UNIVERSIDADE DE LISBOA
FACULDADE DE MOTRICIDADE HUMANA

" Inter and Intra Individual Variability Of The Gait Fundamental Parameters On Healthy Children: Definition of the Clinically Relevant Normative Data."

Dissertação apresentada com vista à obtenção
do grau de Mestre em Ciências da Fisioterapia

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Nesta ocasião, quero expressar o meu profundo agradecimento a todas as pessoas que tornaram possível este passo no mundo académico.

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ABSTRACT

The aim of this study was to determine the norm of the gait fundamental biomechanical parameters for the healthy pediatric population and associated measurement error, for this laboratory.

Twenty-seven children cleared for neurological and musculoskeletal impairments, from a nearby school, aged between 7 and 9 joined this study. Kinematics, Kinetics, Electromyography and Anthropometrics were collected. Children were prepared with 53 passive markers (according to CAST) and instructed to walk through a walkway. Six muscles were bilaterally analyzed, *Gluteus Medius, Adductor Longus, Rectus Femoris, Semitendinosus, Tibialis Anterior,* and *Gastrocnemius*. Eleven children were re-evaluated within a 7 days time window to determine the measurement error (intra-observer).

The analysis of Joint Angular Displacement, Moments, Powers, GRF and EMG revealed a good overlapping of the left and right side curves, with wave patterns in accordance to the literature. Clinical Measurements variables were within published healthy ranges, as were the Gait Parameters variables. Eight variables revealed SEM values between 2º and 5º, while all others were below 2º. Higher SEM was found for the variables Cadence (3.64 steps/min), Mean Value of Pelvic Tilt (2.48º), Maximum Hip Angle (2.56º), Minimum Hip angle (4.94º), Knee Angle at Initial Contact (2.40º), and TT ROM (2.79º).

KEYWORDS: Gait, 3D Kinematics, Kinetics, Electromyography, Pediatrics, Goniometry, Biomechanics, Motion Capture, Normative Database, Anthropometry.

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GLOSSARY

2D – 2-dimension

3D – 3-dimension

A

ASIS – Anterior Superior Iliac Spine;

B

BW – Body Weight;

C

CAST – Calibrated Anatomical System Technique;
CoM – Center of Mass;
CoP – Center of Pressure;
CP – Cerebral Palsy;

D

DoF – Degrees of Freedom;
DF – Dorsiflexion;

E

EGA – Estimated gestational age;
EMG – Electromiography;

F

FMH – Faculdade de Motricidade Humana/ Faculty of Human Kinetics;
FP – Force Platform;
FO – Foot Off;

G

GC – Gait Cycle;
GCS – Global Coordinate System;
GRF – Ground Reaction Force;

H

HS – Heel Strike;

I

IC – Initial Contact;
ISW – Initial Swing;

L

LBMF – Biomechanics and Functional Morphology Laboratory/ Laboratório de Biomecânica e Morfologia Funcional;
LCS – Local Coordinate System;
LED – Light-Emitting Diodes;
LM – Lateral Malleolus;
LR – Loading Response;
LU – Locomotor Unit;

M

MM – Medial Malleolus;
MSW – Midswing ;
MST – Midstance ;
MVC – Maximum Voluntary Contraction;

P

PF – Plantarflexion;
PSW – Pre-Swing;
PU – Passenger Unit;

R

RF – Rectus Femoris;
RMS – Root Mean Square;
ROM – Range Of Motion;

S

SEM – Standard Error of Measurement
SLA – Swing Limb Advancement;
SLS – Single Limb Support;
SSC – Stretch-shortening Cycle;
ST – Stance;
SW – Swing;

T

TST – Terminal Stance;
TSW – Terminal Swing;

U

Ulisboa – Universidade de Lisboa/ University of Lisbon;

W

WA – Weight Acceptance

INTRODUCTION

The present work was developed for the Master on Physical Therapy Sciences of Faculdade de Motricidade Humana (FMH), Universidade de Lisboa (ULisboa), culminating with the final master thesis, on the expertise field of Biomechanics.

On the first semester of 2013 the Laboratório de Biomecânica e Morfologia Funcional (LBMF) of the FMH of ULisboa was contacted by the Hospital Dona Estefânia, in order to understand the possibility of analyzing the gait of children with pathologies capable of affecting the regular pattern of walking, namely children with Cerebral Palsy (CP). Ever since, this laboratory has contacted with internationally renowned professionals in pathologic gait analysis (such as Elke Viehweger, Paulo Selber). Meanwhile, other national hospitals have also shown interest in joining an eventual protocol with this laboratory, so that it could provide them the mentioned gait analysis.

Gait analysis is an established pre-surgical assessment tool. Studies have already reported substantial changes (above 50%) in surgical decisions when the experienced physicians recommendations are followed by clinical gait analysis, avoiding unnecessary costs, and eventual negative outcomes from inadequate surgical approaches[85]. The evolution of health neonatal care has allowed the survival of a growing number of risk children, specifically the very preterm children[1,9,24,31,60], allowing a growing survival at birth rate. In fact, in 2010 the rate of infant mortality reached its minimum ever registered in Portugal, with 2.5 child obits less than 1 year old per 1000 live births (3.6‰ in 2009, 5.0‰ in 2001), increasing again in 2013 to 2.9‰ live births[33]. For this reduction, the great contributor was the reduction on neonatal mortality (children with less than 28 days), with 1.9 obits per 1000 live births in 2013, when compared with the 2.5‰ in 2009[33,87]. Although the percentage of preterm children (estimated gestational age – EGA – bellow 37 weeks) has decreased between 2008 and 2013 from 8,9% to 7,8%[34], studies show that the CP prevalence among these risk children increases, as EGA decreases, with approximately 20% for an EGA inferior to 27 weeks, 12% between 27 and 28 weeks, 8% between 29 and 30 weeks, 7% for 31 weeks, and 4% for 32 weeks[61]. The morbidity rates don't appear to keep up with this increasing of survival at birth rate of risk infants, thus leading to an increasing number of infants with delayed growth and development, with the CP among the most fearsome[1,9]. The modern medicine has grown in the way of monitoring and assisting these surviving children with growing quality, using, namely, technologic support, such as that available on the LBMF. Human motion analysis technologies (*Motion Capture*

Systems) allow quantitative assessments of growing efficacy, and have been globally used as a pre-surgical resource[4,14,21,26,55,56,58]. Creating an adequate protocol for the biomechanical gait assessments for children with gait impairments, can improve the planning quality of clinical approaches (namely, the surgical)[84]. However, with the constant technological modernization there's also a growing responsibility for the professionals performing these motion analysis, where the collection, processing or interpretation errors may lead to serious consequences. It is expected an extraordinary effort from the professionals involved in order to keep themselves, their technological and theoretical supports up to date. It is undeniably necessary to keep adequate and updated reference values, so that the identification of false positives is avoided, when evaluating deviations from normality. To assure this, it becomes fundamental to establish the Norm for the LBMF of the FMH, with the associated errors and its sources, so we can assure an accurate assessment of the biomechanical parameters of the population with gait impairments.

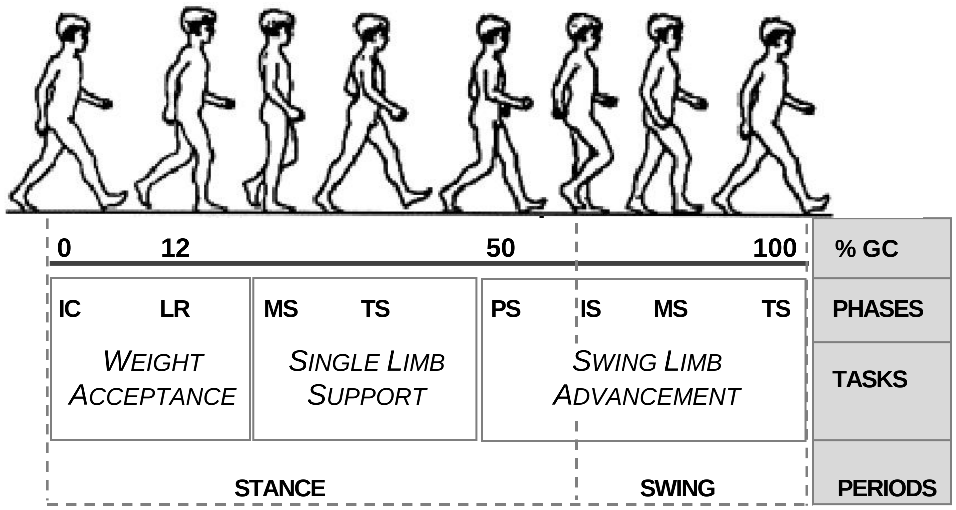
The cooperation with national hospitals to help this specific population may become advantageous, as for the health institutions, since gait biomechanical analysis involves high costs when not for academic purposes[84], as for the faculty itself, since the former can become an extension of the faculty´s educational space.

Regarding this, our investigation intends to establish, for this laboratory, the clinically relevant normative data on healthy children, and associated error (technical error).

In this dissertation it will be presented a brief description of the main theme of this investigation – the normal pediatric gait and its fundamental biomechanical parameters –, followed by the results of the treatment of the collected data, and their discussion in the light of the essential bibliographic references, to give an insight of all the relevant knowledge involved and its evolution through time. All methods and procedures used throughout this investigation will also be detailed. To better understand every procedure and protocol, along the text the reader will be directed to the appendices, where a copy of all the applied forms, protocols and questionnaires is presented.

THE FUNDAMENTALS OF A GAIT CYCLE

The ability to displace oneself while keeping the free use of both hands is a privileged feature of biped animals, best represented and developed to its most specialized form by the Human Being. As this mechanical evolution in the way of displacement is irrevocably connected to the human evolution itself, many efforts have been made to clearly describe and identify the normal way of walking. The best way, the most economical way, the most efficient way of walking, are all themes already explored and thoroughly detailed in the literature[36,40,50,69,77,80]. One of the established methods of approaching Gait is the one presented by Perry[54,55], with the generic terminology proposed by the Rancho the Los Amigos Gait Analysis Committee, as it is more inclusive. According to Perry, the events that take place between two consecutive foot contacts, i. e, one right foot strike and one left foot strike, define a Gait Cycle (GC). This classification focuses on the functional aspects detectable along a GC, dividing each strike in 8 functional phases. Two Periods are considered, the Stance, that begins with Initial Contact (IC), and during which the foot is in contact with the floor, and Swing, that begins with foot-off, and continues as the limb advances to a new floor contact. The Stance has a 60% representation in the gait cycle, and comprises five phases, the IC, the Loading Response (LR), the Mid Stance (MST), the Terminal Stance (TST), and the Pre-Swing (PSW). Along this period, Stance, two moments of double support are detectable, the first beginning with IC and lasting until the end of the LR, where the opposite foot-off occurs, and the second occurring during PSW, when the opposite IC happens. Each double support interval represents approximately 12% of the entire GC, and it is while they occur that the limbs exchange their roles in this cyclic motion of events, that characterize the human gait. As they shorten or even disappear, it informs us that the subject is walking faster, or running, respectively. The Swing takes place on the remaining 40% of the GC. It develops along three phases, the Initial Swing (ISW), the Mid Swing (MSW), and the Terminal Swing (TSW) (see Figure 1).



Source: (adapted)[55]
Figure 1. – Gait Cycle.

The proper performance of these 8 functional phases allows the accomplishment of the three basic tasks: 1) Weight Acceptance (WA), 2) Single Limb Support (SLS) and 3) Swing Limb Advancement (SLA). The WA task is the prevailing one between the IC and LR, as the body weight (BW) must be transferred to the limb that has just ended the Swing. When the heel contact occurs, (at IC), the heel rocker takes place, decelerating the forward motion. The LR begins as the foot descents to a slight plantarflexion that together with a small knee flexion guarantees the necessary shock absorption, while the anterior progression of the body is preserved. This phase lasts until the trailing foot loses the contact to the floor, as the MST phase begins. Here, the SLS becomes the primarily task to ensure. The advancement of the trailing limb until the alignment of the CoM (Center of Mass) over the supporting forefoot happens during MST, beyond that point, the heel rises as a response to an anterior CoM and it concerns the TST phase. This ends just before the other foot contacts the floor. The duration of this unilateral support interval is very revealing per se, as one single limb is responsible for supporting the entire BW, thus closely relating to the stability of gait. Throughout the remaining GC, the SLA is the imperative task, involving the last phase of Stance, PSW, and all the three of Swing, ISW, MSW and TSW. The PSW is initiated as the opposite foot strikes the floor and ends when the foot is lifted from the floor (push-off). This phase occurs with a double limb support, representing the second (terminal) 12% interval of such maximum stability, thus facilitating the acceleration of progression. The ISW occurs when the swinging limb's foot advances from a trailing position, towards the opposite foot, motion achieved when foot clearance is verified. For this, the knee and hip must flex, lifting the foot, and advancing the limb, respectively. While this phase lasts, the ankle is slightly dorsiflexed or neutral. During the MSW phase the limb continues to advance resorting to an increase in hip flexion, until the tibia reaches a vertical position. Hip and knee present equal flexion postures. The position of the ankle remains unchanged. During the final phase of Swing, TSW, the limb continues to advance, mainly due to knee extension, as the hip flexion decreases to approximately 20º. The ankle remains in the previously mentioned position, as it prepares to (re)strike the floor. The percentage at which the gait periods and phases normally occur is published (see Figure 2), and it is the timing of specific kinematic events (described earlier on Table 13) that dictate the end and/or the beginning of each phase.

