host immunologic mechanisms. They then proceed to spread through the blood-brain barrier. It is not possible for infection to take place until the organism has colonized the host through the breathing airways. There are currently no evidence or information on the mechanism of how viruses penetrate the blood-brain barrier and reach the cerebrospinal fluid (CSF). (Owens, D. 2019)

Viral infections have a smaller inflammatory response than compared to a bacterial infection. However, the damage that can be caused is associated with encephalitis and increased intracranial pressure (ICP) can be life-threatening. (Owens, D. 2019)

2.1.3 Incidence and Epidemiology of Aseptic Meningitis

Overall, there are cases that are going underreported that provides a result of an unknown annual incidence of aseptic meningitis. (Mount, H. R., & Boyle, S. D. 2017) The infection has been recorded at all ages, but it is known to be more prevalent in children than in adults. (Kumar R. 2005) There are reports that the general incidence is 11 per 100,000 people per year in the US, 7.5 per 100,000 adults. It is three times more likely to occur in males than females and without any preference for age or racial difference. There are as many 26,000- 42,000 admissions to hospital every year in the US. (Kumar R. 2005) In European studies there has shown to be 70 per 100,000 children up to one year, 5.2 per 100,000 children one to fourteen years of age and lastly 7.6 per 100,000 in adults. (Mount, H. R., & Boyle, S. D. 2017)

In South Korea a study was taken place on children of relatively uniform age distribution. They found there was a higher incidence in children less than one years of age and also the ages between 4 to 7. They also recorded a male-to-female ratio that was 2 to 1. (Lee, K. Y. 2005) Aseptic meningitis has been known to be an all-year round condition. However, in all 3 studies from US, Europe and Korea have noted that in temperate climates there are significant increase during the summer months.
(Kumar R. 2005; Mount, H. R., & Boyle, S. D. 2017; Lee, K. Y. 2005)

2.1.4 Mechanisms of injury/ Clinical Picture

The most common infection of the CNS in children is Aseptic Meningitis (which includes viral meningitis). The infection occurs most commonly up to 1 years of age. The condition causes inflammation of the meninges that's targeted usually by nonbacterial organisms, other disease processes or some specific agents. There still exists no cures to meningitis. Only antimicrobial and supportive therapies are available. Therefore, the morbidity and mortality in children continues to be a cause from CNS infections. (Owens, D. 2019)

Especially in younger children the classic signs and symptoms of Meningeal Syndrome are often absent. When the child is taken to the emergency department it is often a challenge to diagnose the condition. There is risk of neurologic sequelae if the infection is not diagnosed or treated within time; it is difficult for doctors to distinguish children with less serious from the more serious CNS infections. (Owens, D. 2019)

Aseptic Meningitis

Symptoms

The classic symptoms of aseptic meningitis are headache, neck stiffness and photophobia, especially in older children. In younger children these symptoms may be absent, and they present rather with cough, rash, and diarrhoea. Fever may or may not be present and seizures are usually caused by specific viruses. Other symptoms include weakness, lethargy, hypotonia, sore throat, anthralgia and myalgia. If fever is present it may last up to 5 days. Symptoms that are also common include nausea, vomiting, anorexia, and respiratory manifestations. (Owens, D. 2019)

Examination

The younger the child the more unspecific the symptoms. In older children the examinations are more reliable. Examinations performed in older children include evaluating signs of meningism, such as headache, photophobia, neck stiffness, positive Kernig or Brudzinski sign) and focal neurologic signs that are associated with a worse prognosis. (Owens, D. 2019) For confirmation of a definitive sign of meningitis it is essential to perform a lumbar puncture for evaluation of CSF fluid. (Owens, D. 2019)

Complications

Complications include deafness in usually one ear such as in infections after mumps, chronic enteroviral meningitis and after lymphocytic choriomeningitis infection due to hydrocephalus. HSV and AIDs patients after HIV can result in serious neurological condition. (Owens, D. 2019)

2.2 Kinesiology of the Ankle

The Talocrural joint (the upper ankle joint)

The ankle joint is referred to as the talocrural joint which is the articulation between the talus and the crus. (Houglum, A. P. 2012) It is a joint of hinge type and has only one degree of freedom of motion. The ankle controls the leg movements in the sagittal plane relative to the foot. The concave/convex cylindrical mechanical form of the crus and talus respectively with direction of movement is shown in (Fig.2). These movements are essential for walking on flat or rough ground. (Kapandji, A.I. 2007) The resemblance of the joint is like a wood joint called mortise joint used by carpenters (Fig.1). (Neuman, A.D. 2017) This shape provides interlocked tight joint that during single limb support it can be put under to extreme mechanical stresses from the subjection of full weight of the body. It can also be exposed to the dissipated kinetic energy force generated during walking, running, or jumping when the foot rapidly contacts the ground.
(Kapandji, A.I. 2007)

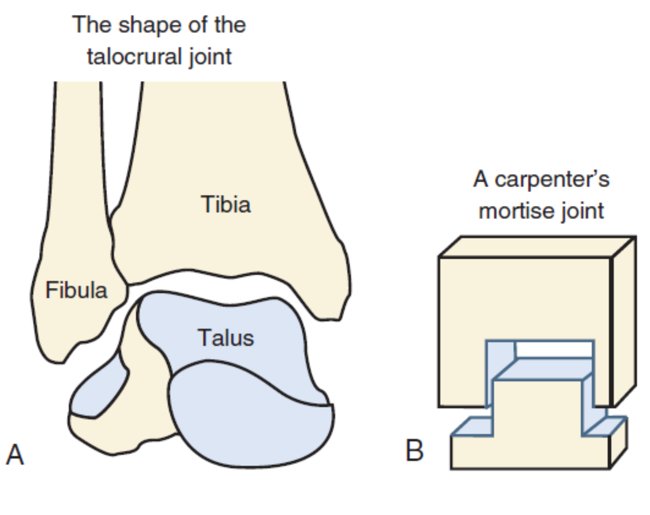

Fig. 1 Talocrural joint shape
(Neuman, A.D. 2017)

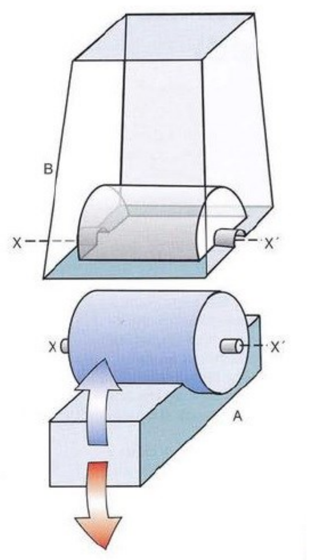

Fig. 2. Mechanical model of talocrural joint
A. talus, B. crus (Kapandji, A.I. 2007)

The Subtalar joint (the lower ankle joint)

In close associated function with the talocrural joint is the subtalar joint which is the articulation between the talus and calcaneus (a.k.a talocalcaneal joint). This is the lower ankle joint whereas the talocrural joint is the upper ankle joint. As the name says, the subtalar joint is located under the talus. This joint is a synovial joint showing three degrees of freedom of motion. Here the ankle is important in providing supination and pronation during static and dynamic activities in both open and closed chain functions. This function is important in allowing the foot to adapt to many varied surfaces while still maintaining good standing balance. (Houglum, A. P. 2012)

In open kinetic chain, supination includes motions of inversion, adduction and plantar flexion. During this open chain the talus is stabilized as it fits within the "mortise" of the talocrural joint and the calcaneus us free to move in three planes of motion (inversion, plantarflexion and adduction). The same is for open kinetic chain in pronation, calcaneus is free to move in three planes of motion in however eversion, abduction and dorsiflexion). (Fig. 3A and 4A)
(Leardini, A., Stagni, R., O'Connor, J.J. 2001)

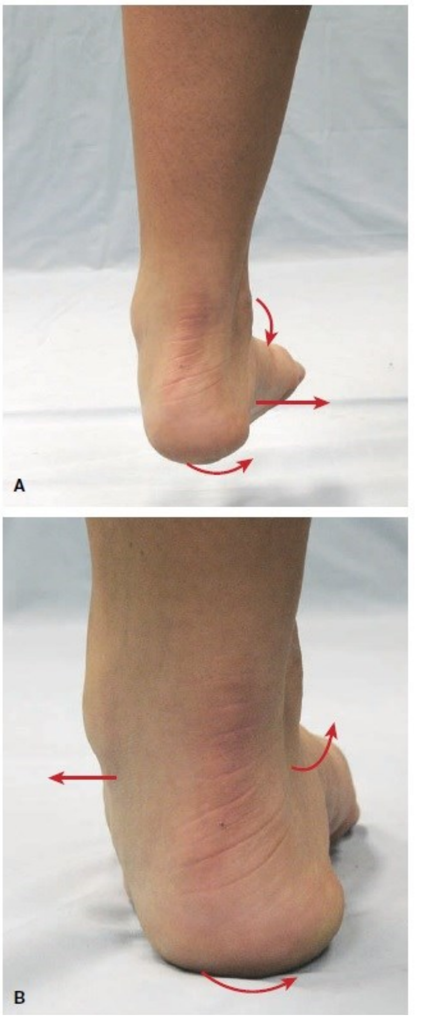

Fig 3. Supination A. Open kinetic chain,
B. Closed kinetic chain. (Houglum, A. P. 2012)

In closed chain, the calcaneus is no longer free to move in frontal plane but can still freely move in the sagittal and transverse planes. When the weight of the body is put on the foot, supination and pronation moves the talus instead of the calcaneus. So, in closed chain pronation, the talus adducts towards it's medial boarder in the transverse plane and the head of the talus plantarflexes in the sagittal plane. In closed chain supination, the calcaneus inverts and the talus rolls laterally and the head of the talus elevates to produce talar abduction and dorsiflexion on the calcaneus. (Fig. 3B and 4B)
(McPoil, T.J., Brocato, R.S. 1985)

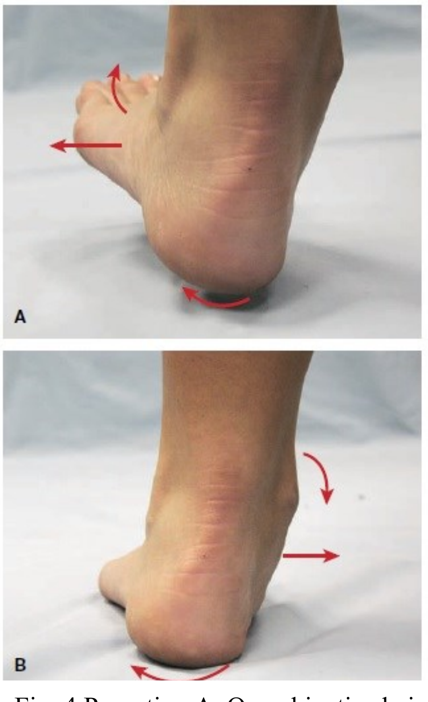

Fig. 4 Pronation A. Open kinetic chain,
B. Closed kinetic chain. (Houglum, A. P. 2012)

In fact, all the joints of the foot play a role in the function of pronation and supination in the ankle however they are not discussed in this paper. The relevance to this function for the patient with previously shortened Achilles tendon is in the limitation of dorsiflexion during walking in stance phase. When the tendon is retracted at the ankle joint, due to its insertion at the calcaneus the talus is limited in dorsiflexion and this function is shifted to the subtalar joint. Here it everts and causes dorsiflexion at the calcaneus instead of the talus – leading to a decompensated walk pattern and possibly pain. (Mosca V. S. 2010) This issue and way to assess the function in the condition known as flexible flat foot with shortened tendon is discussed more in detail in "2.5.1 Podiatry: flexible flatfoot with short Achilles tendon" p. 27 – 28.

2.2.1 Muscles involved in the kinematics of the ankle joint

Flexion in the upper ankle joint is performed by m. triceps surae. The auxiliary muscles are the posterior tibialis muscle, the digitorum flexor muscle, the hallucis longus flexor muscle and the peroneus longus et brevis muscle. The movement is stabilized by the muscles that fix the knee and hip joint. Neutralizing muscles are all the leg muscles that interfere with the supination and pronation effect in the joint. (Dylevský, I. 2009)

The extension in the upper ankle joint is performed by the anterior tibialis muscle. The auxiliary muscles are the posterior tibialis, the flexor digitorum longus, the flexor hallucis and the peroneii. The movement is stabilized again by the muscles fixing the knee and hip joint. The neutralizing muscles are the other leg muscles, which disrupt the supination and pronation in the joint. (Dylevský, I. 2009)

The inversion in the lower ankle joint is performed by the posterior tibialis muscle, the flexor digitorum longus muscle and the flexor hallucis longus muscle. The auxiliary muscle is the triceps surae muscle. The movement is stabilized by the muscles that fix the knee and hip joint. (Dylevský, I. 2009)

Eversion in the lower ankle joint perform peroneus longus and peroneus brevis. The auxiliary muscle is the extensor digitorum longus. The movement stabilizes the muscles that fix the knee and hip joint. (Dylevský, I. 2009)

2.2.2. The role of the muscles of the ankle when walking

Ankle dorsiflexors (extensors)

The ankle dorsiflexors including the anterior tibialis assisted by the extensor hallucis longus and extensor digitorum longus are isometrically activated during the swing phase of gait. This stabilizes the ankle and toes into neutral position, so they can be lifted away the ground. After initial contact in stance phase the group of muscles increase in activity. During the loading response the muscles now contract eccentrically which controls the rate the foot is being lowered to the ground. The effect of this controlled activity also provides shock absorption in the ankle. During the loading response the anterior tibialis has an additional function. The muscle has distal attachments which are to the medial cuneiform and first metatarsal. Due to this it acts in slowing down the foot into pronation during loading response. (Houglum, A. P. 2012)

Ankle plantar flexors (flexors)

The ankle plantar flexors including the gastrocnemius and soleus are activated at the beginning of loading response and increase in activity throughout phase till they peak in activity towards the end of stance phase. The calf muscle is activated eccentrically until the midstance phase the COM of the body moves anteriorly to the ankle. This provides smooth tibia control over the foot. The soleus is activated during initial contact and loading response while the gastrocnemius assists in control of the knee. As the knee continues to flex, the tibia swiftly advances into dorsiflexion between loading response to midstance phase. This requires significant effort from both the gastrocnemius and quadriceps muscles for a smooth motion. At terminal stance when the heel is lifter from the ground, there is peak activity in the gastrocnemius and soleus. (Houglum, A. P. 2012)

In past research found that “indicate that the function of the gastrocnemius and soleus is to provide a burst of force to push off the limb from the floor and propel the body forward.” (Gottschall, J.S., Kram, R. (2003) On the contrary, other older studies show that during terminal stance the heel lifts heel lifts and the body weight is placed on the balls of the feet. This requires increased activity from both gastrocnemius and soleus to stay on the toes. This study found the combination of inertia and rolling off the foot rather than gastrocsoleus propulsion provides the forward advance the COM in a forward direction. (Perry, J. 1992) However in more recent studies it confirms the latter “by controlling the disequilibrium torque, however, triceps can affect the propulsive force through exchange of potential into kinetic energy…the triceps surae is not responsible for the generation of propulsive force but is merely supporting the body during walking and restraining it from falling” (Honeine, J. L., Schieppati, M., Gagey, O., & Do, M. C. 2013)

The auxillary plantar flexors (flexors)

The tibialis posterior, flexor digitorum longus and flexor hallucis longus are classified as plantar flexors, but they only contribute a little in that function because of their poor leverage and small size. They generate only 10% of torque in plantarflexion compared to the soleus. (Perry, J. 1992) On the other hand the auxiliary muscles play an important role in activity at the tarsal joints and toes. There are two peaks of activity in the tibialis posterior, once during loading response in early stance and the other right after the heel lifts from the ground at the end of stance phase. Throughout swing phase the tibialis posterior is inactive. (Perry, J. 1992; Kaye, R.A., Jahss, M. H. 1991) In loading response it acts eccentrically which gives slowing down of the middle foot into pronation and it and eccentrically in loading response to provide a smooth midfoot deceleration into pronation and alters the foot to the ground’s profile. Between midstance and pre-swing, the tibialis posterior contracts concentrically to supinate the foot and provide stabilization for the tarsal joints. Both flexor digitorum longus and the flexor hallucis longus are activated after loading response, in terminal stance they peak, and are then throughout swing phase they are inactive. Importantly, the long toe flexor muscles provide support during flattening and elevation of the longitudinal arch in both pronation and supination as well as assisting in stabilization of the toes on the ground. (Houglum, A. P. 2012)

The Peroneals (ankle evertors)

The ankle evertors (the peroneus brevis and longus) perform phasic activity very much like the gastrocsoleus muscle. The contraction begins after loading response at the beginning of early stance phase. The activity peaks after terminal stance phase when the body weight moves onto the metatarsal heads and toes. (Inman, V.T., Ralstonm, H.J., Todd, F. 1981) The importance of these muscles in conjunction with the tibialis posterior is the function of enabling the foot to alter to the ground’s profile in combination with stability in the mediolateral ankle. This function is provided by the muscles’ control of the tarsal joints and the arches of the foot. Due to the distal attachments on the plantar side of the foot, the peroneus longus plays a crucial role towards the end of stance phase when heel is off ground). These roles are as the function of the main muscle supporting the three-foot arches and stabilizing the MTPI on the ground to convert the foot to the rigid lever. (Kapandji, A.I. 2007)

2.3 Procedure: Achilles Tendon Lengthening

The surgical sectioning of the tendon is called tenotomy. The procedure is used to treat contracted possibly harmful action in muscle. The downside is that it impairs force and joint's moment arm of muscle force. (Fitoussi, F., Bachy, M. 2015) Joint moment arm is defined by "the perpendicular distance between the muscle's line of action and the instantaneous centre of rotation of the joint in which it spans and represents the capacity of that muscle to exert a joint torque". (Pandy, M. G. 1999) Another procedure which will be the focus of this topic is tendon lengthening which serves to restore a more physiological course while conserving function.
(Fitoussi, F., Bachy, M. 2015)

Tenotomy and musculotendinous lengthening are both indicated for the for the various categorical causes (congenital, developmental, neurological etc.) of muscle retraction. There are many techniques that are different anatomically and technically in the way in which the muscle-tendon unit is involved. The various criteria to which the technique is chosen are muscle anatomy (tendon and muscle body length, aponeurosis), location, avoidance of excessive loss of force and degree of correction required. Pure tendon lengthening needs post-operative immobilization to avoid recurrence of contracture or excessive lengthening. On the other hand, lengthening within the muscle or aponeurosis may or may not require immobilization. (Fitoussi, F., Bachy, M. 2015) In selected studies over-correction is due to also biomechanical consequences of the procedure as well as the lengthening technique itself. (Graham, H. K. 2002).