Stance Phase					**Swing Phase**		
Initial Contact	Loading Response	Mid Stance	Terminal Stance	Pre-Swing	Initial Swing	Mid Swing	Terminal Swing
0 – 2	2 – 12	12 – 31	31 – 50	50 – 62	62 – 75	75 – 87	87 – 100%

Figure 2. – Percentage of the gait cycle events purposed by [56].

Overall, during stance a certain combination of events occur to attempt to dissipate the force of loading, to preserve stability and to assure forward motion, while during swing, a different combination of events attempts to assure foot clearance, (and limb clearance), and maximize progression.

In terms of contribution to locomotion, the human body can be divided into two separate units, the least active one, "passenger unit"(PU), being mainly responsible to keep itself upright and aligned while being carried out by the "locomotor unit"(LU), responsible to dislocate the entire body. The head, neck, trunk and arms constitute the PU, also known by HAT (H, head, A, arms, T, trunk) for that fact (Elftman, 1954 in Perry[59]), and the lower limbs and pelvis form the LU. As the PU represents about 70% of the entire BW and incorporates the CoM in its lower third, its stability and minimal displacement becomes crucial, so that the CoM presents its ideal smooth 3D sinusoidal path as a signal of gait efficiency. The CoM alternates from a highest position during MST, when the supporting limb is vertical (unipodal support), to a lowest, during the two double support intervals, while both limbs are obliquely oriented. When considering the lateral displacement of the CoM, it dislocates from a standing still, low and central position, to an upward and ipsilateral one, during each cycle MST. Overall, the CoM presents a vertical and horizontal dislocation 3.2 +/- 0.8 cm, and 3.5+/- 0.9 cm, respectively. The CoM is among the data collected when performing GA. Once, it was seen as a way to properly estimate the energetic cost of walking. It was assumed that the lower the CoM displacement occurred, namely the vertical, the lower the energy required to walk[36]. Today that belief has been discredited, being replaced by the suggestion of several studies, that an optimal vertical CoM may reflect a lower energetic cost[40]. The displacement of the CoM is still a relevant variable to consider, since pathologic gait usually shows alteration in that displacement. Together with all of the other relevant data (kinetic, kinematic, EMG), it will enrich the GA e subsequent analysis. The vertical component of the CoM displacement is expected to show little variations speed related, with a typical displacement of approximately 2.16% to 2.20% of body height[39].The LU has to adequately position itself according to CoM demands, in a way that guarantees forward progression, while assuring body support on each limb, alternately. The forward progression is preserved through determined low energetic cost mechanical strategies, as the forward fall of the BW; the increasing of the hip flexion of the swing limb (as faster it flexes, the more velocity transmits to the gait); and the decreasing of knee flexion of the swing limb (as faster it extends, the more velocity transmits to the gait). This ability of selectively flex one joint, while extending other to attain a certain goal is described as Selective Muscular Control. To efficiently take advantage of this tool, position and motion awareness are essential, so that the right muscle group can be activated, at the ideal intensity and on the ideal time, either the goal is breaking one movement (eccentric muscular action), or accelerating it (concentric muscular action). Along a GC, muscles that are eccentrically breaking the forward motion, suddenly, and advantageously, become concentric propellers of the forward motion. The functional potential of a muscle increases along with its cross sectional area, and with eventual advantageous leverages, accomplished by ideal joint positions. The best modulated (in terms of time and intensity) the muscle activity, the most refined the control is.

Biomechanical Parameters Of a Gait Cycle

When a pathologic state capable of compromising gait develops, the need to overcome pain or any compensation often undermines the efficiency of gait, altering its characteristics. Although there are several ways of assessing it, the most reliable process of comparing gait performances among subjects involves, unavoidably, measurable data collection. The commonly quantifiable parameters selected to characterize human walking are Spatial and Temporal parameters Kinematics, Kinetics and Electromyographic data. Spatial parameters tell us about step and stride length, base of support width… They are often normalized to specific body structures, becoming non-dimensional. These new non-dimensional variables often clarify variations attributable to musculoskeletal growth alone[76]. Time parameters tell us about walking speed, cadence, duration of the step and stride, single and double supports, stance/swing duration... These parameters are also usually presented in a normalized way, to allow comparisons among subjects, this time to a single stride (usually in the percentage form)[19]. Studies have been conducted to determine the reference values for these variables, and assess their repeatability[2,9,75]. The values reported don't seem to differ much (see Table 1), although it has been stablished that both within and between session variability is expectably higher in children, when compared to adults[75].

Table 1. – Reference pediatric values of Time and Spatial parameters.

Parameters	Mean (SD)*		
	ASSI[2]	STOLZE[75]	FROEHLE[19]
Cadence (steps/min)	112.8	118.4 (11.2)	-
Cycle Time (s)	1.01	1.01 (.086)	-
Unipodal support time (s)	.39	.40 (.041)	-
Double support time (s)	.18	.11 (.011)	-
Foot off (%)	58.00	-	-
Stride length (m)	1.12	1.12 (.126)	-
Step Length (m)	.55	.56 (6.3)	
Walking speed (m/s)	1.06	1.10 (.16)	-
Opposite foot off (%)	7.65	-	-

Opposite foot contact (%)	48.00	-	-	
			Females	Males
Base of support**	-	-	2.53 (.50)	2.48 (.53)
Normalized step length	-	-	.873 (.067)	.845 (.08)

*When available

**Base of support as the ratio between pelvic width and ankle spread

ASSI - individuals aged 5 to 15; STOLZE - individuals aged 6 to 7; FROEHLE - individuals aged 8 to 13.

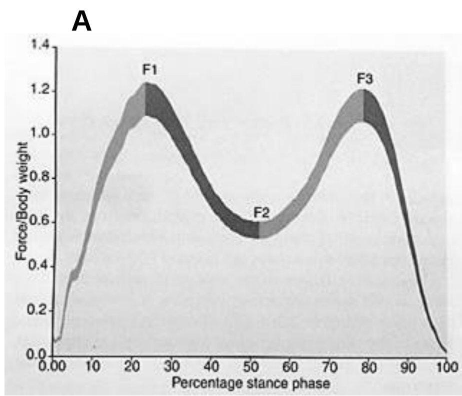
Kinematic data is related to how the segments are moving, ie, the segments' relative position, the linear and angular joint displacement behavior, without regarding the forces acting on the system. Often, to allow a wider comprehension of the individual gait pattern, the results from GA are exposed not just in terms of angular displacement curves, but also resorting to specific spatial, temporal and kinematic events, generally seen as clinically relevant. These are referred to as Gait Indexes, and two are particularly renowned, the Gillette Gait Index (GGI)[66], and the Gait Deviation Index (GDI)[68]. Each of the Indexes resorts to pertinent key kinematic events to detect how much a subject's gait deviates from normalcy, not just looking at a specific joint or muscle, but looking at the overall gait pattern. In the GGI 16 variables were selected for being generally considered relevant in the clinical sense. These variables are "time of toe off", "walking speed/leg length", "cadence", "mean pelvic tilt", "range of pelvic tilt", "mean pelvic rotation", "minimum hip flexion", "range of hip flexion", "peak abduction in swing", "mean hip rotation in stance", "knee flexion at initial contact", "time of peak knee flexion", "range of knee flexion", "peak dorsiflexion in stance", "peak dorsiflexion in swing", "mean foot progression angle". Several studies have been conducted to assess this index's validity, with good results[2,62,83]. In these studies, reference values for each variable were gathered (see Table 2), with a good repeatability, assessed within sessions[2]. The major responsibility of total variability, between and within session, has been attributed to variations/ inconsistency in marker placement, namely when several assessors are involved[45,67]. Generally the sagittal plane reveals higher reliability (with the exception of pelvic tilt), then the coronal plane, and the transverse for last, with values of reliability (CMC or ICC) above .8, between .7 and .8, and below .7, accordingly. The higher variations are usually reported to the hip and knee rotations, and the lowest to the motion of pelvis in the transverse and coronal planes, and hip abduction[45].

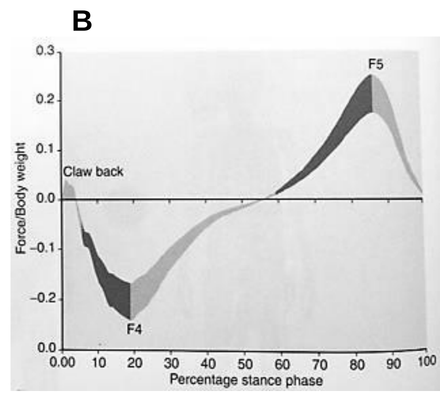
Table 2. – Key kinematic variables constituting the GGI. Reference data for normal individuals.

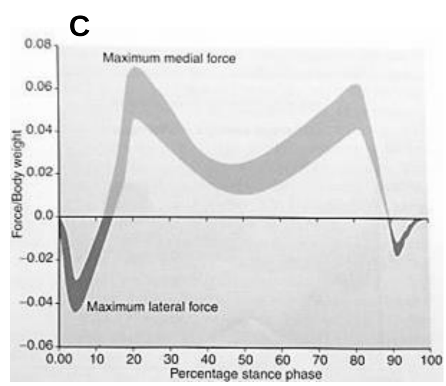
Key kinematic	Mean (SD)	
	ROMEI[62]	ASSI[2]
Time of toe off	58.36 (1.96)	58.09 (1.83)
Walking speed/leg length	1.63 (.13)	1.52 (.30)
Cadence	1.91 (.31)	1.88 (.23)
Mean pelvic tilt	9.43 (5.20)	8.10 (4.00)
Range of pelvic tilt	3.81 (1.25)	3.20 (1.60)
Mean pelvic rotation	-.78 (3.19)	-.04 (2.52)
Minimum hip flexion	-6.59 (6.00)	-5.10 (6.50)
Range of hip flexion	38.98 (4.24)	43.40 (4.50)
Peak abduction in swing	-.16 (3.53)	-8.00 (3.50)
Mean hip rotation in stance	2.03 (8.98)	31.90 (14.00)
Knee flexion at initial contact	6.24 (4.54)	8.50 (6.50)
Time of peak knee flexion	70.06 (1.85)	71.70 (2.30)
Range of knee flexion	56.34 (4.60)	53.60 (8.00)
Peak dorsiflexion in stance	11.68 (3.76)	17.00 (6.80)
Peak dorsiflexion in swing	3.82 (4.08)	9.00 (5.60)
Mean foot progression angle	-11.26 (6.50)	-8.40 (6.70)

ASSI – individuals aged 5 to 15 ; ROMEI – individuals aged 7 to 28.

In the GDI, the variables selected are the pelvic and hip angles, in the 3 planes of motion (pelvic obliquity, tilt and rotation; hip abduction/adduction, flexion/extension and rotation), knee angles in the sagittal plane of motion (flexion/extension), and the ankle angle in the sagittal and transversal planes (dorsiflexion and FPA). Both Indexes show reliable results when assessing gait deviation, ie, the indexes actually report the severity of gait deviation, with higher scores attributed to more severe diagnosis[2,62,66,83]. Although these are the most frequent Indexes used, authors suggest that adding key kinetic events should be a good complement[62]. Kinetic data informs about the forces acting on a system. Usually measurements of Ground Reaction Force (GRF), Moments of Force and Power are use to describe Kinetics, better understood when EMG data is available. The GRF is collected through the Force Platforms (FP), the moments of force are obtained through Inverse Dynamics, and the Power by multiplying the joints moment by its angular velocity. The Inverse Dynamic method resorts to kinematic data and segments' inertial properties to compute the moments of force acting on each joint. When a body is moving, for example, walking, specific forces are acting on that system, internal (weight, force exerted by muscles and other biological structures) and external (GRF, air resistance...). As forces are vectors, their components can be added, and the resultant can be estimated by applying the Newton's Laws of Mechanics. Newton's third law, the law of reaction that concerns the interaction of masses, tells us that for every action, there is a reaction of opposite direction and equal magnitude. This gives us the possibility to infer about the force exerted by the floor on the foot, whenever it strikes the floor, as long as the forces exerted by the body on the floor are measured. The GRF is the reaction force measured in gait analysis and, relating its components, vertical, medio-lateral and antero-posterior, to the joint's position at each GC percentage, one can conjecture about the demands on muscle groups.