2.3.1 Type of Achilles Tendon Prolongation

PERCUTANEOUS TECHNIQUES

Percutaneous techniques are procedures that are performed blindly and are thus used on superficial tendons. The advantages of the techniques include low complication rates, less risk of scarring, low rates of complication and less possibility for an excessive out-patient treatment. (Fitoussi, F., Bachy, M. 2015)

Total tenotomy

The procedure of total tenotomy should be indicated with caution in the lower extremities if being able to walk is not the problem in the patient. First the thumb and forefinger palpate the tendon. Then on the edge of the tendon a minimal incision is made. The tendon is held with forceps, and it is then pulled out through the incision. A cold blade is used to complete the sectioning. For this method the main indication is for use is the serial casting (Ponseti method) in congenital club foot. There are 6 steps to the healing and by 6 months ultrasound is used to assess the physiologically healed structure. (Weigl, D., Copeliovitch L., Itzchak, Y., Strauss, S. 2001). Other than the gastrocsolues, the gracilis and adductor longus can be lengthened using this method. The long head of the biceps brachii can have tenotomy performed arthroscopically to allow resection of the intra-articular part. (Fitoussi, F., Bachy, M. 2015)

Alternating and sliding hemi-tenotomy

The full body of the tendon is lengthened by the sliding of the tendon sheath. The Achilles tendon is indicated for this technique. (Fig. 2) First the tendon is palpated then around 2 to 3 incisions are performed on the edges of the tendon medially and laterally with a cold bade. The procedure is also performed blindly so the knife is required to be handled carefully. To avoid accidental skin lesions or excessive tendon sectioning the blade number 11 is recommended due to its blunted proximal part. The blade is applied at each level parallel to the long axis into the tendon in the middle. Then to enable hemi-sectioning the knife is turned 90° forward and backward. "In the Achilles tendon, low internal transverse hemi-sectioning is performed just above the calcaneal insertion, followed by high external transverse hemi-sectioning." At a higher level, a third hemi-section can be performed in the same direction as the first. By sliding the tendon fibres, the forced joint movement along the stretching plane is lengthened. It is with careful repetition and until complete sectioning is achieved can the sliding be achieved. The section is closed by a simple skin suture and immobilized in cast for 6 weeks. (Fitoussi, F., Bachy, M. 2015)

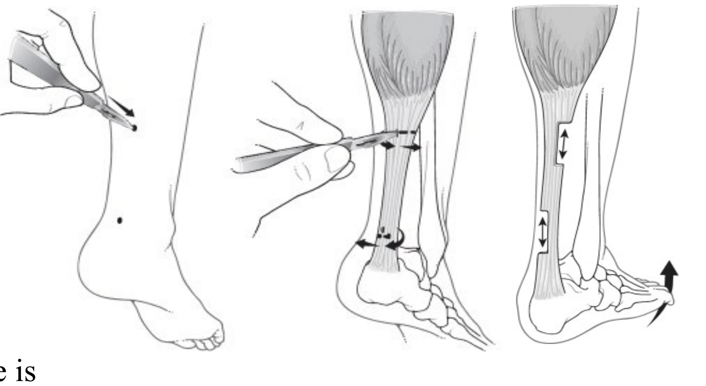

Fig. 5 – Alternating and sliding hemi-tenotomy (Fitoussi, F., & Bachy, M. 2015)

OPEN SURGERY TECHNIQUES

Open surgery techniques may be presented according to anatomic level. In a study of biomechanical tests, it was found that the lengthening performed more distally had greater gain but contributed to instability.
(Firth, G.B., McMullan, M., Chin T., Ma, F., Selber P., Eizenberg, N., et al. 2013)

Proximal release

Two Farabeuf retractors are used to reveal proximal insertion of the muscle and is sectioned by cold blade at the aponeurotic fascia. The hamstrings and gastrocnemius are used in this technique (Silverskiöld procedure), sometimes associated to partial neurotomy (C.M. Silver, S. Simon 1959). The Page-Scaglietti-Gosset procedure is used in the upper limbs to release the flexor/pronator muscles of the medial epicondyle. The complications from paralysis of the brachial plexus in obstetrics, this procedure may relieve retraction of the scapula in internal rotation of the glenoid joint by releasing the subscapularis muscle. (Fitoussi, F., Bachy, M. 2015)

Intramuscular lengthening

The tendon is sectioned by some centimetres above the end of the last muscle fibres. This is to avoid any risk of tearing when the muscle is stretched (Khouri, N. et al. 2010). The following options are possible depending on the muscle involved and gain that is required.

The Vulpius technique consists of 2 level sectioning into chevrons at the end of the gastrocnemius and then back and forward section of the medial raphe of the soleus. (Fig. 3). The semimembranosus can also be sectioned in this chevron technique. Strayer's technique is an additional lengthening for the gastrocnemius where the end of the aponeurotic sheath is sectioned transversely.
(Fitoussi, F., Bachy, M. 2015)

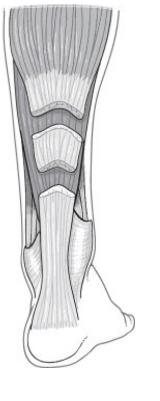

Fig. 6 – Vulpius technique
(Fitoussi, F., & Bachy, M. 2015)

Distal tendinous lengthening

Z-plasty lengthening

The Achilles tendon is most represented in this technique. About around 6 to 7 cm of the calcaneal tendon is exposed. With a cold blade taking care of other elements along the cut, a vertical incision is performed in the middle of the tendon. After the incision is at sufficient length, the blade is turned 90 degrees to section the tendon in half. Then at the opposite end of the lengthening, the contralateral half is also sectioned (Fig. 3). The tendon lengthening during an imposed extension movement and here a suture is made to connect the two free edges. There is a risk of over-correcting the shortened tendon which could result in muscle insufficiency. (Carlioz, H., Kohler, R. 2005) Therefore in this technique it is essential to adjust tension. “For example, the maximal isometric moment of the soleus muscle in mid-stance is reduced by 30% with 1 cm lengthening of the tendon and by 85% with 2 cm lengthening”

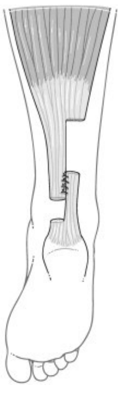

Fig. 7 – Z- plasty lengthening
(Fitoussi, F., & Bachy, M. 2015)

(Delp, S.L., Zajac, F.E. 1992)

Lengthening by doubling

This technique is rarely used for the calcaneal tendon. The tendon is divided int two in the frontal plane by transfixion of the blade which is held flat. At 90 degrees the blade is turned above to exit the back, and also below so as to exit forward. Here the tendon is imposed to move in forced flexion in the stretching plane. This can break the aponeurotic sheath if continually resisted. Once the doubling is reached enough, the tendons are placed over each other by 1 to 2 cm. Now that the tendons are held in the corrected position, they can be sutured together with several stitches. (Fitoussi, F., Bachy, M. 2015)

Baker's aponeurotomy

This technique can be applied for the Achilles tendon. Over a sufficient length, the whole width of the tendon is exposed. Using a cold blade, it is divided into three widths with a U-shaped incision. (Fig. 4). The tendon is lengthened by stretching the joint of the muscle. Here the tension is adjusted and several sutures are made to fix the tendon edges.
(Fitoussi, F., Bachy, M. 2015)

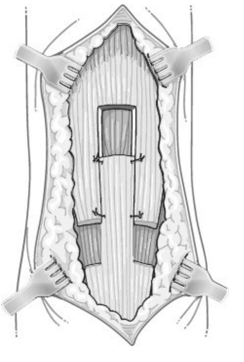

Fig. 8 – Baker U-lengthening
(Fitoussi, F., & Bachy, M. 2015)

2.3.2 Risks and Complications

According to Procedure	Risk
Alternating and sliding hemi-tenotomy Hoke procedure	There is a potential for overlengthening and calcaneal gait as well as possible tendon rupture
Intramuscular lengthening Baumann procedure	The wide area of muscle adds the challenge of full medial to lateral access and finding the proper location of the incision is important for exposure. The Baumann procedure is a less aggressive lengthening.
Distal tendinous lengthening	It is important to maintain an early stretch on the lengthened tissue to avoid recurrence since the underlying soleus muscle tends to pull the two ends together.
Superficial tendinous lengthening	The superficial gastrocnemius procedure is more challenging to perform with the patient supine. The surgery leaves a visible posterior scar and there can be possible nerve issues due to deep scar tissue
'Z' Tendo-Achilles Lengthening	There is a potential for overlengthening or skin healing issues as well as possible tendon rupture
Percutaneous Achilles Tenotomy	Patients can develop a calcaneal gait without bracing.

Table 1 – Risks *Note.* Adapted from (Boffeli, T., Luer, S. 2018)

Complications

Though uncommon, the main concern after the operation for Achilles tendon prolongation is recurrence (of muscle retraction). It is possible to manage the recurrence with an AFO up to 1 year before considering re-operation. It's more common in patients with neuromuscular due to the growth and spasticity of the extremity. It is known that correct use of an orthosis and exercises including stretching can help to prevent this complication. (Krochak, R. 2021)

An exacerbation of patients with toe walking with spasticity or paralytic muscle disease is the worsening of independent gait. These complications can be avoided by cautious preoperative observation with selection and execution of the appropriate procedure. It is always important there is support provided by an AFO in case the tendon lengthen adversely affects the function in any way. (Krochak, R. 2021)

Also included in rare, uncommon complications are cutaneous nerve injury, wound dehiscence and necrosis. (Krochak, R. 2021)

2.3.3 Benefits and Recovery

According to Procedure	Benefits
Alternating and sliding hemi-tenotomy Hoke procedure	This procedure facilitates improved skin healing in patients with edema and/or peripheral vascular disease. One may perform the procedure as an in-office procedure for patients with advanced neuropathy and it offers immediate protected weightbearing for the affected extremity
Intramuscular lengthening Baumann procedure	The Baumann procedure is a true gastrocnemius lengthening with a low chance of overlengthening. It is sural nerve friendly, preserves calf muscle definition and leaves a less visible medial scar.
Distal tendinous lengthening Strayer Procedure	This open procedure allows direct suture repair to avoid both overlengthening and tendon retraction. It also provides direct visualization of the sural nerve.
Superficial tendinous lengthening Vulpius procedure	This open procedure allows direct suture repair to avoid both overlengthening and tendon retraction. It also provides direct visualization of the sural nerve.
'Z' Tendo-Achilles Lengthening	The open procedure offers controlled lengthening, more aggressive lengthening in comparison to gastroc recession for severe conditions and access to the posterior ankle joint if capsulotomy is necessary.
Percutaneous Achilles Tenotomy	There is a low likelihood of recurrence of the condition. This percutaneous approach offers a minimalist approach in frail patients.

Table 2 – Benefits *Note.* Adapted from (Boffeli, T., Luer, S. 2018)

Recovery

After the tendon lengthening procedure, it is typical for the patient to be immobilized for 4 – 6 weeks in a selected type of below-the-knee cast. It is crucial to have the correct position of the ankle in the percutaneous approach as it is possible to control the lengthening if the foot is placed in dorsiflexion for a greater increase in length and in less dorsiflexion if a less significant increase in length is required. (Krochak, R. 2021)

Pain medication is provided in the acute postoperative phase to maintain the patient's comfort and reduce muscle spasms that could affect the altercated length in the tendon. Elevation of the limb is provided for couple to few days until there is resolution of swelling. It is possible to bear weight on the operated limb in case the percutaneous technique is performed. In other techniques the limb is not subjected to weightbearing until around 6 weeks when the tendon is sufficiently healed. (Krochak, R. 2021)

The patient is able start walking on the operated limb again once the cast is removed. It is usual for the patient to have weak plantarflexion and walk flat-footed. Strength in the gastrocnemius and soleus takes some months up to 1 year to return to normal. Important is to monitor the patient with a spastic or paralytic neuromuscular disease in case of recurrences – in this case a combination of orthotics and stretching is needed to hold the correct foot position. (Krochak, R. 2021)

2.4 Assessment and Diagnostic methods

2.4.1 Imaging methods: CT and MRI for migraines

Headache is one of the most common causes of pain in children and it can be from the following affection sites that are sensitive to pain which include the meninges, blood vessels, muscles and para-nasal sinuses. (Behzadmehr, R., Arefi, S., & Behzadmehr, R. 2018) There is a "25.25 per thousand" prevalence in children with severe headaches. (Newacheck, P. W., & Taylor, W. R. 1992) (Rothner A. D. 1993; Lamont, A, C., Alias N. A., & Win, M. N. 2003) There is wide concern between parents and physicians the headaches could be due to neoplastic growth (Al-Twaijri, W. A., & Shevell, M. I. 2002). Before any diagnostic measures are taken it is important to carefully take the patient's medical history and any other clinical pre-cautions. For children with headaches, although imaging is not as common in adults, it is used as one of the diagnostic methods. (Lewis, D. W., & Qureshi, F. 2000) (Krumholz, A., et al. 2007) (Linet, M. S., Stewart, W. F., Celentano, D. D., Ziegler, D., & Sprecher, M. 1989) MRI and CT scans are provided for headaches because it's important to make a differential diagnosis for possible lesions in the brain for in case it is incurable and therefore a level of complex care is necessary to improve quality and longevity of life. (Zubcevic, S., Heljic, S., Catibusic, F., Uzicanin, S., Sadikovic, M., & Krdzalic, B. 2015) In the category of incurable lesions include hydrocephalus, brain tumors, subdural haematoma and vascular malformations (Deda, G., Caksen, H., & Ocal, A. 2000). It is on the same level of importance to alleviate any anxiety formed due to possible presence of an intracranial disease to conduct MRI for headaches to confirm or rule out the diagnosis. (Mortimer, M. J., Kay, J., & Jaron, A. 1992). Cases in which imaging should be performed include important changes in worsening of headache, type of headache, stimulation by awakening from sleep or a sudden development of headache and when it is associated with a neurological symptom. (Behzadmehr, R., Arefi, S., & Behzadmehr, R. 2018)

2.4.2 Genetic Testing for HSP

The signs and symptoms of hereditary spastic paraplegia (HSP) include bilateral lower-extremity spasticity (mainly in hamstrings, quadriceps, adductors and triceps surae muscles) and weakness (mainly in iliopsoas, hamstrings and tibialis anterior muscles). The signs are of spasticity and weakness are variable. The lower extremity is assessed by neurological examination for hyperreflexia in deep tendon reflexes especially in the extensor plantar responses and also vibration sensation. (Hedera, P. 2000)

There are early onset symptoms in very early childhood may be non-progressive and resemble spastic diplegic cerebral palsy. In later onset symptoms may begin in later childhood or after they usually progress slowly and steadily. After a number of years, it is not usual for individuals with progressively worsening gait to experience a "functional plateau" (i.e., the rate of further worsening of gait impairment is similar to that attributable to age). (Hedera, P. 2000)

Classification of HSP include uncomplicated or pure HSP and complicated HSP. Uncomplicated HSP is characterized by limited neurologic impairment that's progressive to spastic weakness in the lower extremity, hypertonic urinary bladder disturbance and reduction in vibration sense. Complicated HSP us characterized by the impairments in uncomplicated and include additional neurological findings such as extrapyramidal disturbance, ataxia, seizures and muscle atrophy. (Hedera, P. 2000)

In order to establish the specific cause of hereditary spastic paraplegia (HSP) it is necessary to take patient anamnesis (importantly family history), perform physical examination and laboratory work. The family history is taken over a span of 3 generations including other more distant relatives that may possibly have HSP by direct examination or reviewing records of neuropathology, examinations, imaging, molecular genetic testing (autosomal recessive, autosomal dominant, X-linked to maternal inheritance patterns have been found in cases of HSP. (Hedera, P. 2000)

The approaches of molecular genetic testing are a combination of tests for targeting genes (such as multigene panel or single-gene testing) and comprehensive genomic testing (such as exome array or exome sequencing). Genomic testing does not require a clinician to hypothesize a possible related gene whereas in gene-targeted testing requires prior selecting of a gene for targeting. Serial single-gene testing if clinical findings as well as the family history provide a particular gene that could be involved. The multigene panel includes an array of genes that are likely to be associated with the genetic cause of the condition and however is limited to gene variants without the classic phenotype of the condition. (Hedera, P. 2000)

Comprehensive genomic testing is considered especially if the clinician does not require to determine the related gene. Most used is Exome sequencing. Exome array is the back up if there is no diagnostic result from exome sequencing. (Hedera, P. 2000)

2.4.3 Electromyography (EMG)

If the patient undergoes negative genetic testing for heredity sensorimotor neuropathies (e.g., HSP) then Electromyography is not necessary as it is usually performed if the diagnosis is suggestive of the hereditary conditions. (Krochak, R. 2021) However, usually found on an EMG is premature activation of the gastrocnemius during swing phase. In healthy children it is usually seen in stance phase. (Kalen, V., Adler, N., Bleck, E. E. 1986)

EMG can also differentiate idiopathic toe walking from CP. In CP there is coactivation of the gastrocsoleus complex with quadriceps during stance phase whereas in idiopathic toe waking children it does not. (Rose, J., Martin, J., Torburn, L., Rinsky, L., Gamble, J. (1999); Policy, J., Torburn, L., Rinsky, L. A., Rose, J. 2001)

2.4.4 Neurological Assessment

Locomotor stages in Spinal Cord Injury (LOSSCI)

Professor. Vojta described the complexity of normal developmental kinesiology in regard to the automatic control of posture, species-specific up-righting against gravity and segmental, goal-directed movements. Prof. Vojta defined specific stages of locomotion for the child with CP based on the fact that motor development in a child with CP takes place in very specific stages of development analogous to that of a typically developing child. For anyone at any age with acquired damage to the CNS, concrete motor improvements occur in a sequential order analogous to normal locomotory ontogeny and consequentially from experience with therapeutic treatment that is shown through there as well. The highest stage achieved by the patient determines the skill level of daily living available for them. The locomotor stages are now applied to spinal cord injuries as well. For cases in spinal cord injuries, it was found that locomotion stages were reliable and an applicable assessment procedure. This quick assessment is a way to confirm the relevant functions required for mobility and for self-reliance and independence of the patient. (Internationale Vojta Gesellschaft e.V. 2020)

Description of the LOSSCI Stages I – V

LOSSCI I – (position in supine) the aim of this stage is for the orientation and goal directed movement of the arms – this tests the ability to control the body posture while enabling orientation to the environment and to performing a goal-directed movement with one arm at a time lifted from the support surface. (Internationale Vojta Gesellschaft e.V. 2020)

LOSSCI II – (position in prone) the aim of this stage is for the up-righting of the trunk and goal-directed movement of the arms – this tests the ability to upright the trunk against gravity in prone through elbow support and the ability to perform a goal-directed movement of each arm by lifting it off the support surface. (Internationale Vojta Gesellschaft e.V. 2020)

LOSSCI III – (position in prone) the aim of this stage is for the forward progression in prone: Creeping with/without assistance of the legs – this tests the ability to move the body forward in space in prone. (Internationale Vojta Gesellschaft e.V. 2020)

LOSSCI IV – the aim of this stage is for the locomotion by means of crawling or walking with upper extremity assistance – this tests the ability to move the body in space either through crawling (support on the hands and knees) or through bipedal gait with support through the arms (use of mobility aids such as crutches or walker). (Internationale Vojta Gesellschaft e.V. 2020)

LOSSCI V – the aim of this stage is for independent walking – this tests the ability to move the body in space through bipedal gait without using the arms for support; this may also include the ability to walk up and down an incline. The one-legged stand is used to test the ability to keep the body erect whilst standing on one leg over a longer period of time with flexion of the other leg in the hip and knee of approx. 90 °. (Internationale Vojta Gesellschaft e.V. 2020)

2.4.5 Functional Assessment

The Gross Motor Function Classification System

The GMFCS consists of a classification system with five levels describing the gross motor function in children typically with CP on their independent self-initiated movements such as standing, walking, sitting and mobility on wheels. The levels are distinguished based on their functional abilities, dependency on assistive technology, including hand-held mobility devices (adivatics such as walkers, crutches, or canes) or wheeled mobility and lastly but not so importantly, the quality of movement. (CanChild. 2022)

The aim of the classification system is to determine which level is best representing the child's abilities and limitations in gross motor function. There is emphasis on the current usual accountable things they do at home, school and community settings rather than what they are known to be able to do (their capacity). The gross motor performance of the present is classified and not so much the quality in the way it can be improved. (CanChild. 2022)

At level 1 children can walk without any restrictions but tend to be limited in some more advanced motor skills, such was the case of the patient in the case-study. At motor function of level 5 children are the mostly limited in the ability to move themselves around even with assistive devices. (CanChild. 2022)

The age range for the GMFCS is for children of 12 to 18 years and is closely tied with the concepts inherent in the World Health Organization's International Classification of Functioning, Disability and Health (ICF). The importance of potential impact of the environment factors (e.g., distance to get to school and around the community) and personal factors (e.g., social preferences and energy demands) on methods of mobility are importantly reflected and described in the age ranges of 6 to 12 years and 12 to 18 years. (CanChild. 2022).

2.5 Therapeutical Methods

2.5.1 Podiatry: flexible flatfoot with short Achilles tendon

The vast majority of infants and many adults present flexible flatfoot as a normal foot-shape. In the first 10 years of a child's life the arch is elevated and there is no longitudinal arch yet created from devices or external forces. In contrast to just simple flexible flat foot, flexible flatfoot with a short Achilles tendon can cause pain and disability in some adolescents and adults. Sometimes the only way to preserve the joint and correct the deformity is through surgery. Usually, prior conservative measurements fail to relieve pain specifically under the talus. The most fundamental and crucial choice of procedure is osteotomy. However, in most cases Achilles tenon lengthening is performed. (Mosca V. S. 2010)

Flatfeet are divided into 3 types: flexible flatfoot (FFF), flexible flatfoot with short tendo-Achilles (FF-STA) and peroneal spastic or rigid flatfoot. Two-thirds of all flat feet consist of the flexible flat foot and it is known very rarely to cause disability. Studies have shown that it is the mobility of the joints and tendons that emphasize the importance in the weight-bearing of the flat arch. (Harris, R.I., Beath, T. 1947; Harris, R.I., Beath, T. 1948). Furthermore, 25% if the total subjects with flexible flat foot had contracture of the Achilles tendon which was associated with functional disability and pain. (Harris, R.I., Beath, T. 1947; Harris, R.I., Beath, T. 1948) It was a mere 9% of those with flatfeet that characteristically had restriction in motion at the subtalar joint and it was noted that tarsal coalitions were not uncommon although usually asymptomatic. (Mosca V. S. 2010)

It is known that FFF and FF-STA have the same mobility at the subtalar joint but FFF-STA differs by limited ankle dorsiflexion. FFF-STA strongly features contractures of just the gastrocnemius or gastrocsoleus complex. During stance phase of gait, these contracted muscles limit the talus of the ankle in dorsiflexion. The force of the dorsiflexion is shifted to the subtalar joint where it everts and enables the calcaneus to dorsiflex instead of the talus. This decompensated dorsiflexion can result in pain of the foot and ankle usually under the head of the talus. (Mosca V. S. 2010)

It is important yet challenging to assess the true dorsiflexion of the Achilles tendon. The movement of the talus needs to be isolated to assess the motion in the ankle joint by inverting the subtalar complex into a neutral locked position. The subtalar joint complex must be inverted to

neutral and held locked in that position to isolate and assess the motion of the talus in the ankle joint. While maintaining neutral alignment of the subtalar joint the knee is flexed and the ankle is dorsiflexed. The ankle between the anterior tibial shaft and lateral plantar is measured during this dorsiflexion. There is contracture of the soleus if there is less than 10° of dorsiflexion which means there is contraction in the Achilles tendon. Again, while maintaining neutral alignment of the subtalar joint the knee is extended while keeping dorsiflexion in the ankle joint. The same measuring principle is used to remeasure this dorsiflexion. With the knee extended there will be less than 10° of dorsiflexion possible and this means that just the gastrocnemius is contracted. Determining the differences in type of contracture whether the whole Achilles tendon or just gastrocnemius can indicate which surgical technique and management is appropriate.
(Mosca V. S. 2010)

2.5.2 Orthotics

The types of knee ankle foot orthoses are divided into healing and functional.

Healing

Wedge boot: this orthotic can be used in conservative treatment after Achilles tendon rupture surgery as it allows the tendon to heal while gradually stretching it. To increase base of support and improve balance, a heel wedge may be used in patients with fixed plantar flexion deformity. (Elattar, O., et al. 2018)

Aircast boot: this is used to support and reduces forces through the bone while healing after fracture injuries. The air cells can be inflated around the foot and ankle, compressing the injury. (Elattar, O., et al. 2018)

Hinge-knee brace: Often used to protect knee surgery, such as meniscal repair (McDermott, I. 2010)

Splints: this type is used in patients with as increase in muscle tone that may require a resting splint to maintain optimal positioning lower limb and also maintain a functional range in affected joints. Important for the patients is to be able to position themselves in seated and supine. (Elattar, O., et al. 2018)

Functional

Ankle- Foot Orthosis (AFO): this orthosis is used to correct alignment of the lower foot and ankle, which closely relates to the alignment of surrounding parts including shin, upper leg and pelvis. The AFO allows the ankle and foot to still participate in swing and stance phase of gait however with some modification. This orthosis can also be used to limit foot drop which reduces the risk of trips and falls. (Quality Improvement Scotland. 2009)

Lateral support ankle brace: this type of orthosis is used in patients after ankle injuries typically to lateral ligaments, or neuromuscular disorders. The stiff lateral supports of this brace prevents excessive pronation or supination at the foot. This helps prevent injuries to secondary fall thus reducing the risk of further injury to lower limb structures. (Gross, M. T., & Liu, H. Y. 2003)

Functional Electrical Stimulation (FES): this special type of dynamic orthosis is for CNS disorder or lesion affected patients (NICE, 2009). It stimulates multiple muscle groups at a time via electrical impulses into peripheral nerves. The orthosis can help with muscle weakness by lessening the impact of knee hyperextension and food drop. Reports say there is also some evidence it helps with general strengthening of muscles. (Glinsky, J et al. 2007) The FES has been shown to improve quality of life at the same time reducing the patient's risk of falls. (Esnouf, J. E., et al. 2010)

Custom Foot Orthotics: Custom orthotics can help correct foot alignment by having an increased input on muscle activity. No matter the level of needs or activities of the patient, they can aid in efficiency of gait and balance. They also reduce fatigue and pain from the feet by minimizing shock absorption through the lower limb, pelvis and spine. These corrective devices vary from rigid, semi-rigid and soft in composition depending on the physical attributes required. They are placed like insoles inside the patients' footwear. (Positano, R.G., Positano, R.C. 2021)

The steps taken for orthosis assessment start with the patient's gait analysis and positioning of foot in static and dynamic situations where asymmetries may occur and are noted. Then a cast is made which usually out of foam which the patient makes an imprint from or the trained professional can sketch and compose a template from skilled experience. This information can then be sent to be fabricated and created in prosthetics or orthotics workshop. Technology in some facilities can analyse a range of properties such as heel strike, push off phase and weight dispersion during the gait cycle in a scanning machine. It is important that the specialist personalizes the orthosis to the patient's needs by assessing their feet and shoes for changes in wear and area of pain that may be associated with it. (Štefanovič, B., et al. 2020)

For flat feet

It is not uncommon for children to have flat foot associated with a wide range of activity-related pain, tiring out quickly, the development of medial foot calluses and the fast destruction of shoes. (Mosca V. S. 2010) A generalized non-specific pain at night can also be common in children with flat feet, along with growing aching legs relate to fatigue and overuse. (Peterson, H. 1986). It was confirmed in a study in the past that in children with flat feet had greater intrinsic muscle activity than in those with arches. (Mann, R., & Inman, V. T. 1964) In regard to orthosis, the soft over the counter and firm custom-moulded shoe inserts have been shown to alleviate or decrease the mentioned flat-footed symptoms. There are not enough studies to prove whether one orthotic is better than another however, it is a step forward for properly utilizing shoes without causing any significantly altering the height of the arch.
(Bordelon, R. L., & Lusskin, R. 1980; Theologis, T. N., et al. 1994)

For flat feet with shortened tendo-Achilles

For any treatment with orthosis in shortened Achilles tendon, it is important to find the right diagnosis of the condition. This is because orthoses could possibly worsen the symptoms. In flat feet with shortened Achilles tendon and contracture, the talus inhibits the ankle from dorsiflexion. Introducing an orthosis would cause an unwanted increase pressure from under the talus causing more pain than without the orthosis. The shortened Achilles tendon therefore does not require an orthosis because it does not assist or help but in fact exacerbate the symptoms already present in the condition. (Mosca V. S. 2010)

After Achilles lengthening surgery

For all the tendons to heal after Achilles tendon lengthening surgery it is necessary to hold the foot in place in a natural position. For the tendon to heal to the new position it takes at least 3 months or 6 weeks. Just after the surgery in theatre, a short leg walking case is applied. This allows the patient to walk on their foot with full weight. It is important to keep the cast dry and prevent from getting wet otherwise skin infection or sores may appear. Heavy plastic cast covers are recommended for patient to be able to shower. Approximately two weeks after surgery, the cast is removed, the bandages are changed and the healing of the incisions is checked. A new short leg walking cast is applied. (Penn Neuro-Orthopaedics Service. 2020)

After six weeks from the surgery the foot may be held in a short-leg brace. For another six weeks this brace can hold the foot in neutral position. It is common to use a short plastic brace which fits inside of the shoe. For the brace to fit comfortably, it is necessary to have a shoe that is

at least one size larger than the patient's normal shoe size. This brace is worn continuously, even while sleeping, for another six weeks to allow further healing and strengthening of the tendons. It is not uncommon for the foot to swell after surgery and frequent elevation of the foot can treat the swelling which is usually temporary. When wearing the brace, an elastic support stocking is also very useful. It is possible to start walking without the brace three months after surgery. In this case for the muscles to strengthen, the brace must be discontinued slowly. Walking and exercising the foot and general strengthening is important for regaining muscle strength.
(Penn Neuro-Orthopaedics Service. 2020)

In the discontinuation of the brace, the patient first takes the brace of for 10 minutes for three to four times during the day. Most patients can then walk safely and comfortably without a brace. Only a minority of patients may still need a brace that's usually lightweight that's made from flexible plastic to improve stability around the joint with improved balance and confidence when walking. (Penn Neuro-Orthopaedics Service. 2020)

2.5.3 Spa Therapy – Balneology

The case study in the case study visited Janské Lázně Spa previously two times in past rehabilitation for complete comprehensive care of the patient's complex condition. The following describes the general conditions and effects from balneology that the patient had been prescribed. The effect of balneology is applied by conditions from the climate and solar radiation. The benefits of the therapy are seen in primary and secondary preventative diseases. It is also used to treat both acute and chronic illnesses but also congenital defects. The medicinal properties are divided by their natural characteristics which include waters, peloids and gases. The following text will describe the use of water in spa therapy, hydrotherapy. (Kolář, P., et al. 2013)

Thermal baths

The defined temperature of the thermal waters are marked at equal or more than 25 °C. Lukewarm waters are between 20 – 25°C, warm waters are 25 – 35°C and hot waters are above 42°C. The most used and suitable temperatures in baths for movement therapy are isothermal (same as skin temperature 34 – 34 °C) and hyperthermal. (Kolář, P., et al. 2013)

Whirlpool bath

A tub of streaming water propelled by a pump which can become a sparkling bubble bath where carbon dioxide is used to saturate the water. The main effect of this hypothermal water is vasodilative. Other additives can be used in baths that have pharmacological effects or may simply release a characteristic smell – aromatherapy. (Kolář, P., et al. 2013)

Climatotherapy

There is always some form of climate provided in every spa treatment. It is important that the climate conditions provide a balance between preservation and irritation factors. A combination of modalities make up the balance which include "pressure, temperature, humidity, air flow, sun irradiation, increased concentration of air anions, radioactivity, air cleanliness and other factors". (Kolář, P., et al. 2013) Movement therapy may be used in conjunction with the therapy.

2.5.4 Physical Therapy

Physical therapy is quite a common treatment for affection of the Achilles or any other tendon. It is possible to use the treatment to decrease mainly the pain and eventually return to daily activities. It is necessary that patients participate in strengthening and allow healing of the tendon other than physical therapy-based treatments. Also stretching and flexibility exercises must remain key to helping the tendon heal without any increase in harm or risk and causing long-term pain. (Blahd, W. 2020)

Physical therapy can be the treatment of a condition by many different forms such as by physical or mechanical means such as through exercise or heat. (Blahd, W. 2020)

There is a wide base of therapies that are can be applied to tendon healing including ultrasound heat therapy. The therapy is a good choice as it improves blood circulation, which may aid the healing process such as the scar and surrounding soft tissue structures. Deep massage is a good way in increasing flexibility and blood circulation of the tissues by relaxing the muscles in the lower leg. (Blahd, W. 2020)

The following biolamp treatment was selected for my case-study during past rehabilitation for stimulating soft tissue and scar healing after the Achilles tendon prolongation procedure.