Source: RICHARDS (adapted)[59].
Figure 3 – Normal GRF during gait.
All graphics' X axis represent the percentage of stance phase, while the Y axis corresponds to the registered magnitude of Force (N), normalized to body weight (BW; like Mass, measured in kg). (A) Vertical component of the GRF; (B) Anterior-posterior component of the GRF; (C) Medial-lateral component of the GRF. Reference data.

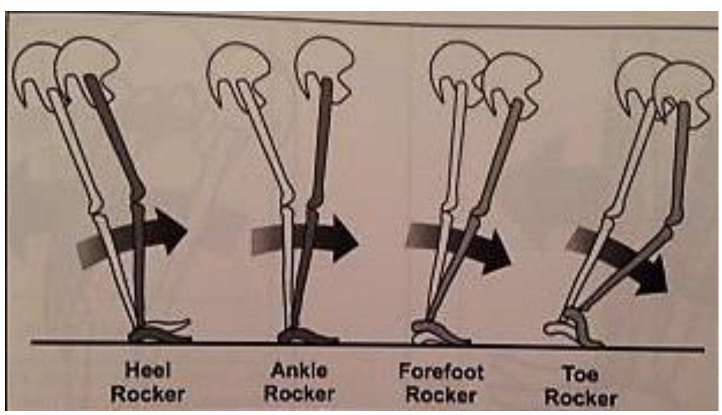
The usual pattern of the vertical component presents two peaks, each reaching approximately 1.2 times the BW, and the dip trough reaching 0.7 of BW. The 1st peak occurs around the 22% of the stance phase, the 2nd around the 78%, and the time to trough happens around 51%. The anterior-posterior component usually presents a maximum posterior loading force around 0.2 the value of BW, and a maximum anterior thrusting force around 0.2 the value of BW. These events occur at 20% of stance, regarding the maximum posterior loading force, 85% of stance for the anterior thrusting force, with the crossing over (moment where no anterior or posterior forces are acting – time of midstance) happening around 55% of stance. Considering the medial-lateral component, it usually presents a maximum medial force between 0.05 and 0.1 of the BW, with the maximum lateral force usually registering a smaller value then the medial (see Figure 3)[59].

When a force is applied at some distance from a joint, a moment is generated (turning effect). It can be presented as an external moment, reflecting the mechanical consequence of the acting force, or as an internal one, reflecting the muscular demands to avoid or control the effects of the acting force, the latter being the most quoted form. Moments are as great as the magnitude of the applied force and perpendicular distance between that force's point of application and the joint center. As moments generate joint motion, the knowledge of joint moments informs about the dominant muscle groups acting on that joint. This information, per se, is not enough to determine the exchanging ways of muscle contraction, even when the EMG data is available. To accurately identify these changes in muscular performance, one must perform a Power analysis, that integrates joint velocity (angular), and moments of force. Power is the rate of change of energy in the system. When moment and angular velocity happen in the same direction it occurs power generation, ie, concentric muscular work. When moment and angular velocity happen in opposite directions, power absorption occurs, ie, eccentric muscular work. Sometimes, the graphics of moment and power will suggest muscle action, and the EMG will not record any activation from the associated muscles. Especially in big joints like the hip and knee, strong ligaments often offer a passive stabilization of the joint, dismissing the need for muscular contraction. The collection of EMG is fundamental for a thorough understanding of kinetic data. Electromyography allows us to analyze the neuromuscular function, namely the muscle activation timing and, if normalization to a maximum contraction value exists, intensity. The EMG signal consists in the electrical activity collection of a contracting muscle, as it produces muscle action potentials. The signal shows the representation of the sum of all muscle action potentials.

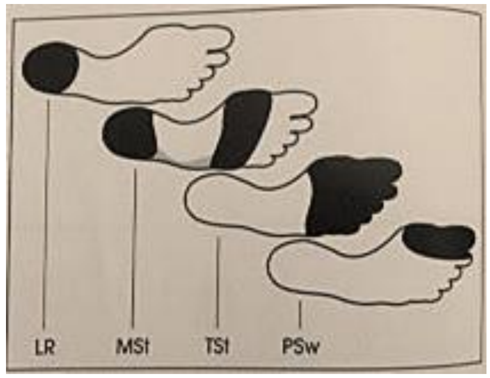
The analysis, normalization and detailed description of all these data enable a comparison among individuals, and eventual identification of deviations from the regular pattern. Also, as each joint presents a typical biomechanical behavior, it is pertinent to consider them individually.

BIOMECHANICS OF THE ANKLE JOINT

The specificities of the ankle joint, are necessarily related to the behavior of the ”foot” segment. The foot motion can be described by 4 known rockers[56], the heel rocker, the ankle rocker, the forefoot rocker, and the toe rocker (see figures 4 and 5). The first rocker, heel rocker (heel support), begins with heel strike at IC. It is preserved until the end of LR by the eccentric decelerating action of the pretibial muscles, that allow a controlled foot drop, without slapping. The ankle rocker (foot-flat support) happens on the stationary foot, when dorsiflexion occurs by the advancement of the tibia, excentricaly decelareted be the soleus action. The forefoot rocker (forefoot support) happens when the BW line reaches the metatarsal heads, forcing the heel to rise. The forward advancement of the CoP accelerates body progression, which is being excentricaly controlled the gastrocnemius and soleus muscles. At last, the toe rocker (first metatarsal and toe support) consists in the elastic recoil of the plantarflexor muscles, potentiated by the stretched Aquilles tendon, leading to the propulsion at the end of PSW.

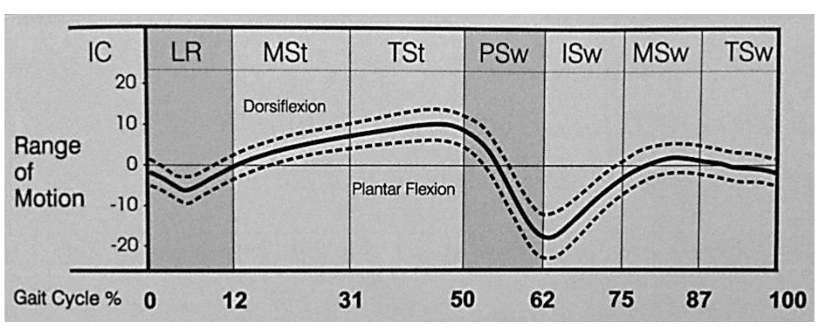


Source: (adapted).[56]
Figure 4. – Foot Rockers.



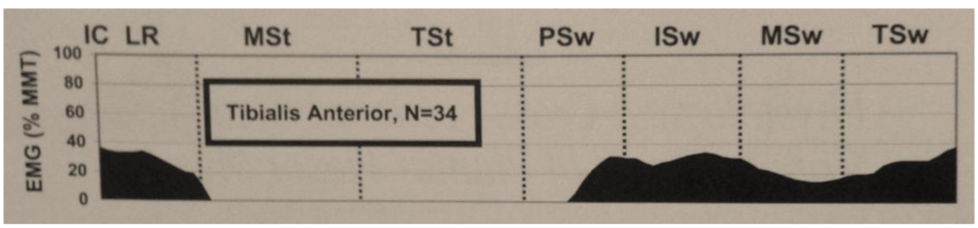
Source: (adapted).[56]
Figure 5. – Sequence of Foot Support during Stance.
Heel support during LR, foot-flat support in MST, forefoot support in TST, first metatarsal and toe support during PSW.

During a normal GC, the ankle joint alternates between two saggital positions. During the ST it assumes a plantarflexion (PF) position during LR and PSW, and dorsiflexion (DF) during MST and TST (see Figure 6). The total range of motion (ROM) reaches, approximately, 25º. At the LR there's a peak of approximately 5º of PF, and at the end of TST it reaches 10º of DF, with the heel rising about 3.5 cm. This heel rise lengthens the trailing limb in TST, and when this rising fails, an ipsilateral hip drop occurs to compensate. During the terminal double support, as the BW is transferred to the leading limb, the trailing ankle is allowed to transition from a 10º of DF to a 15º of PF, as the foot rotates (torques) over the great toe. At the onset of ISW, a rapid ankle DF occurs to assure foot clearance. At the early beginning of MSW, a neutral ankle position has been reached, and then a slight DF (+/- 2º) is verified. As the swing limb prepares a new strike, reaching forward for a full step length in TSW, the ankle appears neutral, and may present about 2º of PF.



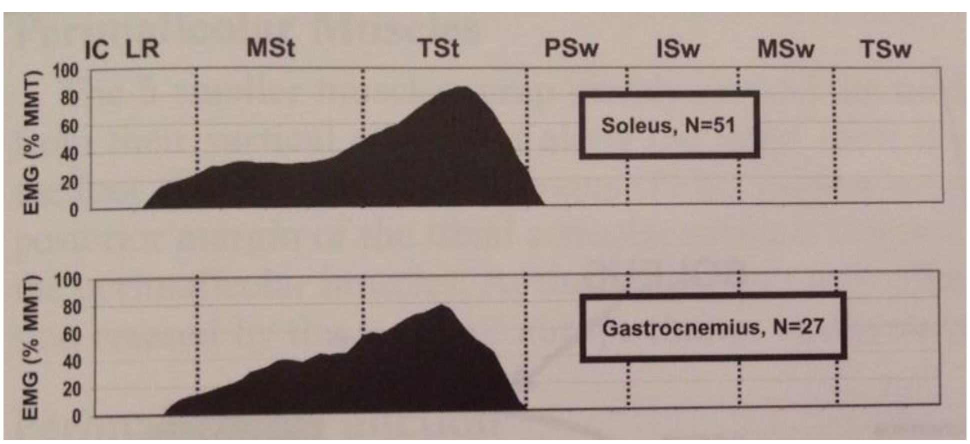
Source: (adapted).[56]
Figure 6. – Normal Joint Angular Displacement of the Ankle joint.
(mean – black line – +/- one standart deviation – dotted line).

Regarding the muscle action, the DF muscles (see Figure 7) are active during IC and LR to decelerate the PF, and provide foot control during swing. The onset happens during PSW, and it remains active until the next GC (until the end of LR), showing a biphasic action. During the IC, the DF muscles show an excentric action (restraining foot drop), and change to concentric in the final half of LR (drawing the tibia forward). During ISW the muscle action remains concentric, changing during MSW to isometric, and remaining this way throughout the TSW. Two peaks are identifiable, the first reaching about 35% MVC (maximum voluntary contraction) during LR , and the second reaching about 37% MVC during TSW. During MSW the contraction reaches about 14% of MVC. The PF muscles (see Figure 8) remain active throughout ST. The onset happens roughly around the 7% of GC (LR), and its action ceases by the onset of PSW. One evident peak happens in the middle of TST (about 40% of the GC, with an intensity of approximately 78% MVC). It is possible to find muscle activity during the MSW.



Source: (adapted).[56]

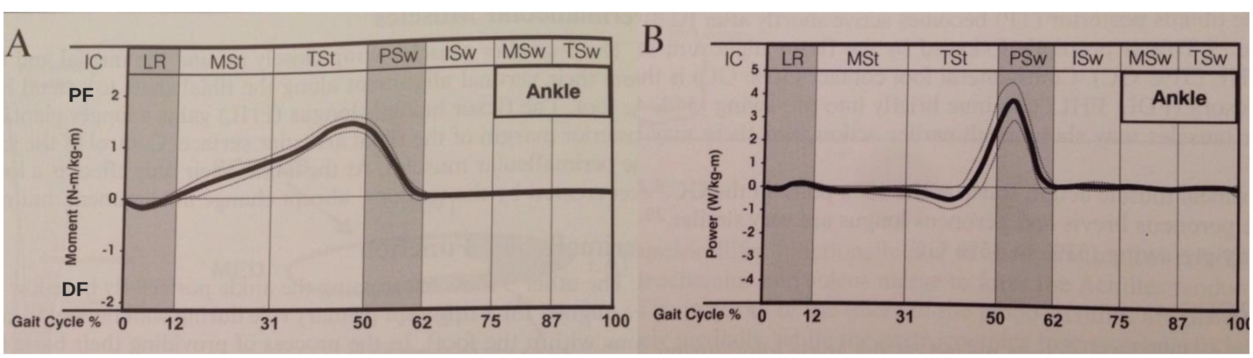
Figure 7. – Normal mean intensity and timing of the ankle DF muscle Tibialis Anterior during a GC.



Source: (adapted).[56]

Figure 8. – Normal mean intensity and timing of the ankle PF muscles, Gastrocnemius and Soleus, during a GC.

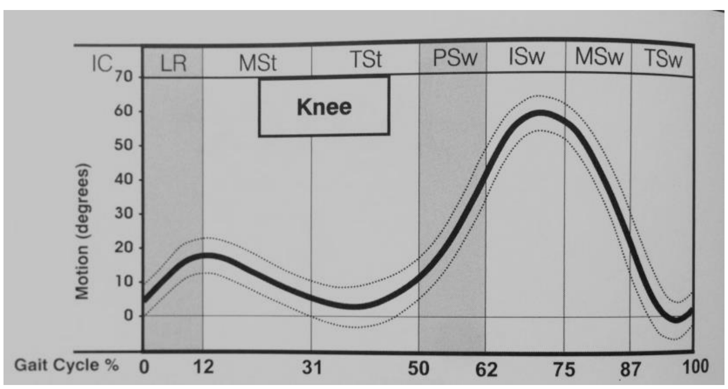
As the foot strikes the floor, the weight line is centered in the heel, which implies it is passing behind the ankle joint, generating a dorsiflexor moment that controls foot lowering (0.18 N.m/Kg.m at 4% GC). This action involves an eccentric behaviour of the DF muscles to prevent a foot “slap”, identifiable on the absorption power peak of approximately 0.15W/Kg.m at 3% GC. As the body moves forward, the vector crosses the ankle joint to an anterior position, and the dorsiflexor moment drops to zero. The low amplitude power generation shown in the Power curve reflects the ongoing concentric work of the DF muscles, drawing the tibia forwardly. During the unipodal support, between the two double support intervals, as the weight vector moves further ahead of the ankle joint, an increasing plantarflexor moment peaks just before the opposite foot strikes (TST) (1.40 N.m/Kg.m at 47% GC). This, together with a corresponding power absorption peak of 0.54 W/Kg.m at 40% GC, reflects the eccentric action of the PF muscles in the effort to limit the dorsiflexion to 10º, thereby preventing an unnecessary vertical displacement of the CoM. This eccentric effort maintained by the PF muscles during TST provides an accumulation of potencial energy, fully explored through the elastic recoil of the stretched tendon, as the BW is transferred to the opposite foot, finally allowing a significant gain in the plantarflexion of 25º (10º of dorsiflexion changing to 15º of plantarflexion). This is represented by a positive power peak (3.7W/Kg.m at 54% GC). This event is commonly called push-off and it is one of the propulsive forces that contributes for the advancement of the swinging limb. During swing, a very low dorsiflexor moment stabilizes the dorsiflexed position of the foot, assuring foot clearance. (See Figure 9).



Source: (adapted).[56]
Figure 9. – (A) Normal ankle internal moments during a GC; (B) Normal ankle joint power during a GC. In graphic (A), plantarflexor (PF) moments alternate with dorsiflexor (DF) moments; In graphic (B) periods of power absoption ((-) often related to an eccentric action), alternate with periods of power generation ((+) often related to concentric action).

Associated to its central position on the LU, linking two of the body's longuest bones, knee stability is a major determinat for the overall stability during ST. It presents the biggest arc of movement and during SW, its flexibility is a determinant factor on limb advancement.

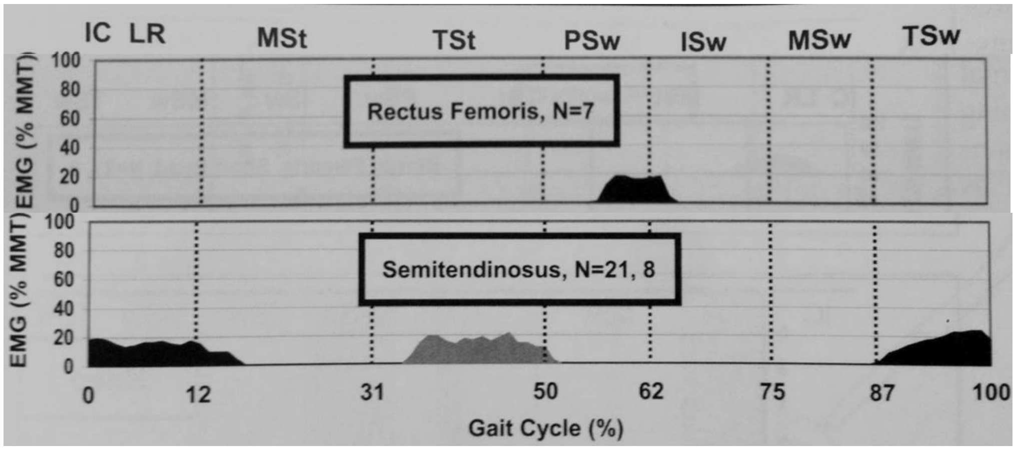
During these 60º of ROM, the knee presents two flexion peaks, the first, of 20º, in the transition between LR and MST (shock absorption related), and the second, of 60º, during ISW (foot clearance related). During IC the knee usually presents a 5º flexion, though it can vary between 0º and 10º, especially when velocity changes are present. After the first peak, at the end of LR, the flexion posture begins to drop until it reaches a minimum at the middle of TST (5º), and then, again, increases flexion. By the end of TST (opposite foot strike) it reaches 10º, and during PSW (as the toe rocker happens) it increases rapidly, reaching 40º. By the middle of ISW it reaches a 60º peak, lowering from this point on, as less knee flexion is required to assist foot clearance. Full extension is reached slightly before the end of TSW, and then a 5º flexion posture is attained by the end of the GC. (See Figure 10).



Source: (adapted).[56]
Figure 10. – Normal Joint Angular Displacement of the knee joint.
(mean – black line – +/- one standart deviation – dotted line).

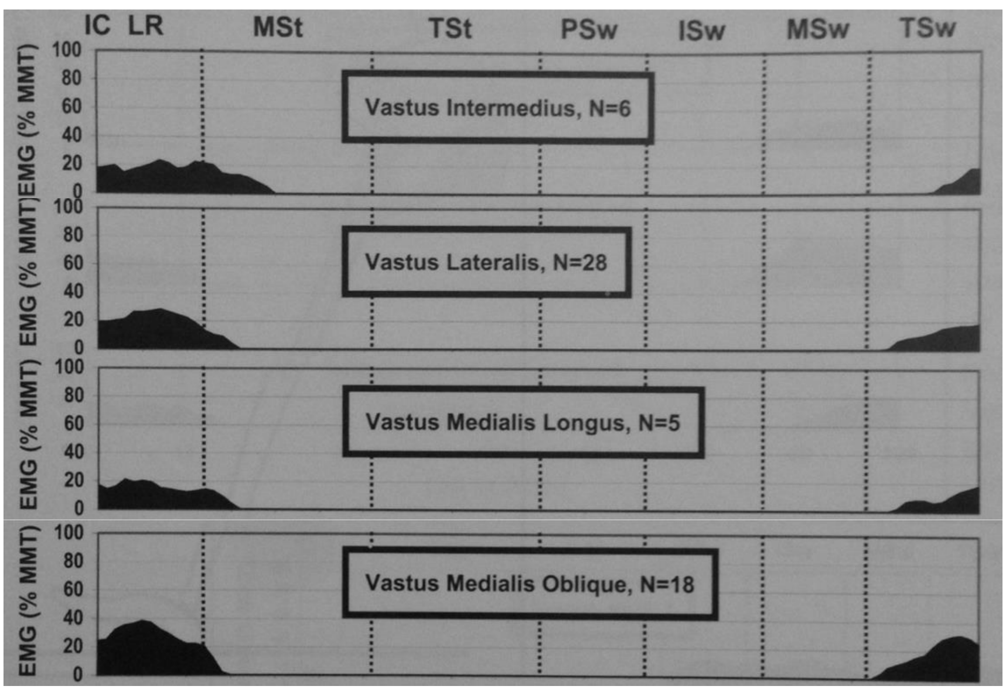
The rectus femoris has a short period of activity, during late PSW and early ISW (eccentrically controlling knee flexion while flexing the hip). The semitendinosus onsets with the beginning of TSW, and ceases during MST. Gastrocnemius also acts as a knee flexor. (See Figure 11).

At IC 2 mechanisms that promote extension are present, a joint anterior vector and activity of the vastii muscles (see Figure 12). To assure joint stabilization, the quadriceps is acting anteriorly, and the hamstrings posteriorly, to avoid hyperextension (see Semitendinosus, Figure 10). As the foot drops, the vector becomes posterior to the joint, and the quadriceps eccentrically resists it, limiting knee flexion to 20º. The activity of the hamstrings gradually diminishes, as their proeminent role is to prevent hyperextension at IC. During early MST the vastii work concentrically to advance the femur over the tibia, attaining 15º of flexion. In late MST, as the vector crosses the joint anteriorly promoting hyperextension, the posterior capsule and tendinous structures resist against it. By the middle of TST the knee flexion reaches 5º. As the BW tends to fall forward, some individuals show activity of some of the hamstring muscles (namely the Semitendinosus) as well as the gastrocnemius, as they act preventing hyperextension. When the maximum extension is reached, the knee begins to flex, and as BW crosses the metatarsophalangeal joints (forefoot rocker), the knee crosses the vector line. The muscles acting before to prevent hyperextension now act to flex the knee, as the heel rises. As the opposite foot strikes (beginning of PSW), an abrupt weight transfer occurs, relieving the contact of the foot in toe rocker position. This and the strongly active calf muscles, allow the tibia to roll forward. The heel rising is accelerated and the kee flexes to a 40º posture. This flexion is eccentrically controlled by the RF (Rectus Femoris), that also acts as an hip flexor. The limb is now prepared for toe clearance during SW. During ISW the knee continues to flex to a 60º position, to assure clearance. This way, the equinus position of the trailing foot and consequent increased limb mechanical length, is compensated. During MSW the knee begins to passively extend until TSW, ie, when the tibia reaches a vertical position. Then, the hamstrings are activated to control knee extension. The quadriceps is also activated during this late SW to assure knee full extension. The RF is not requested here, as it would undesirably augment hip flexion.



Source: (adapted).[56]

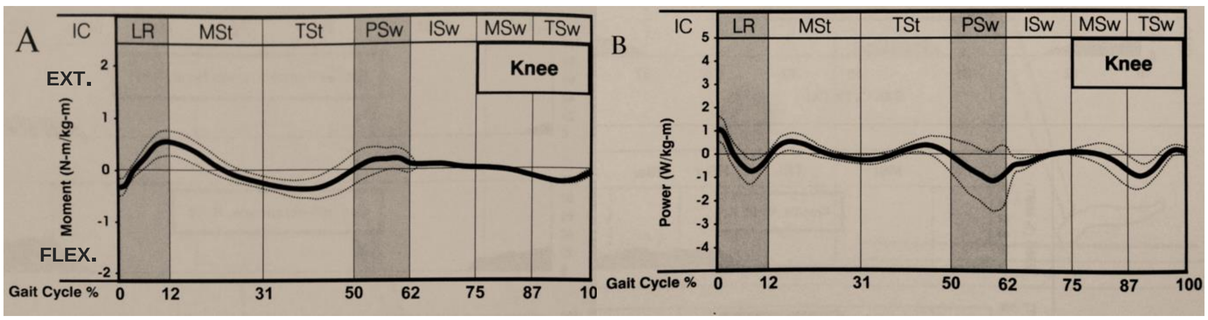
Figure 11. – Normal mean intensity and timing of the knee joint extensor (rectus femoris) and flexor (semitendinosus) muscles during a GC.



Source: (adapted).[5]

Figure 12. – Normal mean intensity and timing of the knee joint extensor muscles during a GC.

At IC the weight vector is anterior to the knee joint, generating a short low amplitude flexor moment (0.35N.m/Kg.m), with power generation (1.0W/Kg.m; concentric action from knee flexor muscles), that avoids hyperextension. During LR the knee flexes and an extensor moment stabilizes the joint, preventing its collapse (0.52N.m/Kg.m) with power absorption (0.8W/Kg.m; eccentric action of the knee extensor muscles). At the beginning of MST a small power generating peak increases knee extension (concentric action of the quadriceps). This moment gradually diminishes and, by the end of MST, a flexor moment appears, being kept through the TST. During PSW and ISW a low amplitude extensor moment controls the knee flexion with a peak power absorption of 1.2 W/Kg.m (eccentric activity of RF). Is late SW the flexor moment increases (0.26N.m/Kg.m) as the knee extends with power absorption (0.9W/Kg.m), with the hamstrings eccentrically controlling the knee extension. (See Figure 13).