The Bio Lamp

The bio lamp such as the Swiss-made bioptron lamp is a "Class 2a" therapeutic medical heat device that can contain a range of minerals that are infused into a ceramic heating element. The infra-red heat and electromagnetic energy is applied to the area and raises the temperature in the body's tissues. (HCAHealthcare UK, 2022) Some of the mechanisms of effect are:

- Boost the micro-circulation through the small blood vessels and capillary vessels.
- Improves blood circulation and helps to remove toxins from the cells.
- Rejuvenate cells, bringing more oxygen and nutrients to these cells.
- Decreased joint stiffness and pain
- Has anti-inflammatory effect up to a depth of 3 cm.
- Increased extensibility of collagen connective tissue.
- Polarized light helps heal:

  Psoriasis, scars, acne, skin defects, cold sores, skin wounds and diseases

(Tereziny lázně Dubí 2022)

2.5.5. Soft Tissue Techniques

Soft tissue techniques play an important role in physical scar management and can be easily overlooked by the therapist and patient. Among other physical therapies for scar include mechanotherapy, occlusive and hydrogenatic therapies and light therapy This is important because scars can negatively impact the quality of life of patients. Symptoms from scars cam be tenderness, itchiness and pain or may even limit the tissue function via contractures. Finally, the look of the scar (aesthetics) can negatively affect the patient psychosocially. The purpose of soft tissue techniques and other scar physical therapies are is that it concentrates primarily on the prevention of an aberrant healing process of the skin. (Paratz, J. D., Stockton, K., Plaza, A., Muller, M., & Boots, R. J. 2012) In a study analysis, physical scar management in adults resulted in control of pain, pigmentation, pliability, pruritus, scar area and thickness. (Deflorin, D., Hohenauer, E., Stoop, R., Van Daele, U., Clijsen, R., Taeymans, J. 2020)

2.5.5 PNF Therapy

PNF Therapy a.k.a. Kabat therapy was founded by Dr. Herman Kabat who integrated Sister Kenny's technique using the Sherrington's principle of successive induction, reciprocal innervation and inhibition and the phenomenon irradiation. Margaret Knott and Dorothy Voss later developed the technique and Ljuba Briskner popularized it in practice. (Sandel, M.E. 2013) The neurophysiologic mechanisms consist of reciprocal inhibition and facilitation, coactivation and balance of tone. The technique features patterns that include diagonal, spiral character that cross over the midline of the body in normal timing from disto-proximal directions and relate to normal everyday ADL. The facilitation mechanism is brought out by commands and communication, with stretch, with maximum resistance, traction and approximation, and visual control. (Prentice, W. E. 2001).

As with Vojta therapy there currently isn't much research in PNF treatment specifically in biparetic paediatric patients however there is plenty in patients with CP and hemiparesis, their positive outcomes to the therapies are discussed further in chapter 2.6 Therapeutic Approach Effects regarding Evidence-Based Medicine. In one study it was found that there was an increase in muscle activity of the rectus femoris, vastus medialis, tibialis anterior, lateral hamstring, and lateral gastrocnemius from the effectivity of the PNF patterns. (Jeong, W.S., Park, S.K., Park, J.H., et al. 2012)

For children with CP, there showed improvement in the lower extremity function when exposed to both PNF and task-oriented therapy. This study focused on improving coordination through using PNF interventions. It was also possible to make the ADL for the children easier. When comparing before and after treatment, there was significant improvement is seen in Berg balance score. Children starting at an earlier age are more plastic due to their development and can therefore take on motor learning and control very quickly. (Kumar, S. Kumar, A. Kaur, J. 2012)

2.5.6 Vojta Therapy

Vojta Therapy was developed in the mid-20th century by neurologist prof. Václav Vojta for treatment of children particular with developmental delays. The treatment method is based on developmental kinesiology and principles of reflex locomotion stimulation applied to specific zones. There are 10 different zones that stimulate reflex motion patterns. The stimulus causes involuntary motor response and performance of certain movement patterns. The method is divided into 2 main phases: reflex creeping and reflex rolling; and reflex locomotion from three main positions including prone, supine and side-lying. The method treats patients with musculoskeletal and central nervous system disorders especially for treatment in children with cerebral palsy. (Internationale Vojta Gesellschaft e.V. 2020)

There is no substantial research for treatment of Vojta therapy specifically in biparetic paediatric patients however there is plenty research of the therapy applied to hemiparetic patients. The benefits of treatment of these patients include addressing the brain plasticity and ability of stereognosis and deep sensation. Further it evokes the global pattern of movement (coordination complexes) to influence complex motor movement such as gait, reaching, grasping and other activities of daily living. (Internationale Vojta Gesellschaft e.V. 2020)

In children, the posture of the body or the normal function of the programs of postural ontogenesis are proportionally dependent on the trophic status and development of the extremities. This statement is seen with conditions of diparesis or hemiparesis where the extremities become hypoplastic from paresis. (Krucký, V. 2016) This topic is further discussed in chapter 2.6 Therapeutic Approach Effects regarding Evidence-Based Medicine where the therapy's positive outcomes are discussed in these patients.

Disproportions in the child tend to normalize in the body with Vojta therapy that is trained with Vojta method on a regular daily basis up to 4 times a day. In regard to diparesis of a developmentally delayed child, the ratio of the length of the lower extremities compared to the length of the body improves in favour for the lower extremities during exercise thus bettering the prognosis of the child. There are also known to be stimulatory, formative and growth influences. This is built by using the centre of gravity of the body to shift and influence change of load on the extremities during reflex locomotion.
(Krucký, V. 2016)

2.5.7 Sensoromotoric stimulation

The method of sensoromotoric stimulation was founded by the Freeman's concept in 1965 but later developed by professor Vladimír Janda and Maria Vávrová (Janda, Vávrová 1992). The aim of the method is to attempt performed movement from automatic reflex muscle activation, so no there is no higher form of control other than the subcortical control. The foot is facilitated to participate in the "short foot" exercise which uses the muscles of the foot such as the m. quadratus plantae to be active. During exercises to shape the foot arch, the longitudinal and transverse axes shorten which results in the changing of position and pressure distribution placed on the joints. This in turn brings about the neurophysiological effect of activating the proprioceptors of the foot (Kolář 2009). This procedure, however, is not the only way to eliminate muscle imbalance by attaining automated muscle activity. The basic human movement patterns such as standing and walking can also be influenced by sensoromotoric stimulation. Further the method can facilitate receptors in the skin, such as in the neck and also foot. (Pavlů 2003). The technique requires to perform a set of balancing exercises in various postural positions. The process starts from distal to proximal parts of the body. It is possible to involve numerous aid such as wobble boards, Bosu, mini trampoline etc. to increase the level of difficulty and effect of sensorimotor stimulation. (Kolář, P., et al. 2013).

2.5.8 Pharmacological therapy - Botulinum Toxin A (BTX-A)

Anti-spastic pharmacological treatment is categorized into systematic and focal treatments. Baclofen and diazepam (used only for short duration) are included in systemic anti-spasticity drugs. These drugs affect several muscular groups and can be effective in diffuse spasticity. They are however known to have various intolerable systemic side effects including dizziness, sedation, confusion, nausea, and vomiting, fatigue, lower seizure threshold, and central nervous system depression. Botulinum toxin is included in focal treatments. The advantage of BTX is that it affects and treats the symptomatic muscles directly.
(Rosenbaum et al., 2002; Majnemer and Mazer, 2004)

Botulin toxin is important in orthopaedics for spastic and dystonic muscle treatment. However, to use BTX as a successful adjunctive, splinting or casting and/or physiotherapy is needed. (Ramachandran and Eastwood, 2006). There is a recorded beneficial effect of BTX where reduction of pain associated with focal muscular hyperactivity (Wissel et al., 2000). In spasticity, extreme vasculature compression is induced by the spasmodic muscle contraction due to simultaneous activation of adjacent motor units. This gives rise to ischemia that causes the nociceptive pain (ischemic muscular pain). The pain is able to subside when the spasm ends and the blood flow returns back to normal. As a result, by inducing muscle relaxation, botulin toxin can reduce pain. (Restivo et al., 2003).

There are studies that have shown the improvements in gait and deformity from short term effects of botulin toxin A in the management of spasticity in lower limbs muscles. Typical treatment of spastic diplegic or hemiplegic children is the injection into the gastrocsoleus which relate to the dynamicity and complexity in gait patterns and also deformities in the foot. (Pavone, V. 2016)

It is widely known that BTX is a powerful neurotoxin that's made its way to be a vital treatment in spastic conditions such as CP. The treatment can be used in children as early as 2 years and can be combined with other types of treatment as the child grows and develops to form spastic sequalae such as contractures and/or deformities. As stated, the indication for treatment is for children with hemi or diplegia in some cases as is the case-study, the level of treatment broadens as the child develops their gait pattern such as is with monitoring treatment after surgery. (Pavone, V. 2016)

2.6 Therapeutic Approach Effects related to Evidence-Based Medicine

The therapeutic approaches I have chosen for recent discussion of therapeutic effects from an evidence-based medicine approach are Vojta method, PNF therapy and sensoromotoric stimulation in children affected by spastic disorders mainly covering cerebral palsy.

2.6.1 Vojta Therapy

There is broad on-going research for proving Vojta therapy in its effectivity qualitatively and quantitatively using various assessment methods i.e., using functional assessments such as the GMFCS system and gait analysis to even state-of-the-art medical imaging. There is available research in both adults and more scarcely in children. I have narrowed my search focusing mainly on children with cerebral palsy and recent imaging-based research.

A study in 2012 found there to be effects of overall gross motor function improvement in in a 12-year-old quadriplegic child with cerebral palsy. The therapy was for 45 mins a day, 5 days a week for 14 weeks and then another 6 weeks. The included Vojta techniques were reflexive rolling and reflexive crawling. The gross motor function, gross motor function classification system and manual ability classification system were measured. Although the patient's GMFCS consistently classified as III throughout the therapy, there were some notable specific motor function improvements. It's shown here that for cerebral palsy patients, even in older children, dynamic locomotor and gross motor development effects can be achieved. (Gajewska, E. & Neukirch, B. 2012)

In 2013 there was a study of Vojta method with effects in walking parameters in 3 children with spastic diplegia, one child of 6 years with GMFCS II, second of 8 years with GMFCS II and third of 12 years with GMFCS I. The subjects could walk independently however difference between the children with GMFCS I and II is that the latter (GMFCS II) can climb the stairs without handrail. The therapy was provided for 30 mins per day, 3 days a week divided into two sets of 8 weeks. The Vojta techniques included reflex creeping, use of 3 – point supporting, 1st position and varied reflex creeping. Measurements in spatiotemporal gait parameters included cadence, walking speed, stride length and single limb support. It was found that cadence increased during the first period (first 8 weeks), walking speed increased compared to baseline and there were changes in sagittal ROM of the joints. Notably the ROM of hip and knee increased while it decreased in the ankle joint. The importance of this study shows that not only can the therapy effect the gross motor development but also improve the individual spatiotemporal parameters in gait.

Regarding Vojta method and its significance in medical imaging, in 2018 there was a study on brain mapping specific to input of Vojta method and the role of the putamen (portion of the brain). In this research there were 2 groups of 16 healthy adult participants, one group receiving specific tactile input stimuli and the other group received stimulation not related to Vojta application. Functional MRI was used to map the brain in vivo while the stimulations were being applied. There was a greater activation in the right cortical areas (temporal and frontal lobes), subcortical resions (thalamus, brainstem and basal nuclei and in the cerebellum. The finding of this study gave preliminary indications for investigating Vojta method further in clinical neurological cases using fMRI in connecting objective evidence with functional improvements of the patient. (Sanz-Esteban, I., Calvo-Lobo, C., Ríos-Lago, M., Álvarez-Linera, J., Muñoz-García, D., & Rodríguez-Sanz, D. 2018)

A case study using the principle of fMRI was used to investigate the effect of Vojta method in a child with developmental delay and hypotonia. The subject was born in 2016 and was after in utero cytomegalovirus infection. The child could roll over and control the head however there were confirmed neuronal damaged. The treatment was from 11 months of age including 40-minute sessions, 3 times a week for 8 months. The techniques included reflex turning, reflex creeping and stretching was performed for 5 minutes prior application. The imaging was produced through diffusion tensor imaging that measured fractional anisotropy, mean diffusion and tract volume of the corticospinal tract. The results of the imaging showed visible change in the neuronal pathways. The change in these neuronal pathways confirm that the objective findings in the brain directly correlates with the gross motor function improvements from the effects of Vojta method approach. (Ha, S-Y., Sung, Y-H. 2021)

2.6.2 PNF Therapy

It's noted earlier in the text how PNF (see 2.5.5. PNF therapy) is closely benefited in its effectivity by linking with task-oriented exercise training. This section will discuss the PNF and task-oriented effects on improving mainly the lower extremities and other functions such as mobility and quality of life in cerebral palsy children.

In 2016 there was a randomized clinical trial on the comparison between task-oriented training and PNF therapy and its effect on lower extremity function in cerebral palsy children. The subjects consisted of 30 patients divided into two groups, one with task-oriented training and the other with PNF. The Paediatric Balance score, gait parameters (gait velocity, stride length and the cadence) were measured from before and after treatment. There was a significant difference in both groups in particular stride length and cadence as well as gait velocity and paediatric balance scale. This shows the importance of the task-oriented therapy compared to PNF therapy in CP children showing significant improvement in function of the lower extremity (Kumar, C., Ostwat, P. 2016)

In 2021 the effect of task-oriented training was also assessed on the mobility function in children with cerebral palsy. The subjects included 10 children divided into two groups, one experimental and other control. The children's GMFCS levels ranged from I-III. The gross motor function measure, time up and go test were assessed. One group received task-oriented training and the other PNF. The therapy was 5 weeks long and there were improvements in the gross function measure and time up and go test in the experimental group. The results of the effects add to the relevance of task-oriented training linked to the importance of positive functional outcome of mobility in CP children. (Badaru, U.M, Ogwumike, O.O., & Adeniyi, A. F. 2021)

Lastly a case study the same year (2021) assessed task-oriented training and the effects on quality of life in cerebral palsy children. There were 39 children in the study divided into two groups, task-oriented therapy and conventional physiotherapy. It showed that task-oriented training was more effective than conventional therapy in improving quality of life in CP children. This consequently confirms altogether the positive outcomes of task-oriented therapy in relation to PNF therapy mentioned in all 3 forementioned studies. (Badaru, U.M, Ogwumike, O.O., & Adeniyi, A. F. 2021)

2.6.3 Sensoromotoric Therapy

Sensoromotorics described earlier in the paper is used to treat patients by improving performed movement through automatic reflex muscle activation through the neurophysiological activation of proprioceptors via somatosensory inputs such as interoception and exteroreception. First, the next section will discuss the somatosensory deficits of the lower extremities in its critical importance in balance and motor function in spastic children. Research has shown that sensoromotorics has been beneficial in preventing falls in cerebral palsy children and even providing more stimulation using game-based activities.

First, before discussing the effect of sensoromotoric therapy it is important to emphasize the significance in assessment of somatosensory deficits on the balance and motor function in the lower extremity in children with cerebral palsy. In a case study in 2020 there were a subject of 10 children that were able to walk and stand without assistive devices with the GMFCS scale between I-III. Three categories were evaluated; for somatosensory: light touch, two-point discriminatory ability of plantar side of foot, vibration sensation and error in joint position of ankle; for balance: balance evaluation system test and postural sway; motor performance: gross motor function measure, spatiotemporal gait characteristic, timed up and go and 6-minute walk, isokinetic dynameter to test volitional isometric contraction of plantar flexors. Associations of the assessments were linked together such as light touch pressure measure was strongly linked to 6-minute walk test and vibration and two-point discrimination were strongly linked to balance performance. The significance of making a thorough assessment of the lower extremity is important in understanding these linked sensory and motor evaluations in performance of balance. It is crucial to use this information to provide reliable motor and sensory aspects of sensoromotoic therapy. (Zarkou, A., Lee, S.C.K., Prosser, L.A., Jeka, J.J. 2020)

In 2012 a case study showed the effects of balance training on postural balance control and risk of fall in children with diplegic cerebral palsy. There was a total of 30 spastic diplegic children between 10 – 12 years. One control group received traditional physical therapy exercise program and one study group received balance training on Biodex balance system. The groups received 30 mins per day, 3 days a week for 3 months. Areas that were assessed were limit of stability and fall risk. The results showed substantially better improvement in the measured parameter for the study group than compared to the control group. The use of balance control in sensoromotorics is an important tool in improving postural balance control in the diplegic cerebral palsy children. (El-Shamy, S.M. & El Kafy, E. M.A. 2014)

Lastly, in 2021 research included a specific type of lower limb sensorimotor training (LoSenseT) for children with CP. There was a total of 20 participants ages 5 to 20 years with GMFCS level between I-III. The therapy lasted 60 min each day including 30 minutes of tactile activities and 30 minutes of proprioceptive activities. The therapies were special in that they were designed in a game format. The tactile activities consisted of a guessing game using a sensory tack and the proprioceptive activities provided an imitation game through execution of yoga postures. This contemporary approach of sensorotomotoric stimulation in CP children provides visual involvement and evokes challenging abilities by promoting strategical planning in game activity environment rather than solely increasing sensory input.
(Santana, C., Tudella, E., Rocha, N., & de Campos, A. C. 2021)

3 SPECIAL PART

3.1 Methodology

The clinical work placement for my bachelor thesis took place at MediCentrum a.s. in Prague in the outpatient Rehabilitation department. The duration of the work was 3 weeks from 12.1. to 2.2. There is a week break between 17.1. to 21.1. where the patient was on holiday. My placement was led under professional supervision of Bc. Vojtěch Oplt.

The goal of the of the work is to provide a detailed protocol based on the patient's medical records from before and after the therapy. This protocol includes individual reports of each session including assessment, procedure and the effects of the therapy. The result therapy effects are concluded from the assessment in the initial and final kinesiological examinations.