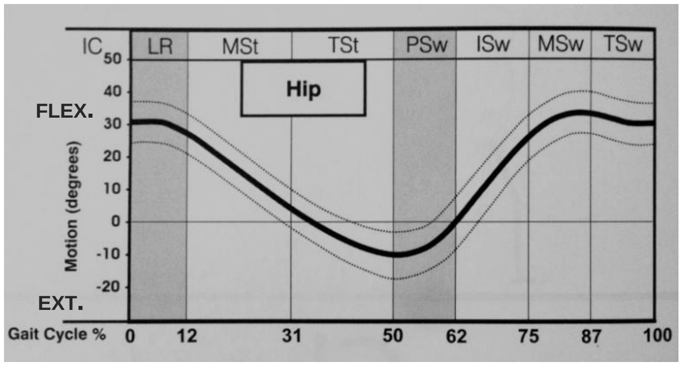
Source: (adapted).[56]
Figure 13. – (A) Normal knee internal moments during a GC; (B) Normal knee joint power during a GC. In graphic (A) the extensor (EXT) moments alternate with the flexor (FLEX) moments; In graphic (B) periods of power absoption ((-) often related to an eccentric action), alternate with periods of power generation ((+) often related to concentric action).

Biomechanics Of the Hip Joint

The hip angular behavior may be assessed as the relative angle between the thigh and pelvis (ie, pelvic-femur angle), or between the thigh and the vertical. If the first relative angle is selected, one must be aware of the pelvic motion influence. For this, some authors defend that the angle should be related to the vertical. However, the influence of the pelvic motion becomes more relevant in pathologic gait, as in normal gait its range is very small, thereby having a slight influence.

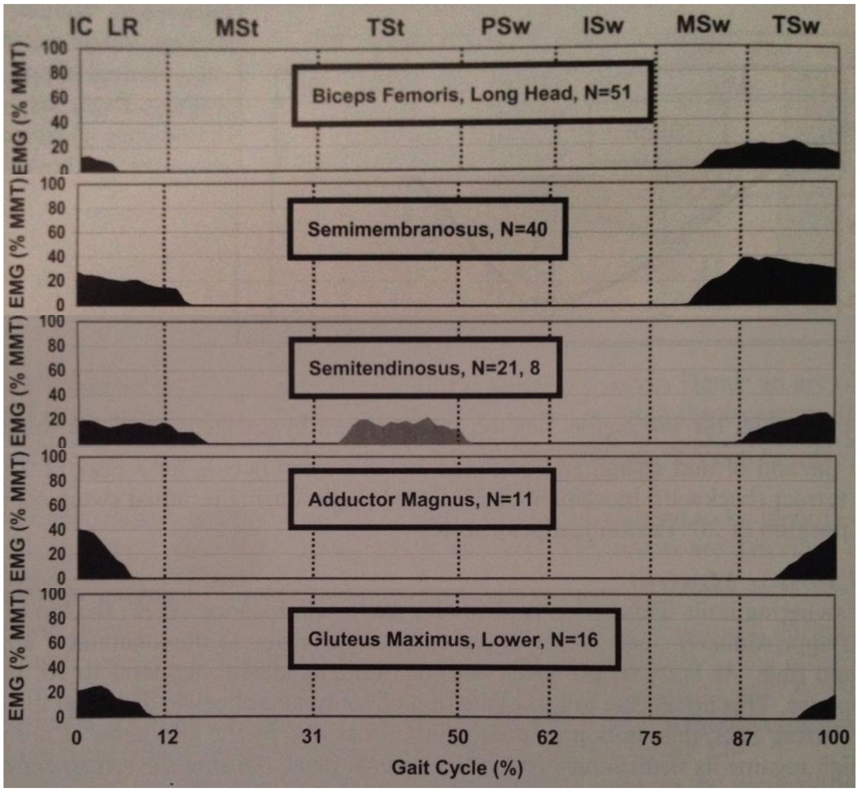
During ST, the hip is very important for the stabilization of the trunk (PU), and during SW it is crucial to limb advancement. Its ROM varies from 30º flexion to 10º of extension (ie, 40º of total ROM). Hip muscular demands are greater during SLS, diminishing with limb advancement (see Figure 14).

At IC the approximately 30º of flexion represent the ideal compromise between step length (forward motion) and hip stability. If the step is exaggerated, the foot may become slippery (compromising stability), if the step is too small, it would slow the progression (forward motion). During LR, the lower portion of the gluteus maximus and the adductor longus, as the extensors only acting at the hip joint, are the most active ones, although all 5 are active.By the end of this phase, an adduction of 10º is present on the ipsilateral hip (weight bearing limb) As the BW is transferred onto the leading limb, there's a necessity to actively stabilize this hip. The unsupported contralateral hip created a necessity to control the drop tendency, so the abductor muscles react, with a power absorption of 0.75W/Kg.m. By the end of LR, there's a peak of internal rotation. During early MST the action of the vastii contributes to knee extension, which promotes hamstrings activation, leading the hip to extend (power burst of 0.72W/Kg.m). During late MST, the hip crosses the weight vector, dismissing the need for the extensors to act. During TST an apparent hyperextension occurs as the limb progresses to a trailing position (forefoot rocker) and the anterior portion of the fascia lata activates to control the extension, as well as the adductor longus, that peaks during late TST. During PSW the toe rocker, with the simultaneous and continued action of the RF restraining knee motion contributes to hip flexion. Around mid PSW there's an abduction peak (+/- 5º), just before toe-off. The adductor longus and gracilis also promote flexion. In the beginning of ISW, the hip is in its most external rotation posture. The action of gracilis (adductor, internal rotator and flexor) is balanced by the sartorius (abductor, external rotator and flexor), increasing hip flexion by 20º (limb clearance), and inducing knee flexion, desirable at this stage (foot clearance). During MSW the hip continues to flex (adds 10º), mostly in a passive way, with minimal or absent muscular effort. During TSW the muscles start to prepare a new foot strike by limiting further flexion, namely the hamstrings, that also contribute to knee deceleration. During late TSW, the hamstrings lower their intensity, being replaced by the gluteus maximus and adductor magnus. Also, the gluteus medius is active to counteract the adduction action from the single joint hip extensors. As the foot strikes, the hip presents a little internal rotation, probably related to the stronger medial hamstrings.



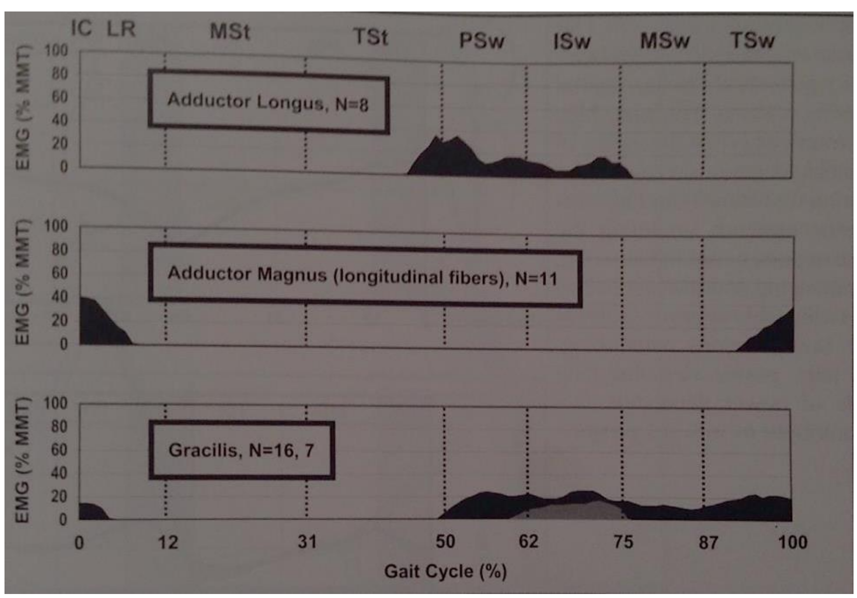
Source: (adapted).[56]
Figure 14. – Normal Joint Angular Displacement of the hip joint (pelvic-femur angle). (mean – black line – +/- one standart deviation – dotted line).

During ST, extensors and abductors are the most active hip muscles, during SW, the flexors are. The muscles involved in the hip extension are the hamstrings, the adductor magnus and the lower portion of gluteus maximus. They all cease their activity by the end of LR, except the semimembranosus end semitendinosus, that cease activity during early MST. All hamstrings onset their activity at late MSW, and all peak during PSW. Both the adductor magnus and lower portion of gluteus maximus, onset at late TSW, peaking during IC. The muscles involved in hip abduction are gluteus medius, upper portion of gluteus maximus, and the tensor fascia lata. Both gluteus show similar activation patterns, with the onset around late TSW, a peak during LR, and cessation during MST. The anterior and posterior portions of the tensor fascia lata show different activation patterns, with the anterior activating during TST, and the posterior activating with the beginning of LR. The muscles involved in hip flexion are the adductor longus, adductor brevis, gracilis, rectus femoris (RF), sartorius and iliacus. They present an overall low activity, although it tends to increase with varying walking speed. The adductor longus onsets in late TST, peaks as PSW is initiated, and ceases activity by the end of ISW. The adductor brevis shows similar behavior to that of the adductor longus (yet to be confirmed). The gracilis onsets at the beginning of PSW, peaks during ISW, and ceases by the beginning of LR. Rectus Femoris presents an inconsistent activity. It activates during PSW and ceases during early ISW. The sartorius and iliacus muscles show similar behavior to that of RF. The muscles involved in hip adduction are the adductor longus, adductor magnus, and gracilis. Adductor longus and gracilis also have a flexor function, and the adductor magnus have an extensor one. (See Figures 15, 16, and 17).



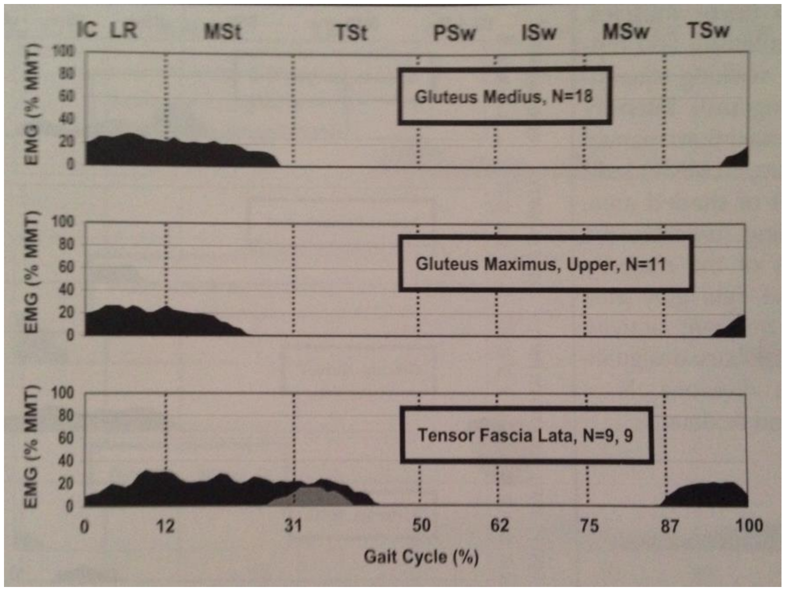
Source: (adapted)[56]

Figure 15. – Normal mean intensity and timing of the hip joint extensor muscles during a GC.



Source: (adapted)[56]

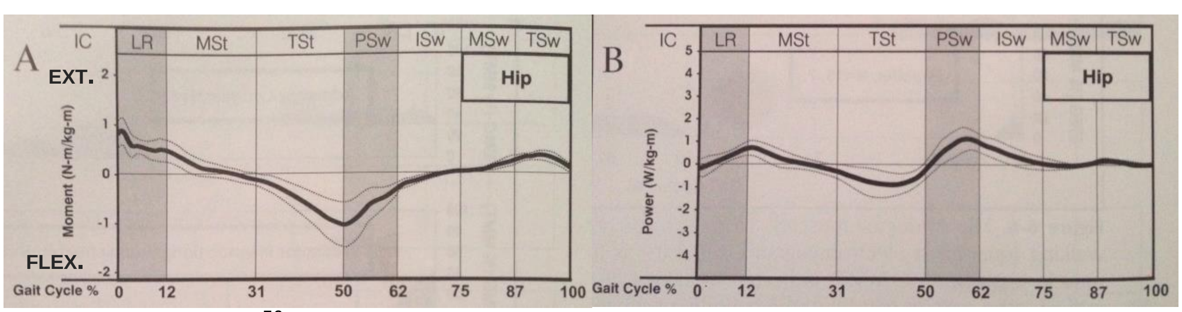
Figure 16. – Normal mean intensity and timing of the hip joint adductor muscles during a GC.



Source: (adapted)[56]

Figure 17. – Normal mean intensity and timing of the hip joint abductor muscles during a GC.

At IC, the hip shows a 30º flexion posture, and the vector passes very anteriorly to the joint, creating a huge leverage and, therefore, a peak in the extensor moment of 0.84N.m/Kg.m. This extensor moment progressively decreases, and by the end of LR, the extensor moment has already reached half of its peak value. Here, a peak in power generation of 0.72W/Kg.m contributes to hip extension. During MST the vector crosses the joint and the previous extensor moment changes to a flexor one. This moment continues to augment until it peaks at the beginning of PSW (.06N.m/Kg.m). With the BW being transferred to the opposite limb, the flexor moment declines, and a new power generation peak (1.14W/Kg.m) appears, reflecting the low level activity of the hip flexor muscles. During late SW the rate og thigh extension is controlled by the action of the hamstrings (low extensor moment). (see Figure 18).