The patient, male, is 11 years old who is 3 months after bilateral Achilles tendon prolongation. Prior to the procedure the patient is after unsuccessful conservative treatment for toe walking because of spastic biparesis of neuroinfectious aetiology. I had the opportunity to work with the patient for 6 sessions in the duration of 30 minutes over the course of 3 weeks with 1 week break. The reason for 6 sessions is because it was the maximum the patient and parent could provide of their time. Instead of planning to come for once a week, the patient and parent agreed to come in twice a week to the outpatient clinic with consideration of providing extra of their time for my case study work.

I performed all therapeutic techniques for the patient except for Vojta reflex method that was performed by my supervisor. Before the therapy I made a quick examination to make an assessment for use on precise therapeutic technique. The aim of my approach was to meet the current goals of the patient by making the therapy engaging and challenging enough to effectively improve the patient's rehabilitation prognosis.

The individual therapeutical sessions took place in the outpatient physiotherapy treatment room. The equipment available in the room is Vojta therapy table. The techniques used are sensoromotorics, soft tissue techniques, stretching, strengthening, PNF, and Vojta method. The devices used for the strengthening exercises were blocks, soft pads, Bosu, wobble board, wooden pole, barbell (5 kg) and wall ladder. The tools used for kinesiological examination were measuring tape, plastic goniometer and neurological hammer.

The patient and their parental guardian were informed about my student position and the of collecting information from the patient's medical records for my bachelor thesis case study research. The patient and parental guardian agree to the study and willingly cooperated to my case study procedures. The informed consent was signed on the $14^{th\ of}$ January 2022 by the patient and their parental guardian. A version of the informed consent is attached in appendix 6.6. The original copy of the Ethics Committee Approval was received in favourable opinion and is attached on the final page of the thesis.

3.2 Anamnesis

Examined person: L. B, Male　　　　　　Year: 2009

Diagnosis: M67 – planned operation of Bilateral Achilles tendon prolongation due to no longer reacting to conservative therapy for toe walking after contracture of tendons after Spastic Biparesis from Meningeal Neuroinfection subsequently to respiratory infection

Status praesens:

Objective: Patient doesn't have any problems in communication, is fully oriented in place and time. Doesn't use assistive devices. Dominant limb is right. Body type- endomorph.

Height – 147 cm

Weight – 40 kg

BMI – 18.5, 61st percentile

Subjective: patient is 3 months after operation of prolongation of both Achilles tendons at the department of Orthopaedics at Motol University Hospital at the beginning of October. After the procedure the patient was provided with 6 weeks fixation by AFO and in November spent 1 month at Spa in Janské Lázně for Spastic Diparesis and Achilles Tendon prolongation.

Family anamnesis:

Father: works as technical manager, healthy

Mother: works as teacher, healthy

Brother: 3 years older, healthy

No signs of spreading neuro-infection in the family

Personal anamnesis:

Neonatal anamnesis: Physiological course of pregnancy and birth, birth weight/length: 3830g/51cm, as neonate 1 day on ICU due to aspiration of amniotic fluid, without jaundice, hips within norm

Nutrition: breast fed till 8 months, tolerated weaning, gained weight

Vaccinations: full record, underwent chicken pox in 2014

Psychomotoric development: motor development within norms, first frontal walking 11.5 months, first words at 9 months

Injuries Anamnesis: tibial fracture at 3.5 years

Hospitalizations:

December 2014 Podiatry – long steps, left and right back of foot leans into supination, right and left ankle valgosity.

Fig. 9 – Plantogram of patient

November 2015 hospitalized at Thomayerova Nemocnice for 6 days with 40 °C fever, couldn't stand up, muscle pains, confirmed Meningeal Syndrome, negative lumbar puncture, sent home from hospital on 7th day, migraines started, problems with disbalance. Could not ride bicycle – would fall. Started to walk on toes. Started rehabilitation 2 – 3 months after, but didn't improve – could not step on whole foot.

February 2016 Neurology check-up for Migraines

December 2019 CT scan of spine and MRI of brain and brainstem – physiological findings

February 2020 Molecular Genetic Testing for genes related to Hereditary Spastic Paraparesis– negative findings

August 2020 rehabilitation at Spa in Janské Lázně for 1 month dysbalance and toe walking

March 2021 in Motol Orthopaedic outpatients – prescribed 1x week physiotherapy, 3x week autotherapy

October 2021 operation of prolongation of Achilles tendon

November 2021 rehabilitation at Spa in Janské Lázně for 1 month for Spastic Diparesis and Achilles Tendon prolongation

Allergies: intolerant to poppy seeds

Medication Anamnesis: none

Social Anamnesis: attends 6th grade at primary school, favourite subject is mathematics

Functional Anamnesis:

Lives alternatively every other week at mother's and father's flat. Mother's flat has a lift and father's flat does not and is situated on the 3rd floor. Enjoys playing ball games twice a week at school and is learning to play the guitar. Rides the bicycle and likes to ski.

GMFCS: 1

Locomotor stage (according to Vojta): 8

Prior rehabilitation:

August 2020 rehabilitation at Spa in Janské Lázně for 1 month dysbalance and toe walking
November 2021 rehabilitation at Spa in Janské Lázně for 1 month Spastic Diparesis and Achilles Tendon prolongation

Rehabilitation Indications:

Continue follow-up outpatient rehabilitation at Medicentrum after procedure, exercises for maintaining muscle strength and balance of the lower extremities (preventing laxity in the knees and improving base of support). Also, therapy for soft tissue (scar therapy) and stretching of the Achilles tendon with mobilizations of joints in the foot.

3.3. Initial Kinesiological Examination

3.3.1. Aspection of posture

There is no apparent anomalies in the head, upper extremities, shoulders, however there is slight lordosis in curvatures of spine – otherwise within correct alignment in all aspects. The lower extremities show valgosity in the ankles, especially the left ankle – causing substantial flat foot – there is loading to the medial side of the foot and flattening of the transverse arch with abduction of toes. The knees tend to go into recurvatum especially the right.

3.3.2 Palpation of pelvis

a. frontal plane: Right ASIS shows slight elevation compared to left side. Iliac crests on both side show no deviations or asymmetry.

b. sagittal plane: slight anterior pelvic tilt. The angle between floor and axis going through SIAS and PSIS is greater on the left side on the right side which has a smaller angle.

c. transversal plane: no visible rotation of the pelvis

3.3.3. Base of support

Left: a moderate-severe flat longitudinal arch compared to the right foot. Suggests foot showing weight being applied more on the medial side of the foot due to valgosity in the ankle; increasing support in toes (toes are in abduction and flexion) and therefore also flat transverse arch of the foot. Valgosity in 2nd toe. Proportionate length in foot.

Right: proportionate length, slight-moderate flattened arch and angles of foot.

3.3.4 Specific testing of posture

a) Romberg test:

I: Negative II: Negative III: Negative

b) Single-leg stance test:

i. Left – good stability and posture – open eyes, closed eyes – activity of anterior tibialis

ii. Right – good stability and posture – open eyes, closed eyes – activity of anterior tibialis and grabbing floor

c) Vele's test: grade 1

d) Trendelenburg – Right hip turning into internal rotation – weakened external rotators

Test with paper, does not fit well under toes

3.3.5. Modification of standing

a) Tiptoes standing, S1 triceps surae: can't go completely onto toes, restriction in ankle

b) Heels standing, L5 peronei: difficulty in achieving position on heels, lack of balance

c) Squat, L4 quadriceps femoris: can't make a deep squat without losing balance and due to restriction in ankle

3.3.6. Anthropometric measurement

Lower Extremity

	Left	Right
Length		
Anatomical Length	68cm	68cm
Functional Length – SIAS	77cm	78cm
Functional Length – umbilicus	82 cm	83 cm
Thigh	33 cm	32 cm
Middle Leg	32 cm	34 cm
Foot	21 cm	21 cm
Circumferences		
Thigh 10 cm	32 cm	32cm
Thigh 15 cm	37 cm	37cm
Knee	31 cm	31 cm
Tuberositas Tibiae	28 cm	29 cm
Calf	29 cm	29 cm
Ankle	23 cm	24 cm
Heel	29 cm	29 cm
Foot	21 cm	21 cm

Table 3 – Anthropometric measurement. Initial KE.

3.3.7. Muscle Length Test (according to Janda)

Lower Extremity

		Left	Right
Gastrocnemius		0	0
Soleus		0	0
Hip Flexors	One joint	0	0
	Two joint	0	0
Adductors	One joint	0	0
	Two joint	0	0
Hamstrings		1	1

Table 4 – Muscle Length Test (according to Janda). Initial KE.

3.3.8. Hypermobility Test (according to Janda and Sachse)

Lower Extremity

	Left	Right
Extension Knee Joint (Sachse)	A 0°	B 0 – 10°
Flexion Knee Joint (Janda)	Hypermobile	

Table 5 – Hypermobility Test (according to Janda and Sachse). Initial KE.

3.3.9 Measurement of ROM (goniometry, SFTR method, in), according to Janda

Lower Extremity

	Left	Right
Hip		
Extension/Flexion	Sa: 10/30 – 0 – 120/135 Sp: 10/30 – 0 – 120/135	Sa: 10/30 – 0 – 120/135 Sp: 10/30 – 0 – 120/135
External/ Internal Rotation	$T_{F90°}$: 30/45 – 0 – 30/45	$T_{F90°}$: 30/45 – 0 – 30/45
Abduction/Adduction	Fa: 30/50 – 0 – 10/30 Fp: 30/50 – 0 – 10/30	Fa: 30/50 – 0 – 10/30 Fp: 30/50 – 0 – 10/30
Knee		
Extension/ Flexion	Sa: 0/10 – 0 – 125/160 Sp: 0/10 – 0 – 125/160	Sa: 0/10 – 0 – 125/160 Sp: 0/10 – 0 – 125/160
Ankle		
Dorsal/Plantar Flexion	Sa: 10/30 – 0 – 45/50 Sp: 10/30 – 0 – 45/50	Sa: 10/30 – 0 – 45/50 Sp: 10/30 – 0 – 45/50
Eversion/Inversion	Ra: 15/30 – 0 – 35//50 Rp: 15/30 – 0 – 35//50	Ra: 15/30 – 0 – 35/50 Rp: 15/30 – 0 – 35/50
MTP I		
Abduction/Adduction	Ta: 15/25 – 0 – 15/25 Tp: 15/25 – 0 – 15/25	Ta: 15/25 – 0 – 15/25 Tp: 15/25 – 0 – 15/25
IP I		
Extension/Flexion	Sa: 0/50 – 0 – 70/90 Sp: 0/50 – 0 – 70/90	Sa: 0/50 – 0 – 70/90 Sp: 0/50 – 0 – 70/90

Table 6 – Measurement of ROM (goniometry, SFTR method, in), according to Janda. Initial KE.

3.3.10 Muscles Strength Testing (according to Janda)

Lower Extremity

	Left	Right
Gluteus Maximus	4+	4+
Iliopsoas	5	5
Sartorius	4-	4-
Tensor Fasciae Lata	4	4
Quadriceps Femoris	4	3+
Hip Adductors	4	4
Hip Flexors	4	4
Gluteus Medius	4 -	3+
Lateral Rotators of Hip	3+	4
Medial Rotators of Hip	4 -	4 -
Lateral Hamstrings	4	4
Medial Hamstrings	4 -	4-
Ankle Plantar Flexors	3+	3+
Soleus	3-	3-
Peroneus longus, brevis	4	3
Tibialis Posterior	3	4
Tibialis Anterior	3	4
Extensor Hallucis lg +br	4	4-
Flexor Hallucis br.	5	5
Extensor digitorum lg +br	4+	4+
Peroneus Tertius	4	4-
Flexor Hallucis Brevis	4+	4+
Flexors Hallucis Longus	5	5
Dorsal Interossei	5	5
Plantar Interossei	5	5
Flexor Digitorum Brevis	5	5
Abductor Hallucis	4	3+
Adductor Hallucis	4+	4+

Table 7 – Muscles Strength Testing (according to Janda). Initial KE.

3.3.11 Gait Analysis

Back View

Width of the base of support	Evenly spaced in each step with width slightly narrower than hips
Position of the feet (angle)	Tendency of right foot to have moderately wider angle (toes are pointing out more laterally).
Walking rhythm (periodic, non-periodic)	Periodic
Walking speed	Careful steps
Stride length (short steps/long steps)	Long strides
Movement of the foot (heel strike, flat foot, loading response, heel-off, toe-off)	Calf muscles are activated at every heel strike on either leg in succession. The entire foot does not meet flat foot phase because of tendency to reduce heel strike due to restriction of ankles in dorsiflexion. CoG shifted behind feet, especially that of the left foot due relief of load on operated ankles and limit in extension – swinging or propelling of leg forward than using extensors.
Axial position of the lower limb (flatfoot, knock knee, coxvalga/vara)	Normal positioning of cox. Thighs turn a little into internal rotation. Knees are in axis. Ankles are valgus, especially left. Flat feet, especially on left.
Movement and position of the knee and hip (extension)	Knee can flex without issue, however, are propelled forward with underuse of hamstrings (limited extension), heel is not able securely lock due to impact force on the whole foot at once and unlocks early propelling the foot back and forward instead of controlled manner.
Position and movements of pelvis (compensatory anteversion, rotation, lateral tilt max 4cm)	Pelvic shift to right and lateral tilt left side. Shoulder and spine upright and pelvis a little in anteversion to compensate for weaker hip flexors.
Movement of centre of gravity (COG – max 4.5cm)	Left and right shift in CoG from internally rotating hips which in turn gives a waddling effect.
Activity of abdomen muscles	-
Position and movement of the trunk (latero-flexion, rotation, max Th7)	Slight marked angle of latero-flexion on the left (according to anatomical point of view) side
Activity of back muscles	Active paravertebral muscles on both sides
Position of shoulders (upper part of the trunk)	Symmetrically neutral, scapulas are only slightly protracted.
Position and movements of the head	Head is upright but tilted forward to watch steps, kept still and not moving in any direction.
Movements of the upper extremity (synchronicity, synkinesia, max 45 degrees)	More movement in the right arm, no swing movement in left arm. Arms both flexed at around 30 degrees. Minimal counter rotation of thorax.
Stability of walking	Slight wobble with every right step as the foot lands on flat foot and stiffness in the valgus ankle as a result the pelvis shifts to the right.

Table 8 – Gait Analysis. Back View. Initial KE.

Side View

Width of the base of support	Evenly spaced in each step with width narrower than hips
Position of the feet (angle)	-
Walking rhythm (periodic, non-periodic)	Periodic
Walking speed	Careful steps
Stride length (short steps/long steps)	Takes Long strides
Movement of the foot (heel strike, flat foot, loading response, heel-off, toe-off)	Greater impact force into heel of foot; especially right foot. Floppy forefoot, as foot falls with restricted ankle in uncontrolled plantar flexion of foot. As toe peels off at end off heel rise phase, foot swerves more laterally than that of the left foot.
Axial position of the lower limb (flatfoot, knock knee, coxvalga/vara)	Poor axial position of ankles, structurally in valgosity especially the left with flat foot – pes planovalgus. The positioning of the knee has the tendency to go into genu excurvatum especially right. Normal positioning of cox.
Movement and position of the knee and hip (extension)	Same as above
Position and movements of pelvis (compensatory anteversion, rotation, lateral tilt max 4cm)	Pelvis is visibly tilted to the left on ambulation noted in the swinging phase of both right and left leg.
Movement of centre of gravity (COG – max 4.5cm)	Centre of gravity is shifted behind the feet due posture of pelvis in slight anterior tilt.
Activity of abdomen muscles	Activation of abdominal muscles is not optimal, the rectus abdominis is slightly weak due to greater activation of lower back extensors.
Position and movement of the trunk (latero-flexion, rotation, max Th7)	Trunk is slightly tilted backward behind the centre of gravity.
Activity of back muscles	-
Position of shoulders (upper part of the trunk)	Shoulder are slightly protracted forward. Minimal counter rotation to trunk and mainly pelvis – more shifting than rotation.
Position and movements of the head	Same as above.
Movements of the upper extremity (synchronicity, synkinesia, max 45 degrees)	Same as above.
Stability of walking	Same as above.

Table 9 – Gait Analysis. Side View. Initial KE.

Front View

Width of the base of support	Evenly spaced in each step with width same as hips
Position of the feet (angle)	Tendency of left foot to have moderately wider angle (toes are pointing out more laterally)
Walking rhythm (periodic, non-periodic)	Periodic
Walking speed	Careful steps
Stride length (short steps/long steps)	Long steps
Movement of the foot (heel strike, flat foot, loading response, heel-off, toe-off)	Less control in keeping toes facing forward, with ball of foot landing almost same time as heel leg rotates inwards at hip. As toe peels off at end off heel rise phase, foot propels due to lack of dorsiflexion from restricted valgus ankle and also more laterally than that of the right foot.
Axial position of the lower limb (flatfoot, knock knee, coxvalga/vara)	-
Movement and position of the knee and hip (extension)	Same as above.
Position and movements of pelvis (compensatory anteversion, rotation, lateral tilt max 4cm)	Pelvis suggests being at slight anteversion postion on pre-swing phase and increased retroversion on stance phase.
Aaz\Movement of centre of gravity (COG – max 4.5cm)	Same as above.
Activity of abdomen muscles	Abdominals are not very activated.
Position and movement of the trunk (latero-flexion, rotation, max Th7)	Back is in hyperextension due to compensation of inactive abdominals.
Activity of back muscles	Back muscles activated; pelvis is in slight anteversion
Position of shoulders (upper part of the trunk)	Slightly protracted shoulders
Position and movements of the head	Same as above.
Movements of the upper extremity (synchronicity, synkinesia, max 45 degrees)	Same as above.
Stability of walking	Same as above.