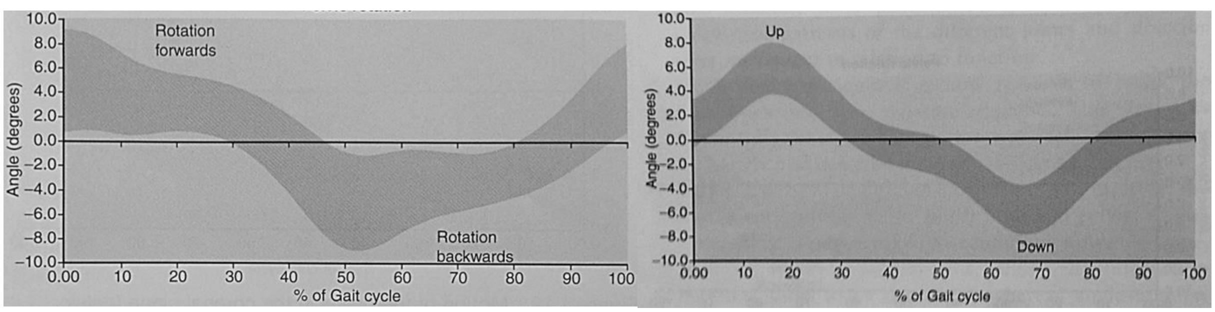


Source: (adapted)[56]

Figure 18. – (A) Normal hip internal moments during a GC, (B) Normal hip joint power during a GC.
In graphic (A) the extensor (EXT) moments alternate with the flexor (FLEX) moments; In graphic (B) periods of power absoption ((-) often related to an eccentric action), alternate with periods of power generation ((+) often related to concentric action).

During a regular GC (see Figure 19) the pelvic bone presents a rotation ROM of 4º in the frontal plane, and a 10º rotation ROM in the transversal plane. The actual motion occurring in the sagittal plane is approximately 4º, and it happens around the physiological anterior tilt of 10º. The pelvic sagittal motion is intimately related to the hip sagittal motion. Then, when the hip increases flexion (IC), the pelvis is expected to tilt posteriorly, and as the hip goes to extension, the pelvic bone is expected to tilt anteriorly (PSW).

At IC the pelvis presents 5º of forward rotation (contributing to augment step length), with no frontal asymmetric drop. During LR a contralateral drop of 4º occurs, as a response to weight transferal. At MST, both rotations are neutral, and in TST a backward rotation (transverse plane) of 5º occurs, being kept through PSW, as an ipsilateral drop of 4º also occurs, as response to the opposite foot strike. The 5º of backward transverse rotation is preserved during ISW, and the rotation in the frontal plane returns to 0º. Only during MSW the transverse rotation also reach 0º, as it happened during MST, as these two are transitional phases. During TSW, the transverse plane rotation reaches 5º, now in the forward direction, as a new foot strike is prepared.



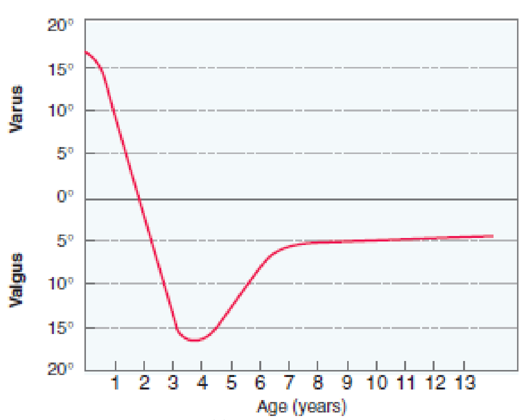
Source:(adapted) [59]
Figure 19. – Normal Joint Angular Displacement of the pelvic bone.
(A) Motion in the transverse plane, with forward, or backward rotations; (B) Motion in the frontal plane, with interchanging lateral drops.

The abductors and extensors of the hip joint are also the major muscles controlling the pelvic bone. The upper portion of gluteus maximus and gluteus medius onset during late TSW, peak around LR and cease around mid MST. During LR the contralateral pelvic drop is decelerated by the ipsilateral hip abductor muscles. As one limb becomes unloaded, the pelvic bone is free to rotate forward.

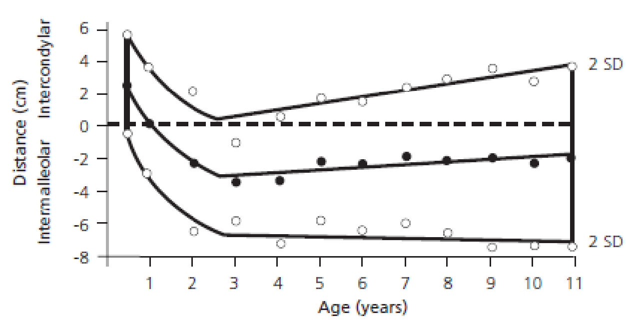
All of the joints parameters, whether angular, force, or EMG related, show significant changes when a variation in the self-selected walking speed is imposed[56, 69].

<u>Orthopedic Fundamentals of a Child</u>

A frequent source of parents concern, and, therefore, orthopedics consultation is related to torsional or angular issues, in the transverse or frontal plane, respectively[31,18,72,53]. Whether it is bowlegs, knock-knees, in-toeing, or out-toeing, the knowledge of the normal variants for limb rotation and angulation for a determinate state of development it is fundamental. As the regular child development involves/implies considerable changes, with inversion of rotation and angular patterns, the knowledge of the healthy variations is determinant when identifying and managing any possible orthopedic deformity. When the child is born, it is expected to present a geno varum, with an intercondylar distance up to 6 cm, or with a tibiofemoral angle up to 16/17º. This geno varum presentation should evolve towards neutral and valgum presentation by the age of 2/3 years. Around 3 or 4 years of age, the child should present a peak in geno valgum up to 15º/16º in the tibiofemoral angle, with an intermalleolar distance of approximately 6 cm. By the age of 7 or 8, the geno valgum reaches about 5º of tibiofemoral angulation, and approximately 2 cm of intermalleolar distance. Little variation is expected from this point on (see Figures 20 and 21; see Table 3).



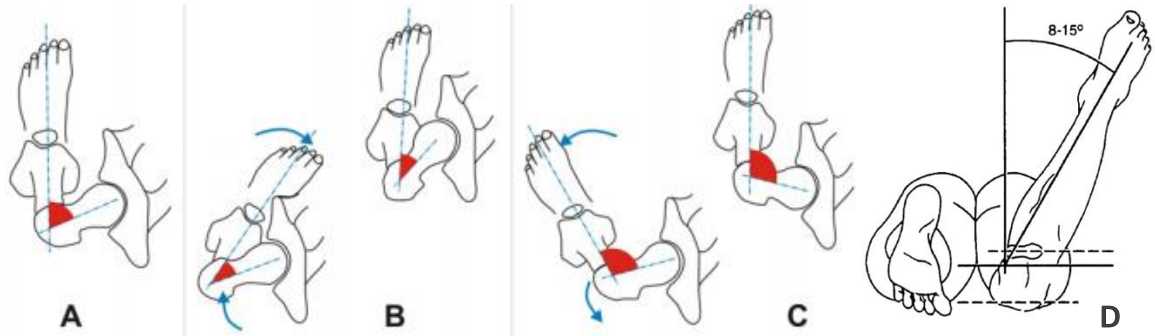
Source:(adapted) [29]
Figure 20. – Femoral-tibial angle behavior in the healthy child



Source: (adapted) [53]
Figure 21. – Intercondylar and intermalleolar distance in the healthy developing child.

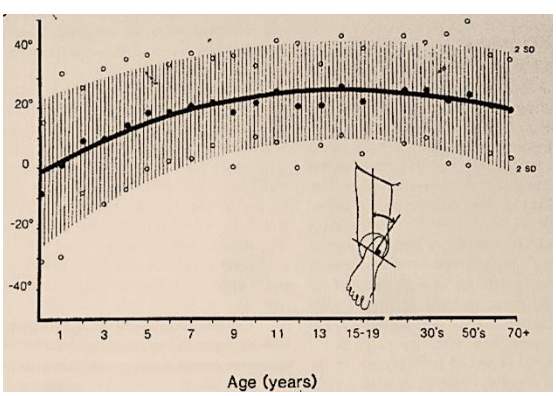
Some confounding characteristics may interfere with the diagnosis of really augmented geno valgum, such as fat thighs, ligamentous laxity, pes planus and increasing in the femoral anteversion angle. The occurrence of asymmetric geno angular presentation is a suggesting factor of actual pathology[73]. It is important to distinguish the contributions of each plane (frontal and/or transverse) to the actual potential deformity, since they may coexist, and the augmented torsion may be misinterpreted as angular deformities, due to optical illusion. A full examination should take place when diagnosing a developing child. Measures of available range of motion (ROM), femoral and tibial version, ligament laxity, weight (high to percentile often related with alterations in the angular pattern[29,73]), height (low to percentile heights are often related to potencially pathologic torsion or augmented angular presentations[29,73]), and inferior limbs length should be collected, and compared with age-matched reference values[29,73].

Collection of the ROM values for all of the lower limb joints is a regular clinical assessment procedure. The normal ranges of ROM for each joint tend to vary according to gender and age. It is well stablished that a physiological decrease in the overall ROM occurs as age increases[47]. The child is usually born with some joints ROM increased, while others show limitations. Flexion contractures are frequent, namely on the knee (with flexum up to 45º, as long as no other pathologic associations occur) and hip. The hip internal rotation and plantarflexion of the tibiotarsal joint are also often decreased. However hip external rotation and tibiotarsal dorsiflexion are usually augmented. The ROM of all joints tends to approximate to the regular adult value as soon as the 3rd month, with the flexion contractures resolving spontaneously, except for the hip, that continues to adjust its internal and lateral rotations until the age of 2 (upper limit). It is expectable that children exhibit higher joints ROM, as they present higher laxity then adults. The same thing can be said about the female gender, relative to the male gender, for the same reason. The knee joint, in particular, may exhibit some degrees of hyperextension, beyond the physiological full extension (0º), that tend to decrease as age increases[29]. The specific evolution of the hip medial and lateral rotations reflects the evolution of the femoral version[47]. The angle of femur anteversion consists in the relative angle between the femoral neck axis, and the femoral shaft axis, in the coronal plane (see Figure 22, A, B, C). It is measured with the child lying prone, hips extended, ipsilateral knee flexed to 90º, and tibiotarsal joint in neutral position. The femoral anteversion angle is given by the angle between the axis of a virtual line, perpendicular to the table, and projecting from the centre of the thigh, and the axis of the leg (axis projects towards the 2nd toe), in the transverse plane (see Figure 22, D).

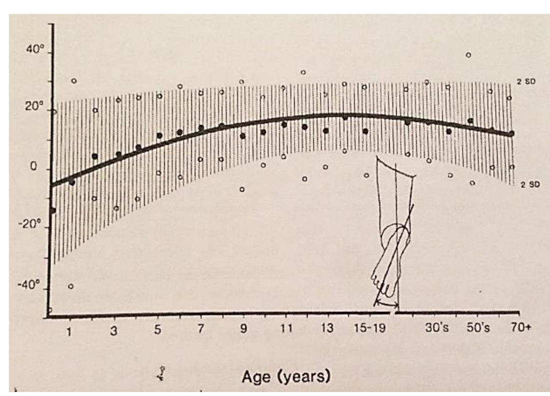


Source: https://www.iadms.org/page/325 **.** (adapted)[86]
Figure 22. – Femoral version; A – Physiological anteversion (16º); B – Femoral antetorsion (augmented femoral anteversion); C – Femoral retroversion; D – Assessment of the femoral version, with the femoral neck parallel to the table top.

It is a crucial measure, not only per se, but also when assessing the relative tibial version. The tibial version angle refers to the rotation of tibia in the transversal plane, in relation to the femur. It is usually expressed by the angle of the transmalleolar axis (see Figure 23) or the thigh-foot angle (see Figure 24). The assessment is executed with the child lying prone, hips in extension and ipsilateral knee flexed to 90º, and tibiotarsal joint in the neutral position. The angle of the transmalleolar axis is given by the angle between the axis of the thigh, and the axis of a virtual line towards the heel, perpendicular to another virtual line that crosses the center of the malleolus. The thigh-foot angle is given by the angle between the axis of the thigh and the axis of the foot (if the bisector line of the hindfoot falls on the 2nd toe, if not, the bisector line of the hindfoot axis should be the reference).



Source: (adapted)[72]
Figure 23. – Tibial version reference values measured with the angle of the transmalleolar axis method.