Table 10 – Gait Analysis. Front View. Initial KE.

3.3.12 Modification of Gait

Walk on tiptoes: when walking, during stance on the left foot, the strides are quickly shifting to change stance on the right foot.

Walking with arms up: there is increased lordosis when on left stance – prominent flat left foot.

Walking backwards: no limitations of Achilles tendon

3.3.13 Muscle Palpation

Lower extremities

Both thighs and calves are hypotonic due mobilization of the ankles for 6 weeks in an AFO orthosis. There is substantial hypotonicity mainly in the quadriceps, lateral rotators, and ankle plantar flexors. The left leg shows slight better tonicity and size in the thigh but right leg shows better tonicity and size in the calf.

	Left	Right
Gluteus Maximus	Eutonic	Eutonic
Iliopsoas	Eutonic	Eutonic
Sartorius	Hypotonic	Hypotonic
Tensor Fasciae Lata	Hypotonic	Hypotonic
Quadriceps Femoris	Hypotonic	Hypotonic
Hip Adductors	Eutonic	Eutonic
Hip Flexors	Eutonic	Eutonic
Gluteus Medius	Hypotonic	Hypotonic
Lateral Rotators of Hip	Hypotonic	Hypotonic
Medial Rotators of Hip	Eutonic	Eutonic
Lateral Hamstrings	Hypotonic	Hypotonic
Medial Hamstrings	Hypotonic	Hypotonic
Ankle Plantar Flexors	Hypotonic	Hypotonic
Soleus	Hypotonic	Hypotonic
Peroneus longus, brevis	Hypotonic	Hypotonic
Tibialis Posterior	Hypotonic	Hypotonic
Tibialis Anterior	Hypotonic	Hypotonic

Table 11 – Muscle Palpation. Initial KE.

3.3.13 Scar examination

Both scars are about the same length around 14cm and healed per primam without any sign of infection or inflammation. The left scar is longer towards the heel but more hypertrophic on the level of the malleoli. The right scar is longer towards the calf and some hypertrophy is also present at the level of the malleoli but not as significant on the left.

3.3.14 Joint Play examination (according to Lewit)

Lower Extremity

	Left	Right
Patella	Free movement to all directions	Free movement to all directions
Knee joint	Free movement to all directions	Free movement to all directions
Fibula	Free movement to all directions	Free movement to all directions
Talocrural	Free movement to all directions	Free movement to all directions
Calcaneal-talar	Free movement to all directions	Free movement to all directions
Calcaneal-navicular	Free movement to all directions	Free movement to all directions
Subtalar	Free movement to all directions	Free movement to all directions
Talocalcaneonavicular	Free movement to all directions	Free movement to all directions
Tarsometatarsal	Free movement to all directions	Free movement to all directions
IP I	Restricted in all directions	Restricted in all directions

Table 12 – Joint Play examination (according to Lewit). Initial KE.

3.3.15 Neurological Assessment

Irritative Signs of Lower Extremity

	Left	Right
Extension phenomena		
Babinski	+	+
Siccard	–	–
Brissaud's phenomenon	–	–
Roche sign	+	+
Oppenheim	–	–
Strümpel Symptom	–	–
Vitek's Symptom	–	–
Gordon phenomenon	–	–
Flexion phenomena		
Rossolimo	–	–
Zkukovsky-Kornilov	–	–
Mendelian-Bechterev	–	–
Weingrow	–	–

Table 13 – Neurological Assessment. Irritative Signs of Lower Extremity. Initial KE.

\+ positive

– negative

Superficial Sensation
Lower Extremities

	Left	Right
Light touch: monofilament, proximally to distally	+, no asymmetry	+, no asymmetry
Temperature, proximally to distally	+, no asymmetry	+, no asymmetry
Pain: pinprick, proximally too distally	+, no asymmetry	+, no asymmetry
2 – point discrimination, 2 points, proximally to distally	+, no asymmetry	+, no asymmetry
Graphesthesia	Not tested	
Stereognosis	Not tested	

Table 14 – Neurological Assessment. Superficial Sensation. Initial KE.

\+ present
– not present

Deep sensation
Lower Extremities

	Left	Right
Vibration	Not tested	
Joint Position Sense: passive change of toe	+, no asymmetry	+, no asymmetry
Kinesthesia/Movement sense: direction of toe movement	+, no asymmetry	+, no asymmetry

Table 15 – Neurological Assessment. Deep Sensation. Initial KE.

\+ present
– not present

Deep Tendon Reflex
Lower Extremities

	Left	Right
Patella L2 – L4	+	+
Achilles S1,S2	++	++

Table 16 – Neurological Assessment. Deep Tendon Reflex. Initial KE.

– absent	+ present
+/– present-decreased	++ increased

Spastic ROM according to Ashworth Scale

The muscles of the lower extremity were assessed for spastic ROM according to the Ashworth scale. No resistance was found throughout the course of fast passive movement. The result scoring is 0 for both lower extremities.

3.3.16 Initial Examination Conclusion

The patient is after substantial improvement in tone of muscle, strength, and stability of the lower extremities after mobilization of ankle in AFO orthosis for 6 weeks. Standing still on both feet is without difficulty. Modified standing is challenging especially one leg stance on the right leg. Walking is overall good but unstable with several decompensations by pes planovalgus, hypermobility in the knees, positioning of pelvis and weakness in hip and calf muscles.

There is no abnormal healing of the scar, only some small hypertrophy on one part of each scar. On palpation of muscle, there is a general hypotrophy of the mainly rotators of hip, knee extensors, plantar and dorsiflexors. Notably there is asymmetry of decreased hypotonicity in right thigh and left calf. The range of motion in both hip, knee ankle and foot are within normal ranges and the joint play assessment show no visible restriction in both lower extremities.

Lastly, neurological examination shows positive pathological irritative Babinski and Roche sign on left and right lower extremities. The deep tendon reflex of both Achilles show hypereflexia. The signs of spasticity are still present however they do not directly affect the tonicity, strength, ROM and sensation of the lower extremities.

The patient's ADL is not limited by the ability to walk or any other activities at home or school. Participates in sports at school including ball games like basketball and floorball. Only complains of tiredness after walking for longer periods of time or after exercising more intensely.

3.4 Short-term and Long-Term Physiotherapy Plan

3.4.1 Short-term physiotherapy plan

- Soft tissue techniques for scar, release restriction
- Facilitation of muscles of the lower extremities mainly external rotators of hip and plantar flexors of the foot.
- Relaxation of the biceps femoris
- Stretching of plantar tendons and Achilles tendon
- Prevention of foot and ankle stiffness
- Improve laxity of the foot and ankle joints
- Strengthening of knee extensors, hip rotators, plantar flexors and dorsiflexors.
- Improve overall fitness

3.4.2 Long-term physiotherapy plan

- Improve stereotype in walking
- Advance in more difficult and challenging exercises in balance with unstable surfaces
- Instructions for self-treatment
- Incorporate progress into activity of daily living
- Encourage variety of sports that encourage strengthening of the lower extremities

3.5 Therapy Progress

The patient is assigned 5 therapy sessions 30 minutes long over the span of 3 weeks with one week break due to patient on holiday. The sessions are provided by me for the first 15 – 20 minutes and then by my supervisor or 30 minutes fully by me.

SESSION 1

Date 12.1.2022

Status praesens:
Subjective – patient is feeling a little tired since it is the morning. The documents of medical records are available from past medical examinations, treatment, and rehabilitation. The orthopaedic surgeon's approval for outpatient rehabilitation is present.
Objective – the patient's confidence is a slightly decreased. They are accompanied by their mother for parental support. Does not wear or use any assistive devices, neither has any special insoles.

Goal of today's therapy unit: initial assessment and focus on neurophysiological reaction to Vojta therapy

Proposed therapy: Initial Kinesiological Examination and Vojta therapy (performed by supervisor)

Procedure: Assessment of gait, assessment of posture, anthropometric measurements, goniometry, hypermobility, scar examination
Vojta reflex method (performed by supervisor): Zone 1 – lying with knees bent and ankles off the edge of table, one arm extended and other along body, trigger zone right lateral calcaneal tubercle and lower angle of scapula Result: activation of supination in ankle with flexion of toes, activation gluteus, straightening of spine into extension

Self-therapy: squats 20x, 3x day
Result:
Objective – therapy tolerated, unspecific pain or tension in legs in heel raises, otherwise no other issues during the session
Subjective – patient feels no change since the beginning of the session

SESSION 2

Date 14.1.2022

Status praesens:
Subjective – patient is feeling well, the session starts in the afternoon. They are back from holiday in the mountains last week, there were no issues with skiing. The activity was enjoyable.
Objective – the patient feels more confident in practice of exercises at home and successful skiing trip, They are accompanied by their father for parental support.

Goal of today's therapy unit: conditional exercises, manual therapy, soft tissue techniques, strengthening hip and plantar flexors and eversion (quadriceps, peroneus), educate about small foot

Proposed therapy: Initial Kinesiological Examination, stretching and strengthening exercises with balance, soft tissue techniques for scar and fascia

Procedure: Assessment of muscle length, muscle strength, muscle palpation, goniometry, joint play, neurological examination, scar treatment, stretching of Achilles tendon, squat with changing base of support, introduce to small foot, transfer to single leg squats and calf raises on both legs.

Self-therapy: eccentric calf raises from step 20x, 3x day, squats 20x, 3x day
Result:

Objective: - therapy tolerated, no issues during the session
Subjective: - patient feels no change since the beginning of the session

SESSION 3

Date 24.1.2022

Status praesens:
Subjective – patient is feeling well, the session starts in the afternoon.
Objective – the patient can demonstrate home exercises with rigor, they are accompanied by their father for parental support.

Goal of today's therapy unit: focus on neurophysiological reaction to PNF, conditional exercises with focus on strengthening hip rotators, soft tissue technique for scar and fascia

Proposed therapy: stretching and strengthening with use of PNF and exercises with balance

Procedure: therapy for scars in all directions with emphasis on stretching of Achilles tendon and surrounding fascia, 1st flexion and extension of lower extremity with emphasis of strengthening rectus femoris pars medialis and stretching of the biceps femoris by extension of the knee, 2nd flexion and extension of lower extremity with emphasis of strengthening gastrocnemius pars lateralis by flexion of the knee and vastus lateralis by extension of the knee, practice of strengthening exercises single leg squat on unstable surfaces,

Self-therapy: eccentric calf raises from step 20x, 3x day, single leg squats 20x, 3x day

Result:
Objective:- therapy tolerated, no issues during the session
Subjective: - patient feels no change since the beginning of the session

SESSION 4

Date 26.1.2022

Status praesens:

Subjective – patient is feeling well, the session starts in the afternoon

Objective – the patient wants to advance with more difficult exercises, they are accompanied by their father for parental support.

Goal of today's therapy unit: conditional exercises

Proposed therapy: stretching and strengthening with exercises with balance and coordination, repetition of small foot and sensorimotorics

Procedure: the patient is prompted to form small foot and keep the dynamic posture when introduced to the unstable surfaces, exercises with change of difference bases of support including wobble board and bosu. Patient is asked to catch and throw over-ball in squat and then progress one leg stance etc. The movements are fast with quick progression in ability to adapt and compose the difficulty in exercise.

Self-therapy: use of ball catching in the usual home exercises

Result:

Objective: - therapy tolerated, no issues during the session

Subjective: - patient feels no change since the beginning of the session

SESSION 5

Date 31.1.2022

Status praesens:
Subjective – patient is feeling well, the session starts in the afternoon
Objective – the patient is most confident at performing home exercises so far. They are accompanied by their mother for parental support.

Goal of today's therapy unit: conditional exercises and focus on neurophysiological reaction to Vojta method

Proposed therapy: stretching and advanced strengthening, Vojta method (performed by supervisor)

Procedure: Vojta reflex method (performed by supervisor): reflex creeping second phase in flexion and support phase, trigger zones on extremities including medial humeral epicondyle, lateral calcaneal tubercle. Activation of scapula in abduction and external rotation, pelvis retroflexion and ankle into supination with toes into flexion. Single leg squats with holding weights and introduction of plyometric exercises also on unstable surfaces, one leg eccentric calf raises on step.

Self-therapy: using weights in single leg squats 20x and usual home exercises

Result:
Objective: - therapy tolerated, no issues during the session
Subjective: - patient feels no change since the beginning of the session

SESSION 6

Date: 02.2.2022

Status praesens:
Subjective – patient is feeling well, the session starts in the afternoon
Objective – the patient is most confident at performing home exercises so far. They are accompanied by their father for parental support.

Goal of today's therapy unit: conditional exercises

Proposed therapy: stretching and strengthening with exercises with balance and coordination, repetition of small foot and sensorimotorics

Procedure: Assessment for small foot and training in highest position level, now jumping, repetition of single leg squats with holding weights and continuation of plyometric exercises concentrating on frequency and height of jumps and also in forward and side to side directions – trying this with throwing and catching the ball from different angles and also heights, one leg eccentric calf raises on step.

Self-therapy: using weights in single leg squats 20x and plyometric exercises 15x and usual home exercises

Result:
Objective: - therapy tolerated, no issues during the session
Subjective: - patient feels no change since the beginning of the session

Note: for conditional exercising continue in style of basketball training with catching and throwing ball from different angles and heights. The activity can be challenged by changing the style of jump by increasing frequency and/or height in jumps, alternate limb patterns, direction of movement and addressing obstacles such as hurdles and boxes.

3.6 Final Kinesiologic Examination

3.6.1 Aspection of posture

There is no apparent anomalies in the head, upper extremities, shoulders, however there is slight lordosis in curvatures of spine – otherwise within correct alignment in all aspects. The lower extremities show valgosity in the ankles, especially the left ankle – causing substantial flat foot – there is loading to the medial side of the foot and flattening of the transverse arch with abduction of toes.

3.6.2 Palpation of pelvis

a. frontal plane: Right ASIS shows slight elevation compared to left side. Iliac crests on both side show no deviations or asymmetry.

b. sagittal plane: slight anterior pelvic tilt. The angle between floor and axis going through SIAS and PSIS is greater on the left side on the right side which has a smaller angle.

c. transversal plane: no visible rotation of the pelvis

3.6.3 Base of support

Left: a moderate-severe flat longitudinal arch compared to the right foot. Suggests foot showing weight being applied more on the medial side of the foot due to valgosity in the ankle; increasing support in toes (toes are in abduction and flexion) and therefore also flat transverse arch of the foot. Valgosity in 2^{nd} toe. Proportionate length in foot

.

Right: proportionate length, slight-moderate flattened arch and angles of foot.

3.6.4. Specific testing of posture

a) Romberg test:

I: Negative II: Negative III: Negative

b) Single-leg stance test:
i. Left – good stability and posture – open eyes, closed eyes – activity of anterior tibialis
ii. Right – good stability and posture – open eyes, closed eyes – activity of anterior tibialis and grabbing floor

c) Vele's test: grade 1,

d) Trendelenburg – better maintenance of hip in correct position
Test with paper, fits better under right toes, still not under left

3.6.5 Modification of standing

a) Tiptoes standing, S1 triceps surae: can stay for only a several seconds on toes, restriction in ankle

b) Heels standing, L5 peronei: achieves position on heels for few seconds, lack of balance

c) Squatting, L4 quadriceps femoris: can make deep squat without losing balance

3.6.6 Anthropometric measurement

Lower Extremity

	Left	Right
Length		
Anatomical Length	68 cm	68 cm
Functional Length – SIAS	77 cm	78 cm
Functional Length – umbilicus	82 cm	83 cm
Thigh	33 cm	32 cm
Middle Leg	32 cm	34 cm
Foot	21 cm	21 cm
Circumferences		
Thigh 10 cm	32 cm	32 cm
Thigh 15 cm	37 cm	37 cm
Knee	31 cm	31 cm
Tuberositas Tibiae	28 cm	29 cm
Calf	29 cm	29 cm
Ankle	23 cm	24 cm
Heel	29 cm	29 cm
Foot	21 cm	21 cm

Table 17 – Anthropometric measurement. Final KE.

3.6.7 Muscle Length Test (according to Janda)

Lower Extremity

		Left	Right
Gastrocnemius		0	0
Soleus		0	0
Hip Flexors	One joint	0	0
	Two joint	0	0
Adductors	One joint	0	0
	Two joint	0	0
Hamstrings		1	0

Table 18 – Muscle Length Test (according to Janda). Final KE.

3.6.8 Hypermobility Test (according to Janda and Sachse)

Lower Extremity

	Left	Right
Extension Knee Joint (Sachse)	A 0°	B 0 – 10°
Flexion Knee Joint (Janda)	Hypermobile	

Table 19 – Hypermobility Test (according to Janda and Sachse). Final KE

3.6.9 Measurement of ROM (goniometry, SFTR method, in), according to Janda

Lower Extremity

	Left	Right
Hip		
Extension/Flexion	Sa: 10/30 – 0 – 120/135 Sp: 10/30 – 0 – 120/135	Sa: 10/30 – 0 – 120/135 Sp: 10/30 – 0 – 120/135
External/ Internal Rotation	$T_{F90°}$: 30/45 – 0 – 30/45	$T_{F90°}$: 30/45 – 0 – 30/45
Abduction/Adduction	Fa: 30/50 – 0 – 10/30 Fp: 30/50 – 0 – 10/30	Fa: 30/50 – 0 – 10/30 Fp: 30/50 – 0 – 10/30
Knee		
Extension/ Flexion	Sa: 0/10 – 0 – 125/160 Sp: 0/10 – 0 – 125/160	Sa: 0/10 – 0 – 125/160 Sp: 0/10 – 0 – 125/160
Ankle		
Dorsal/Plantar Flexion	Sa: 10/30 – 0 – 45/50 Sp: 10/30 – 0 – 45/50	Sa: 10/30 – 0 – 45/50 Sp: 10/30 – 0 – 45/50
Eversion/Inversion	Ra: 15/30 – 0 – 35//50 Rp: 15/30 – 0 – 35//50	Ra: 15/30 – 0 – 35/50 Rp: 15/30 – 0 – 35/50
MTP I		
Abduction/Adduction	Ta: 15/25 – 0 – 15/25 Tp: 15/25 – 0 – 15/25	Ta: 15/25 – 0 – 15/25 Tp: 15/25 – 0 – 15/25
IP I		
Extension/Flexion	Sa: 0/50 – 0 – 70/90 Sp: 0/50 – 0 – 70/90	Sa: 0/50 – 0 – 70/90 Sp: 0/50 – 0 – 70/90

Table 20 – Measurement of ROM (goniometry, SFTR method, in), according to Janda. Final KE.

3.6.10 Muscles Strength Testing (according to Janda)

Lower Extremity

	Left	Right
Gluteus Maximus	4+	4+
Iliopsoas	5	5
Sartorius	4-	4-
Tensor Fasciae Lata	4	4
Quadriceps Femoris	4+	4+
Hip Adductors	4	4
Hip Flexors	4+	4+
Gluteus Medius	4 +	4+
Lateral Rotators of Hip	4	4
Medial Rotators of Hip	4 -	4 -
Lateral Hamstrings	4	4
Medial Hamstrings	4 -	4-
Ankle Plantar Flexors	4+	4+
Soleus	4	4
Peroneus longus, brevis	4	4
Tibialis Posterior	4	4+
Tibialis Anterior	4	4+
Extensor Hallucis lg +br	4	4-
Flexor Hallucis br.	5	5
Extensor digitorum lg +br	4+	4+
Peroneus Tertius	4	4-
Flexor Hallucis Brevis	4+	4+
Flexors Hallucis Longus	5	5
Dorsal Interossei	5	5
Plantar Interossei	5	5
Flexor Digitorum Brevis	5	5
Abductor Hallucis	4	4
Adductor Hallucis	4+	4+

Table 21 – Muscles Strength Testing (according to Janda). Final KE.

3.6.11 Gait Analysis

Back View

Width of the base of support	Evenly spaced in each step with width slightly narrower than hips
Position of the feet (angle)	The foot is corrected to toes facing forward after few strides
Walking rhythm (periodic, non-periodic)	Periodic
Walking speed	The steps increase in pace once reached comfortable rhythm
Stride length (short steps/long steps)	Long strides
Movement of the foot (heel strike, flat foot, loading response, heel-off, toe-off)	There is some dorsiflexion in the feet on both side inducing propelling the foot with use of the ankle in extension. The CoG is moved forward
Axial position of the lower limb (flatfoot, knock knee, coxvalga/vara)	Thighs are turned more neutrally towards external rotation. No tendencies for excurvatum. Ankles remain the same as in initial.
Movement and position of the knee and hip (extension)	The knee can make use of full extension with increased activity of hamstrings and more controlled unlocking of the ankle moving the foot in a steady timely manner.
Position and movements of pelvis (compensatory anteversion, rotation, lateral tilt max 4cm)	There is still some pelvic shift but there is an attempt to correct to rotational forward movement than changing quickly from one side to another.
Movement of centre of gravity (COG – max 4.5cm)	There is better positioning of hips towards neutral and the waddling is decreased when warmed up after a few strides.
Activity of abdomen muscles	-
Position and movement of the trunk (latero-flexion, rotation, max Th7)	Slight marked angle of latero-flexion on the left (according to anatomical point of view) side
Activity of back muscles	Active paravertebral muscles on both sides
Position of shoulders (upper part of the trunk)	Symmetrically neutral, scapulas are only slightly protracted.
Position and movements of the head	Head is upright and looking in front in direction of walking once rhythm is established
Movements of the upper extremity (synchronicity, synkinesia, max 45 degrees)	More movement in the right arm, no swing movement in left arm. Arms both flexed at around 30 degrees. Minimal counter rotation of thorax.
Stability of walking	The is still flat feet and the tendency to wobble every now and then due to pes planovalgus however due to improved movement in hips and ankles the tendencies are lower.

Table 22 – Gait Analysis. Back View. Final KE.

Side view

Width of the base of support	Evenly spaced in each step with width narrower than hips
Position of the feet (angle)	-
Walking rhythm (periodic, non-periodic)	Periodic
Walking speed	Careful steps
Stride length (short steps/long steps)	Takes Long strides
Movement of the foot (heel strike, flat foot, loading response, heel-off, toe-off)	Plantar flexors are allowing the foot to land in a more controlled manner. There is still some swerving in the feet due to flat feet.
Axial position of the lower limb (flatfoot, knock knee, coxvalga/vara)	Positioning of knee no longer has tendencies to go into excurvatum.
Movement and position of the knee and hip (extension)	Same as above
Position and movements of pelvis (compensatory anteversion, rotation, lateral tilt max 4cm)	Pelvic tilt is less severe but still present
Movement of centre of gravity (COG – max 4.5cm)	There is better coactivity in the muscles around the hip providing better positioning of tilt in pelvis.
Activity of abdomen muscles	Activation of abdominal muscles is not optimal, the rectus abdominis is slightly weak due to greater activation of lower back extensors.
Position and movement of the trunk (latero-flexion, rotation, max Th7)	The trunk is centred more neutrally towards a stable corrected midline position
Activity of back muscles	-
Position of shoulders (upper part of the trunk)	Shoulder are slightly protracted forward. Minimal counter rotation to trunk and mainly pelvis – more shifting than rotation.
Position and movements of the head	Same as above.
Movements of the upper extremity (synchronicity, synkinesia, max 45 degrees)	Same as above.
Stability of walking	Same as above.

Table 23 – Gait Analysis. Side View. Final KE.

Front View

Width of the base of support	Evenly spaced in each step with width same as hips
Position of the feet (angle)	Tendency of left foot to have moderately wider angle (toes are pointing out more laterally)
Walking rhythm (periodic, non-periodic)	Periodic
Walking speed	Careful steps
Stride length (short steps/long steps)	Long steps
Movement of the foot (heel strike, flat foot, loading response, heel-off, toe-off)	More control in keeping toes forward. The heel lands slightly earlier than the ball of foot and the hip remain stable in neutral. The foot is moving in a controlled manner with increased activity of dorsiflexion and coactivity of other muscles
Axial position of the lower limb (flatfoot, knock knee, coxvalga/vara)	-
Movement and position of the knee and hip (extension)	Same as above.
Position and movements of pelvis (compensatory anteversion, rotation, lateral tilt max 4cm)	There pelvis moves more rotationally than in frontal tilting however it is still anteversion is still present
Aaz\Movement of centre of gravity (COG – max 4.5cm)	Same as above.
Activity of abdomen muscles	Abdominals are not very activated.
Position and movement of the trunk (latero-flexion, rotation, max Th7)	Back is in hyperextension due to compensation of inactive abdominals.
Activity of back muscles	Back muscles activated; pelvis is in slight anteversion
Position of shoulders (upper part of the trunk)	Slightly protracted shoulders
Position and movements of the head	Same as above.
Movements of the upper extremity (synchronicity, synkinesia, max 45 degrees)	Same as above.
Stability of walking	Same as above.

Table 24 – Gait Analysis. Front View. Final KE.

3.6.12 Modification of Gait

Walk on tiptoes: when walking, during stance on the left foot, the strides preferable shift to change stance on the right foot but not as much as in the beginning.

Walking with arms up: there is slightly increased lordosis when on left stance – prominent flat left foot.

Walking backwards: no limitations of Achilles tendon

3.6.13 Muscle Palpation

Lower extremities

Both thighs and calves are show better symmetry overall. There are still some hypotonicity mainly in the quadriceps, lateral rotators but ankle plantar flexors show improvement.

	Left	Right
Gluteus Maximus	Eutonic	Eutonic
Iliopsoas	Eutonic	Eutonic
Sartorius	Hypotonic	Hypotonic
Tensor Fasciae Lata	Hypotonic	Hypotonic
Quadriceps Femoris	Hypotonic	Hypotonic
Hip Adductors	Eutonic	Eutonic
Hip Flexors	Eutonic	Eutonic
Gluteus Medius	Hypotonic	Hypotonic
Lateral Rotators of Hip	Hypotonic	Hypotonic
Medial Rotators of Hip	Eutonic	Eutonic
Lateral Hamstrings	Hypotonic	Hypotonic
Medial Hamstrings	Hypotonic	Hypotonic
Ankle Plantar Flexors	Eutonic	Eutonic
Soleus	Eutonic	Eutonic
Peroneus longus, brevis	Hypotonic	Hypotonic
Tibialis Posterior	Hypotonic	Hypotonic
Tibialis Anterior	Hypotonic	Hypotonic

Table 25 – Muscles Palpation. Final KE.

3.6.13 Scar examination

Both scars are about the same length around 14cm and healed per primam without any sign of infection or inflammation. The left scar is longer towards the heel but more hypertrophic on the level of the malleoli. The right scar is longer towards the calf and some hypertrophy is also present at the level of the malleoli but not as significant on the left.

3.6.14 Joint Play examination (according to Lewit)

Lower Extremity

	Left	Right
Patella	Free movement to all directions	Free movement to all directions
Knee joint	Free movement to all directions	Free movement to all directions
Fibula	Free movement to all directions	Free movement to all directions
Talocrural	Free movement to all directions	Free movement to all directions
Calcaneal-talar	Free movement to all directions	Free movement to all directions
Calcaneal-navicular	Free movement to all directions	Free movement to all directions
Subtalar	Free movement to all directions	Free movement to all directions
Talocalcaneonavicular	Free movement to all directions	Free movement to all directions
Tarsometatarsal	Free movement to all directions	Free movement to all directions
IP I	Limited in lateral-lateral direction	Limited in lateral-lateral direction

Table 26 – Joint Play examination (according to Lewit). Final KE.

3.6.15 Neurological Assessment

Irritative Signs of Lower Extremity

	Left	Right
Extension phenomena		
Babinski	+	+
Siccard	–	–
Brissaud's phenomenon	–	–
Roche sign	+	+
Oppenheim	–	–
Strümpel Symptom	–	–
Vitek's Symptom	–	–
Gordon phenomenon	–	–
Flexion phenomena		
Rossolimo	–	–
Zkukovsky-Kornilov	–	–
Mendelian-Bechterev	–	–
Weingrow	–	–

Table 27 – Neurologic Assessment. Irritative Signs of Lower Extremity. Final KE.

+ positive
– negative

Superficial Sensation
Lower Extremities

	Left	Right
Light touch: monofilament, proximally to distally	+, no asymmetry	+, no asymmetry
Temperature, proximally to distally	+, no asymmetry	+, no asymmetry
Pain: pinprick, proximally too distally	+, no asymmetry	+, no asymmetry
2 – point discrimination, 2 points, proximally to distally	+, no asymmetry	+, no asymmetry
Graphesthesia	Not tested	
Stereognosis	Not tested	

Table 28 – Neurologic Assessment. Superficial Sensation. Final KE.

+ present
– not present

Deep sensation
Lower Extremities

	Left	Right
Vibration	Not tested	
Joint Position Sense: passive change of toe	+, no asymmetry	+, no asymmetry
Kinesthesia/Movement sense: direction of toe movement	+, no asymmetry	+, no asymmetry

Table 29 – Neurologic Assessment. Deep sensation. Final KE.

+ present
– not present

Deep Tendon Reflex
Lower Extremities

	Left	Right
Patella L2 – L4	+	+
Achilles S1,S2	++	++

Table 30 – Neurologic Assessment. Deep Tendon Reflex. Final KE.

– absent
+/– present-decreased
+ present
++ increased

Spastic ROM according to Ashworth Scale

The flexor and extensor muscles of the lower extremity were assessed for spastic ROM according to the Ashworth scale. No resistance was found throughout the course of fast passive movement.

The result scoring is 0 for both lower extremities.

3.7 Evaluation of the Effect of the Therapy, prognosis:

Aspection of posture

Initial The knees tend to go into recurvatum especially the right.	**Final** The knees show no more tendencies into recurvatum.

Table 31 – Evaluation of the Effect of the Therapy. Aspection of Posture

The improvement in stability of knee was also shown during the exercises especially in eccentric calf raises.

Specific testing of posture

Trendelenburg	**Initial** Right hip turning into internal rotation – weakened external rotators	**Final** Better maintenance of hip in correct position

Table 32 – Evaluation of the Effect of the Therapy. Specific Testing of Posture

During the paper test, previously could not fit paper under toes but finally fitted at least under right toes.

Modification of standing

	Initial	**Final**
Tiptoes standing, S1 triceps surae	can't go completely onto toes, restriction in ankle	can stay for only a several seconds on toes, restriction in ankle
Heels standing, L5 peronei	difficulty in achieving position on heels, lack of balance	achieves position on heels for few seconds, lack of balance
Squatting, L4 quadriceps femoris	cannot make a deeper squat without losing balance and due to restriction in ankle	can make deep squat without losing balance

Table 33 – Evaluation of the Effect of the Therapy. Modification of standing

Muscle Length Test (according to Janda)

Hamstrings	**Initial**		**Final**	
	Left 1	Right 1	Left 1	Right 0

Table 34 – Evaluation of the Effect of the Therapy. Muscle Length Test

The length improved after stretching and relaxation of hamstrings in the right leg

Muscle Strength Test (according to Janda)

	Initial		Final	
	Left	Right	Left	Right
Quadriceps Femoris	4	3+	4+	4+
Hip Flexors	4	4	4+	4+
Lateral Rotators of Hip	3+	4	4	4
Ankle Plantar Flexors	3+	3+	4+	4+
Soleus	3 -	3 -	4-	4-
Tibialis Posterior	3	4	4	4+
Tibialis Anterior	3	4	4	4+
Abductor Hallucis	4	3+	4	4

Table 35 – Evaluation of the Effect of the Therapy. Muscle Strength Test (according to Janda)

There is a global increase on mainly flexors of the proximal and distal part of the lower extremity. The activity of the dorsiflexors increase with also release in restriction of the ankle.

Gait Analysis

Back view

	Initial	**Final**
Position of the feet (angle)	Tendency of right foot to have moderately wider angle (toes are pointing out more laterally).	The foot is corrected to toes facing forward after few strides
Walking speed	Careful steps	The steps increase in pace once reached comfortable rhythm
Movement of the foot (heel strike, flat foot, loading response, heel-off, toe-off)	Calf muscles are activated at every heel strike on either leg in succession. The entire foot does not meet flat foot phase because of tendency to reduce heel strike due to restriction of ankles in dorsiflexion. CoG shifted behind feet, especially that of the left foot due relief of load on operated ankles and limit in extension – swinging or propelling of leg forward than using extensors.	There is some dorsiflexion in the feet on both side inducing propelling the foot with use of the ankle in extension. The CoG is moved forward between feet.
Axial position of the lower limb (flatfoot, knock knee, coxvalga/vara)	Normal positioning of cox. Thighs turn a little into internal rotation. Knees are in axis but some tendency for excurvatum. Ankles are valgus, especially left. Flat feet, especially on left.	Thighs are turned more neutrally towards external rotation. No tendencies for excurvatum. Ankles remain the same as in initial.
Movement and position of the knee and hip (extension)	Knee can flex without issue, however, are propelled forward with underuse of hamstrings (limited extension), heel is not able securely lock due to impact force on the whole foot at once and unlocks early propelling the foot back and forward instead of controlled manner.	The knee can make use of full extension with increased activity of hamstrings and more controlled unlocking of the ankle moving the foot in a steady timely manner.
Position and movements of pelvis (compensatory anteversion, rotation, lateral tilt max 4cm)	Pelvic shift to right and lateral tilt left side. Shoulder and spine upright and pelvis a little in anteversion to compensate for weaker hip flexors.	There is still some pelvic shift but there is an attempt to correct to rotational forward movement than changing quickly from one side to another.
Movement of centre of gravity (COG – max 4.5cm)	Left and right shift in CoG from internally rotating hips which in turn gives a waddling effect.	There is better positioning of hips towards neutral and the waddling is decreased when warmed up after a few strides.
Position and movements of the head	Head is upright but tilted forward to watch steps, kept still and not moving in any direction.	Head is upright and looking in front in direction of walking once rhythm is established
Stability of walking	Slight wobble with every right step as the foot lands on flat foot and stiffness in the valgus ankle as a result the pelvis shifts to the right.	The is still flat feet and the tendency to wobble every now and then due to pes planovalgus however due to improved movement in hips and ankles the tendencies are lower.

Table 36 – Evaluation of the Effect of the Therapy. Gait Analysis. Back View.