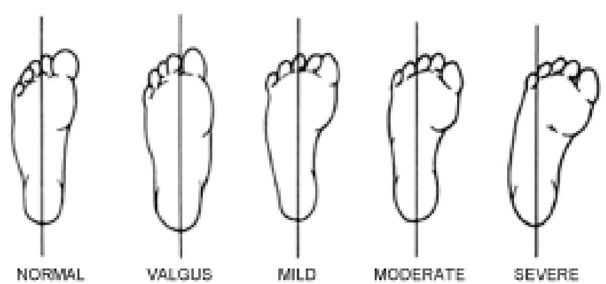
Source: (adapted) [72]
Figure 24. – Tibial version reference values measured with the thigh-foot ankle assessment method.

Table 3. – Tibial version and femoral anteversion reference values for the 7, 8 and 9 year old child.

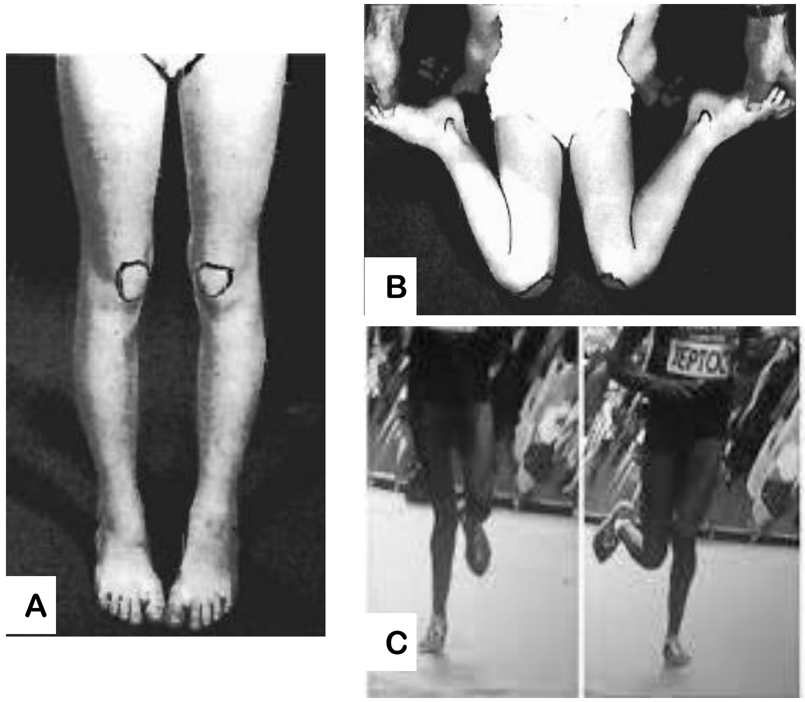
		7y	8y	9y
Femoral Anteversion (º)	Female	31	26.69	18.14
	Male	16.27	12.03	13.11
Tibial Version (º)	Female&Male	33.82	34.53	36.25

Source: (adapted) [33]
The tibial version in presented with the transmalleolar axis assessment method.
y – years old.

The torsional relation of the segments femur and tibia assumes more frequently four possible combinations, normal femoral anteversion (internally rotated), with normal tibial version (externally rotated), this being the most common presentation; normal femoral anteversion, with low tibial version (internally rotated); augmented femoral anteversion, with normal tibial version; and, augmented femoral anteversion with diminished tibial version, the least common presentation torsional profile[33]. The femoral retroversion is a less common torsional presentation, usually accompanied by an excessively laterally rotated tibia, and frequently indicator to relatively urgent surgical correction, as it tends to evolve to osteoarthrosis. The angle of femoral anteversion shows a physiological tendency to decrease, from 32º in the 1 year old child, to 16º, stablished approximately at 16 years of age. It presents symmetrically, with the female gender presenting higher angles (intimately related with the female wider pelvic span[29]). The tibial version increases with age, usually from 5º to 15º at maturity, though it presents little changes after 5/6 years of age[18]. It presents symmetrically, and equally among genders. When the value of physiological version exceeds +/- 2SD from the mean, it becomes torsion, a deformity[72]. The combination of torsions between these two bones leads to the well-known presentation of intoeing or out-toeing. The intoeing is usually related to the presence of metatarsus adductus (more frequent in the female gender; alone or with internal tibial torsion, it is the main cause of intoeing in the first year of life), internal tibial torsion (frequently asymmetrical, equally distributed among genders; together with the metatarsus adductus [see Figure 25], it explains the majority of intoeing clinical cases in the toddler), and femoral antetorsion (main cause of intoeing during childhood; presents symmetrically and it occurs more frequently in the female gender). Metatarsus adductus is a medial deviation of the forefoot relative to a normal hindfoot. It occurs very frequentely, and often presents asymmetrically, with female gender preference. It should be assessed with the child lying prone, with the knee flexed to 90º. A line that bisects the heel should cross the 2nd toe in the healthy foot. This line, Bleck's heel bisector line, will be more lateral then the 2nd toe in metatarsus adductus, and the condition is considered as severe as the line falls laterally. The out-toeing presentation is much less frequent then the intoeing, and it is often related to femoral retroversion and tibial torsion. Usually torsional deformities resolve themselves without intervention, as the child develops. Infantile internally rotated tibia presentation is commonly not problematic, as it physiologically tends to rotate externally, however, when the torsional tibial pattern is excessive lateral, it doesn't solve itself, it only aggravates. Femoral antetorsion usually doesn't require correction as it tends to decrease with the child development around the age of 6, unless it achieves 50º or +/- 3SD[53], which is an indication to intervention[18]. The femoral antetorsion is more common in the female gender, with manifestations such as "W" sitting, "kissing"patella while standing, and "egg-beater" running pattern (see Figure 26). The presence of this phenomenon is accompanied with increased hip medial rotation[47], and consequent decreased hip lateral rotation, as the total hip rotation ROM is approximately 90º/100º[72]. The medial femoral torsion (femoral antetorsion) is mild, if the hip medial rotation is augmented from 70º to 80º, with a diminished hip lateral rotation from 10º to 20º; moderate, if the hip medial rotation is augmented from 80º to 90º, with a diminished hip lateral rotation from 0º to 10º; severe if the hip medial rotation is augmented over 90º, with absence of hip lateral rotation.

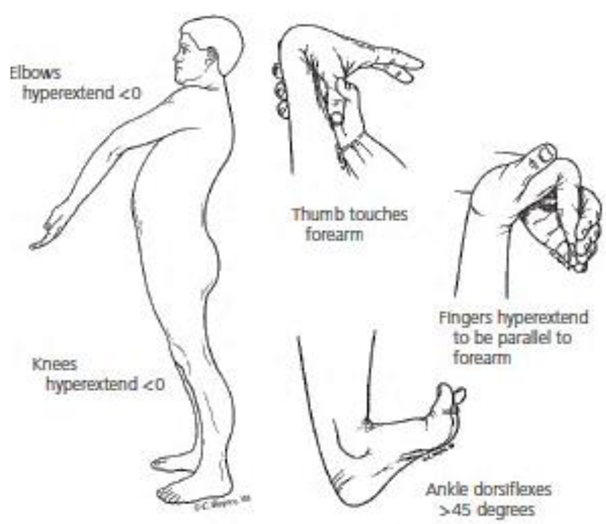


Source: (adapted) [35]
Figure 25. – Bleck's heel bisector line. Severity of Metatarsus Adductus



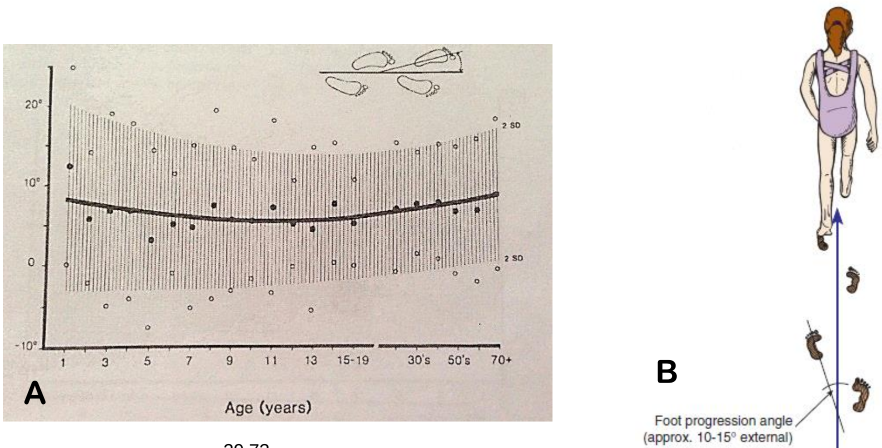
Source: http://www.running-physio.com/priscah-jeptoos-knee/. (adapted)[8]
Figure 26. – A – medially rotated femur, with “kissing patella”; B – Child in a “W” sitting position; C - “egg-beater” running pattern

When the joint laxity is the source of alteration of hip rotation ROM, both medial and lateral rotations are augmented. Specifically in the inferior limbs, the knee and tibiotarsal joints are affected by ligament laxity, with the former showing an hyperextension of approximately 5º/10º, and the latter an increase in dorsiflexion beyond 45º (see Figure 27).



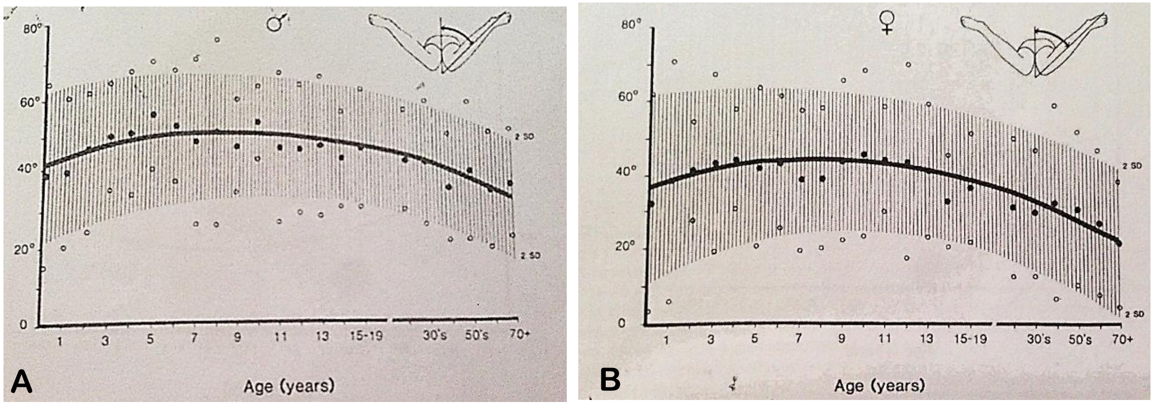
Source: (adapted)[53]
Figure 27.– Ligament laxity assessment.

The Foot Progression Angle (FPA) is also a commonly collected measure in the clinical context, and reflects the degrees of out-toeing (+) or intoeing (-) during gait (see Figure 28, B). It is expected to present more variability during infancy and little changes from childhood on. The normal range varies from -3º to 20º, with a mean value of approximately 10º [73] (see Figure 28, A).



Source: (adapted)[29,73]
Figure 28. – A – Reference values for the foot progression angle, from 1 to 70 years of old; B – Foot progression angle assessment.

Hip medial rotation peaks during early childhood, and then gradually declines from late childhood on. The reference published data varies a little, with some authors advocating higher hip medial rotation is expected for the female groups (female group showing a 59.8º mean, and the male group a 51.7º mean)[47], while others found differences among genders, with the males showing the higher hip medial rotation values (female group showing a 40º mean, and the male group a 50º mean; see Figure 29)[72]. This difference may be related to differences in the constitution of the sample, since the first included subjects from 4 to 16 years of age, and the second included subjects from bellow 1 to 70 years of age. The reference data for the mean value, during childhood and regardless of gender, has been reported from 54º (see Table 4)[29] to 61.2º [47] (see Table 5).



Source: (adapted)[72]
Figure 29. – Reference values for the hip medial rotation from 1 to 70 years of old. A – Male subjects; B – Female Subjects.

Table 4. – Reference values of hip range of motion.

	Age			
Motion	Newborn	4 Years	8 Years	11 Years
Flexion	128 ± 4.8	150 ± 12.5	146 ± 11.3	138 ± 14.5
Extension	−30 ± 3.9	29 ± 6.3	27 ± 6.3	25 ± 4.0
Abduction	79 ± 4.3*	54 ± 9.0	49 ± 7.3	45 ± 10.8
Adduction	17 ± 3.5	30 ± 5.0	28 ± 6.0	29 ± 6.3
Internal rotation	76 ± 5.6	55 ± 17.8	54 ± 17.5	48 ± 6.0
External rotation	92 ± 3.0	46 ± 16.8	43 ± 17.5	42 ± 15.3

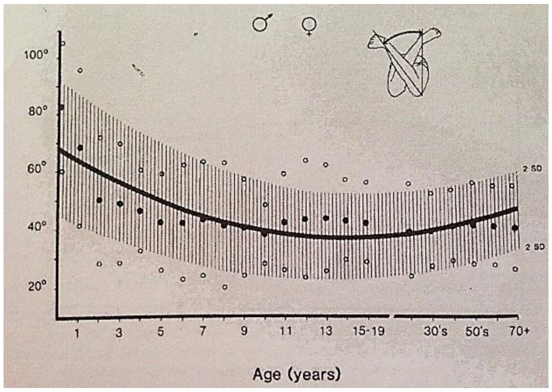
Source: (adapted) [29]

Table 5. – Reference Goniometric values for the age group 8-11.