Side view

Movement of the foot (heel strike, flat foot, loading response, heel-off, toe-off)	Greater impact force into heel of foot; especially right foot. Floppy forefoot, as foot falls with restricted ankle in uncontrolled plantar flexion of foot. As toe peels off at end off heel rise phase, foot swerves more laterally than that of the left foot.	Plantar flexors are allowing the foot to land in a more controlled manner. There is still some swerving in the feet due to flat feet.
Axial position of the lower limb (flatfoot, knock knee, coxvalga/vara)	Poor axial position of ankles, structurally in valgosity especially the left with flat foot – pes planovalgus. The positioning of the knee has the tendency to go into genu excurvatum especially right. Normal positioning of cox.	Positioning of knee no longer has tendencies to go into excurvatum.
Position and movements of pelvis (compensatory anteversion, rotation, lateral tilt max 4cm)	Pelvis is visibly tilted to the left on ambulation noted in the swinging phase of both right and left leg.	Pelvic tilt is less severe but still present
Movement of centre of gravity (COG – max 4.5cm)	Centre of gravity is shifted behind the feet due posture of pelvis in slight anterior tilt.	There is better coactivity in the muscles around the hip providing better positioning of tilt in pelvis.
Position and movement of the trunk (latero-flexion, rotation, max Th7)	Trunk is slightly tilted backward behind the centre of gravity.	The trunk is centred more neutrally towards a stable corrected midline position

Table 37 – Evaluation of the Effect of the Therapy. Gait Analysis. Side View.

Front side

Movement of the foot (heel strike, flat foot, loading response, heel-off, toe-off)	Less control in keeping toes facing forward, with ball of foot landing almost same time as heel leg rotates inwards at hip. As toe peels off at end off heel rise phase, foot propels due to lack of dorsiflexion from restricted valgus ankle and also more laterally than that of the right foot.	More control in keeping toes forward. The heel lands slightly earlier than the ball of foot and the hip remain stable in neutral. The foot is moving in a controlled manner with increased activity of dorsiflexion and coactivity of other muscles.
Position and movements of pelvis (compensatory anteversion, rotation, lateral tilt max 4cm)	Pelvis suggests being at slight anteversion postion on pre-swing phase and increased retroversion on stance phase.	There pelvis moves more rotationally than in frontal tilting however it is still anteversion is still present

Table 38 – Evaluation of the Effect of the Therapy. Gait Analysis. Front View.

There is notable improvement in the movement pattern during walking from the initial and final examinations. The muscles surrounding the hips and ankles show greater coactivity and versatility. There is visible correction in dynamic parts of the foot placement in stride and stance phases. Stability in the walk is better due to improved quality of movement in the hip and ankle and lower tendencies for the knee into excurvatum.

4. CONCLUSION

Patient shows a gradual improvement in strength and balance in the lower extremities, but notably quick to improve in the fine details in quality of movement overall. The joints of the pelvis, hip and knee became more centrated due to activation and stimulation of weakened postural muscles such as hamstrings, hip rotators and flexors. The knees show improvement in the capacity to not go into recurvation during the exercises. The patient otherwise holds good posture in spine, shoulder, and head. During gait analysis the patient shows after some warming up better fluency and control in pattern after few strides. From heel to toe the foot lifts with more finer movement pattern and less propulsion from the restricted ankles. This effect of waddling is decreased with less shifting at the pelvis and the patient can look up in the direction of walking showing confidence in balance and stability.

The patient is greatly motivated to be challenged in ways that make the exercise more difficult while keeping to precise detail. The physical re-training of the decompensation in bipedal mobility formed a groundwork to performing a gait pattern that appears more effortless. While keeping to the rehabilitative process the patient was mentally focused and driven in cooperating with activities at home or in sports at school.

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6. APPENDIX

6.1 Abbreviations

ADL – activity of daily living

AFO – ankle foot orthosis

a.k.a. – also known as

ASIS – anterior superior iliac spine

Br. – brevis

BTX-A – botulinum toxin A

CoG – centre of gravity

COM – centre of mass

CP – cerebral palsy

CNS – central nervous system

CSF – cerebrospinal fluid

CT – computer tomography

E-30 – Echovirus

ECHO - enteric cytopathic human orphan (ECHO) virus

EBV – Epstein-Barr virus

EMG – Electromyography

EV – Enterovirus

Fa – Frontal axis (active)

Fp – Frontal axis (passive)

FES – Functional Electrical Stimulation

FFF – flexible flatfoot

FFF-STA – flexible flatfoot with short tendo-Achilles

GMFCS – Gross Motor Function Classification System

HPeV – human parechovirus virus

HSP – hereditary spastic paraplegia

ICP – intracranial pressure

ICU – intensive care unit

IPI – 1st interphalangeal joint

KE – kinesiological examination

LOSSCI - Locomotor Stages in Spinal Cord Injury

Lg. – longus

Mm. – muscles

MMR – measles mumps rubella vaccine

fMRI – functional magnetic resonance imaging

MRI – magnetic resonance imaging

MTP I – 1st meta-phalangeal joint

UK – United Kingdom

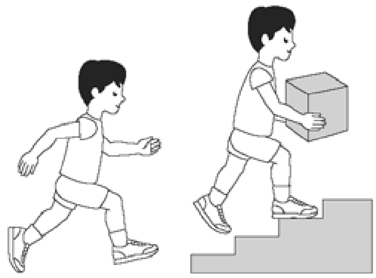
US – United States

6.2 Figures list

6.3 Tables list

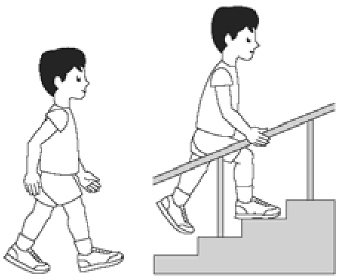
6.4 GMFCS Scale

GMFCS E & R between 6th and 12th birthday: Descriptors and illustrations



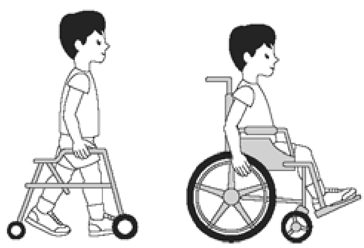
GMFCS Level I

Children walk at home, school, outdoors and in the community. They can climb stairs without the use of a railing. Children perform gross motor skills such as running and jumping, but speed, balance and coordination are limited



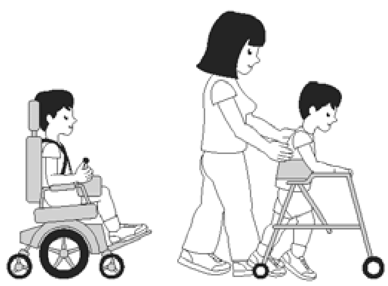
GMFCS Level II

Children walk in most settings and climb stairs holding onto a railing. They may experience difficulty walking long distances and balancing on uneven terrain, inclines, in crowded areas or confined spaces. Children may walk with physical assistance, a hand-held mobility device or used wheeled mobility over long distances. Children have only minimal ability to perform gross motor skills such as running and jumping.



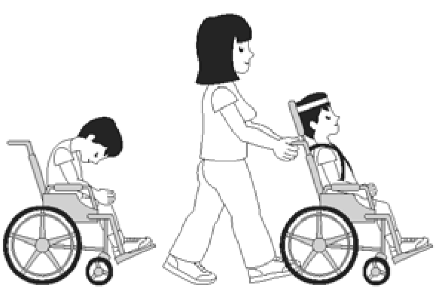
GMFCS Level III

Children walk using a hand-held mobility device in most indoor settings. They may climb stairs holding onto a railing with supervision or assistance. Children use wheeled mobility when traveling long distances and may self-propel for shorter distances.



GMFCS Level IV

Children use methods of mobility that require physical assistance or powered mobility in most settings. They may walk for short distances at home with physical assistance or use powered mobility or a body support walker when positioned. At school, outdoors and in the community children are transported in a manual wheelchair or use powered mobility.



GMFCS Level V

Children are transported in a manual wheelchair in all settings. Children are limited in their ability to maintain antigravity head and trunk postures and control leg and arm movements.

GMFCS descriptors: Palisano et al. (1997) Dev Med Child Neurol 39:214-23
CanChild: www.canchild.ca

6.5 Locomotor Stages according to Vojta

Locomotor Stages in Spinal Cord Injury (LOSSCI)

Patient ______________________________

Date of birth ______________________________

City, Date of Assessment ______________________________

Stage I – Orientation and goal-directed movement of the arms

Test items (assessed in supine)		+	–		+	–
(1) Fixation of gaze and following an object	to the right			to the left		
(2) Touching or grasping an object	right hand			left hand		

Stage II – Uprighting of the trunk and goal-directed movement of the arms

Test items (assessed in prone)		+	–		+	–
(1) Arm support to orientate	Propping on the right			Propping on the left		
(2) Single arm support, grasping with contralateral hand	Grasping with right hand			Grasping with left hand		

Stage III – Forward progression in prone: Creeping with / without assistance of the legs

Test items (assessed in prone)	+	–
(1) Creeping		

Stage IV – Locomotion by means of crawling or walking with upper extremity assistance

Test items	+	–
(1) Crawling with 3 points of support		
(2) Reciprocal crawling – 2 contralateral points of support		
(3) Walking with upper extremity assistance (cruising or use of an upper extremity assistive device)		

Stage V – Independent walking

Test items		+	–
(1) Walking on a flat surface and stopping on command – maximal 1 extra step			
(2) Walking up an incline (not stairs)			
(3) One-legged stand > 3 seconds	right leg		
	left leg		

Is the highest item in the highest stage achieved? YES ☐ NO ☐

Is the highest item in the previous stage achieved? YES ☐ NO ☐

Is a stage not achieved? YES ☐ NO ☐

If „YES", which stage? __________

6.6 Informed Consent

UNIVERZITA KARLOVA
FAKULTA TĚLESNÉ VÝCHOVY A SPORTU
José Martího 31, 162 52 Praha 6-Veleslavín

INFORMOVANÝ SOUHLAS

Vážená paní, vážený pane,

v souladu se Všeobecnou deklarací lidských práv, nařízením Evropské Unie č. 2016/679 a zákonem č. 110/2019 Sb. – o zpracování osobních údajů, Helsinskou deklarací, přijatou 18. Světovým zdravotnickým shromážděním v roce 1964 ve znění pozdějších změn (Fortaleza, Brazílie, 2013) a dalšími obecně závaznými právními předpisy Vás žádám o souhlas s prezentováním a uveřejněním výsledků vyšetření a průběhu terapie prováděné v rámci praxe na[1] ……………………………………………, kde Vás příslušně kvalifikovaná osoba seznámila s Vaším vyšetřením a následnou terapií. Výsledky Vašeho vyšetření a průběh Vaší terapie bude publikován v rámci bakalářské práce na UK FTVS, s názvem[2] …………………

Cílem této bakalářské práce je ……..

Získané údaje, fotodokumentace, průběh a výsledky terapie budou uveřejněny v bakalářské práci v anonymizované podobě. Osobní data nebudou uvedena a budou uchována v anonymní podobě. V maximální možné míře zabezpečím, aby získaná data nebyla zneužita.

Jméno a příjmení řešitele .... Podpis:........................

Jméno a příjmení osoby, která provedla poučení[3]................................. Podpis:........................

Prohlašuji a svým níže uvedeným vlastnoručním podpisem potvrzuji, že dobrovolně souhlasím s prezentováním a uveřejněním výsledků vyšetření a průběhu terapie ve výše uvedené bakalářské práci, a že mi osoba, která provedla poučení, osobně vše podrobně vysvětlila, a že jsem měl(a) možnost si řádně a v dostatečném čase zvážit všechny relevantní informace, zeptat se na vše podstatné a že jsem dostal(a) jasné a srozumitelné odpovědi na své dotazy. Byl(a) jsem poučen(a) o právu odmítnout prezentování a uveřejnění výsledků vyšetření a průběhu terapie v bakalářské práci nebo svůj souhlas kdykoli odvolat bez represí, a to písemně zasláním Etické komisi UK FTVS, která bude následně informovat řešitele.

Místo, datum ....

Jméno a příjmení pacienta .... Podpis pacienta: ....

Jméno a příjmení zákonného zástupce[4] ....…

Vztah zákonného zástupce k pacientovi .... Podpis: ....

1 Uveďte pracoviště,
2 Uveďte název práce, nebo alespoň název předběžný,
3 Je-li řešitel s pacientem v závislém postavení, poučení provádí jiná příslušně kvalifikovaná osoba,
4 Uveďte pouze v případě, má-li pacient omezenou způsobilost k právním úkonům (např. je-li nezletilý).

6.7 Approval by Ethics Committee

CHARLES UNIVERSITY
FACULTY OF PHYSICAL EDUCATION AND SPORT
José Martiho 31, 162 52 Prague 6 – Veleslavin

Application for Approval by UK FTVS Ethics Committee

of a research project, thesis, dissertation or seminar work involving human subjects

The title of a project: Case Study of Physiotherapy Treatment of a Patient with Bilateral Achilles Tendon Prolongation after Spastic Biparesis of Neuroinfectious Aetiology

Project form: Bachelor Thesis

Period of realization of the project: January 2022 – February 2022

The research will be carried out in accordance with the valid epidemiological measures of the Ministry of Health of the Czech Republic.

Applicant: Theresa Southwood, UK FTVS, Department of Physiotherapy

Main researcher: Theresa Southwood, UK FTVS, Department of Physiotherapy

Workplace: MediCentrum Praha, a.s.

Supervisor: Mgr. Ilona Kučerová

Project description: The aim of the project is to rehabilitate the patient after Achilles Tendon Prolongation procedure. The main goal for the patient is to improve the quality of function of the lower extremities in activities of daily living. The type of study provides theoretical background of the patient's complex diagnosis and its aetiology. It includes data of the patient's anamnesis, initial kinesiological assessment, description of the therapy units and lastly the final kinesiological assessment. The method of data will be collected in the form of observation and using tools such as plumb-line, tape measure, goniometer, and neurological hammer. The therapy will be provided by equipment such as Vojta therapy table, wall ladder, unstable surfaces and step board. The results are provided in form of tables or text.

Characteristics of participants in the research: The research includes one male patient that. The patient is checked by their Orthopaedic Surgeon and is indicated for rehabilitation. The patient has a history of previous rehabilitation. They are informed about their current and planned activities that they participate in and are fully willing to cooperate in the treatment. Patients with acute (especially infectious) diseases do not participate in therapy.

Ensuring safety within the research: Either mother or father of the patient is present during the research for parental supervision. An experienced physiotherapist is present for guidance in supervision of the therapeutical practice. Mgr. Ilona Kučerová is available for supervision and guidance for this study. Non-invasive methods are used in the research. Risks of therapy and methods will not be higher than the commonly anticipated risks for this type of therapy.

Ethical aspects of the research: Data will be collected in line with the rules given by European Union no. 2016/679 and the Czech Act no. 110/2019 Coll. – on personal data processing.
The collected data will be anonymized within one week after the end of working with the patient. I understand that anonymization means that the text does not use any item of information or combination of Items that could lead to the identification of a person. I will be careful not to enable recognition of a person in the text of the thesis, especially within the anamnesis. After the text has been anonymized, any personal data still kept elsewhere will be deleted.
Photographs of the participant will be anonymized within one week after being taken by blurring the face, parts of the body or any characteristics that could lead to identification of the person. After anonymization any non-anonymized photographs will be deleted. All collected data will be safely stored on a PC safeguarded by a keyword in a locked room, any data in paper form will be kept safely under lock and key in a locked room. The data will be processed, safely retained and published in an anonymous way in the bachelor thesis.
Photographs: Photographs of the participant will be anonymized within one week after being taken by blurring the face, parts of the body or any characteristics that could lead to identification of the person. After anonymization any non-anonymized photographs will be deleted.
All collected data will be safely stored on a PC safeguarded by a keyword in a locked room, any data in paper form will be kept safely under lock and key in a locked room. The data will be processed, safely retained and published in an anonymous way in the bachelor thesis.
I shall ensure to the maximum extent possible that the research data will not be misused.
Informed Consent: attached

It is the duty of **all participants of the research team** to protect life, health, dignity, integrity, the right to self-determination, privacy and protection of the personal data of all research subjects, and to undertake all possible precautions.

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Responsibility for the protection of all research subjects lies on the researcher(s) and not on the research subjects themselves, even if they gave their consent to participation in the research.
All participants of the research team must take into consideration ethical, legal and regulative norms and standards of research involving human subjects applicable not only in the Czech Republic but also internationally.
I confirm that this project description corresponds to the plan of the project and, in case of any change, especially of the methods used in the project, I will inform the UK FTVS Ethics Committee, which may require a re-submission of the application form.

In Prague, 14.1.2022 Applicant's signature: *[signature]*

Approval of UK FTVS Ethics Committee

The Committee: Chair:	Doc. PhDr. Irena Parry Martínková, Ph.D.	
Members:	Prof. PhDr. Pavel Slepička, DrSc.	Prof. MUDr. Jan Heller, CSc.
	PhDr. Pavel Hráský, Ph.D.	Mgr. Eva Prokešová, Ph.D.
	Mgr. Tomáš Ruda, Ph.D.	MUDr. Simona Majorová

The research project was approved by UK FTVS Ethics Committee under the registration number: 048/2022

Date of approval: 14.1.2022

UK FTVS Ethics Committee reviewed the submitted research project and **found no contradictions** with valid principles, regulations and international guidelines for carrying out research involving human subjects.

The applicant has met the necessary requirements for receiving approval of UK FTVS Ethics Committee.

UNIVERZITA KARLOVA
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José Martího 31, 162 52, Praha 6
– 20 –

Stamp of UK FTVS Signature of the Chair of UK FTVS Ethics Committee