Measures	Methods	8–11 years (*n*= 17)
Hip extension	Modified Thomas test	13.0° (6.4)
Hip abduction	Hips and knees extended	36.4° (4.8)
	Hip extended, knee flexed	39.8° (5.4)
	Hips and knees flexed	57.2° (6.5)
Hip rotation	Internal rotation	61.2° (10.7)
	External rotation	44.1° (7.9)
Femoral anteversion		29.1° (7.0)
Hamstring length	Popliteal angle	27.8° (11.5)
	True popliteal angle	24.8° (9.8)
Knee extension[a]		4° (6)
Knee valgus		5° (3)
Ankle dorsiflexion	Knee flexed	27.4° (6.9)
	Knee extended	21.9° (4.4)
Bimalleolar axis[b]		14.3° (5.0)

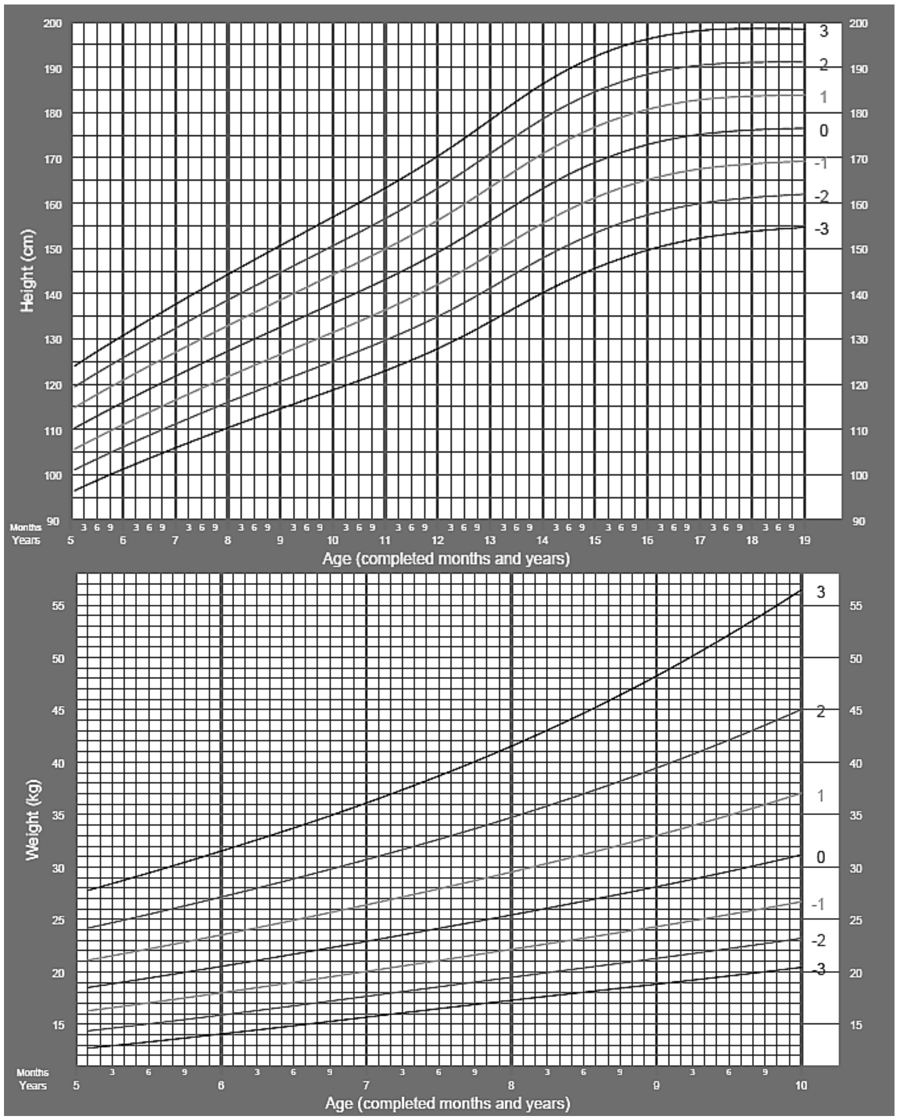
Source: (adapted)[47]

The hip lateral rotation, unlike the internal, tends to diminish until adolescence, stabilizing during adulthood. No differences among genders are reported, with a general reference mean from 43º (see Table 4)[29] to 45º [72] (see Figure 30).

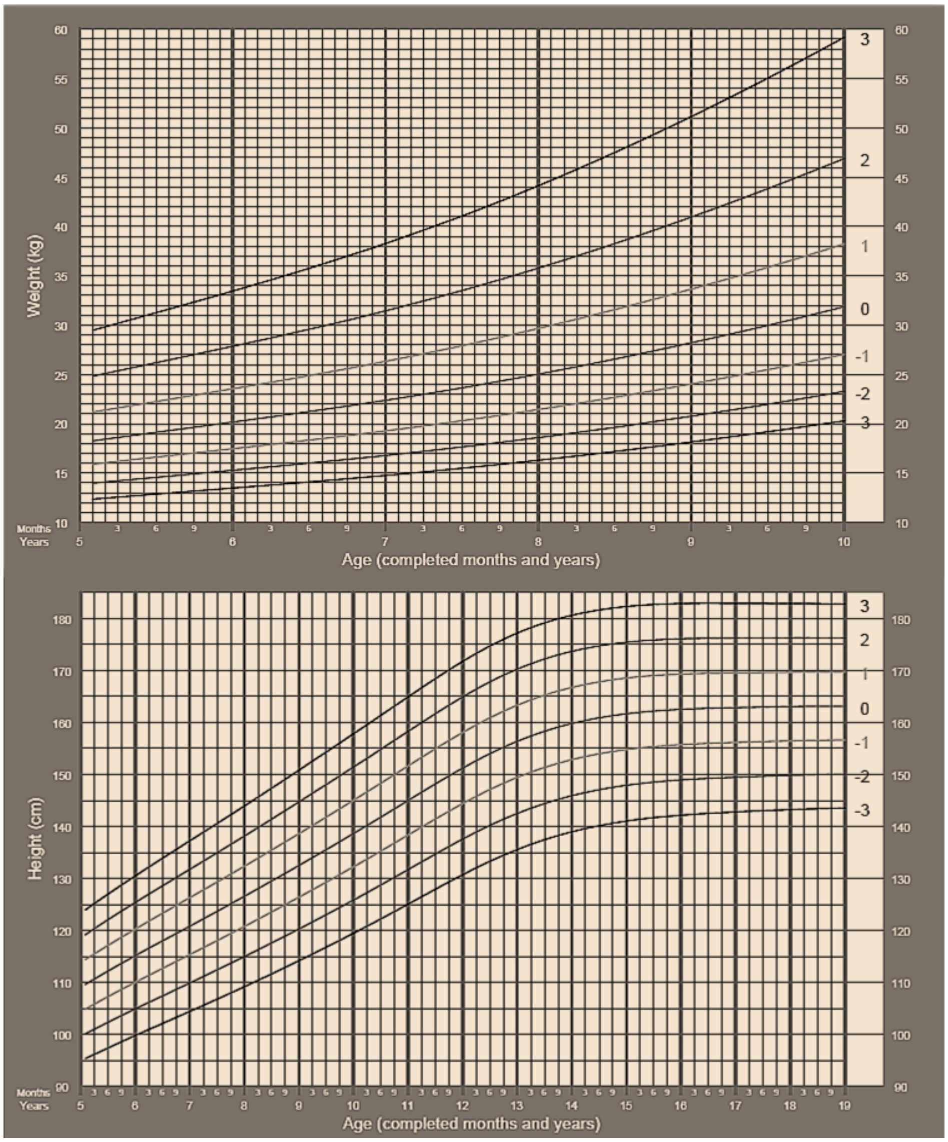


Source: (adapted)[72]
Figure 30. – Reference values for the hip lateral rotation from 1 to 70 years of old.

The rate of overall growth decreases rapidly from birth, until the child is approximately 6 years old. Between the first and second years of life the child shows an average height increment of approximately 10 cm, and between the 3 and 4 years of age, that increment is of approximately 7 cm. Beyond the 6 years of age, and until the child reaches 10, the average height increment is approximately 5.7 cm, with the rate of annual growth showing little changes[15,29] (see Figures 31 and 32).



Source: http://www.who.int/growthref/who2007_weight_for_age/en/ [81]
Figure 31. – Growth Charts (z-scores): Height-for-Age indicator relative to boys aged between 5 and 19 years old; Weight-for-Age indicator relative to boys aged between 5 and 10 years old.



Source: http://www.who.int/growthref/who2007_weight_for_age/en/ [81]
Figure 32. – Growth Charts (z-scores): Height-for-Age indicator relative to girls aged between 5 and 19 years old; Weight-for-Age indicator relative to girls aged between 5 and 10 years old.

Also during this period, the trunk develops at a slower rate than the lower limbs, therefore altering body proportions. The femoral length increases at an average annual rate of approximately 2 cm, and tibial's of approximately 1.6 cm (see Tables 6 and 7). It is early, during this period, that the femoral and tibial proportion is stablished, usually with a tibial length of about 80% the femoral length. A peak in the overall growth rate occurs during puberty, between 10 and 12 years old for female children, and between 12 and 14 for male children. After this peak, the rate progressively declines for the following 4 years, until growth ceases[15,29].

Table 6. – Femoral and tibial growth in length for female subjects.

Femur (cm)				Tibia (cm)			
No.	Age (yr)	Mean	σ	No.	Age (yr)	Mean	σ
30	1	14.81	0.673	61	1	11.57	0.646
52	2	18.23	0.888	67	2	14.51	0.739
63	3	21.29	1.100	67	3	16.81	0.893
66	4	23.92	1.339	67	4	18.86	1.144
66	5	26.32	1.437	67	5	20.77	1.300
66	6	28.52	1.616	67	6	22.53	1.458
67	7	30.60	1.827	67	7	24.22	1.640
67	8	32.72	1.936	67	8	25.89	1.786
67	9	34.71	2.117	67	9	27.56	1.993
67	10	36.72	2.300	67	10	29.28	2.193
67	11	38.81	2.468	67	11	31.00	2.384
67	12	40.74	2.507	67	12	32.61	2.424
67	13	42.31	2.428	67	13	33.83	2.374
67	14	43.14	2.269	67	14	34.43	2.228
67	15	43.47	2.197	67	15	34.59	2.173
67	16	43.58	2.193	67	16	34.63	2.151
67	17	43.60	2.192	67	17	34.65	2.158
67	18	43.63	2.195	67	18	34.65	2.161

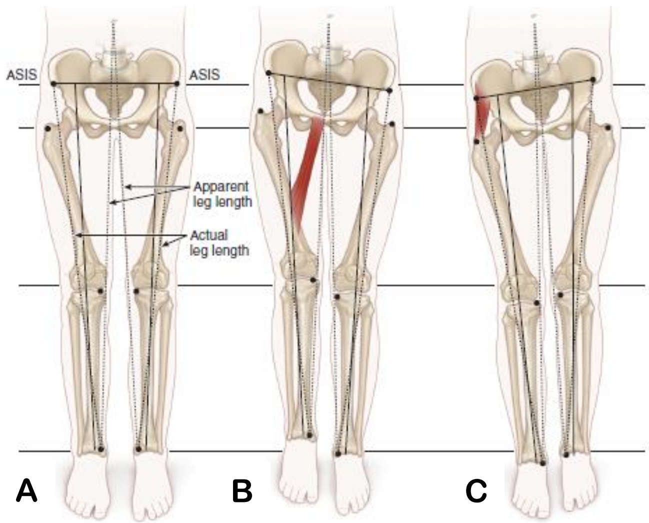
Source: (adapted)[29]

Table 7. – Femoral and tibial growth in length for male individuals.

Femur (cm)				Tibia (cm)			
No.	Age (yr)	Mean	σ	No.	Age (yr)	Mean	σ
21	1	14.48	0.628	61	1	11.60	0.620
57	2	18.15	0.874	67	2	14.54	0.809
65	3	21.09	1.031	67	3	16.79	0.935
66	4	23.65	1.197	67	4	18.67	1.091
66	5	25.92	1.342	67	5	20.46	1.247
67	6	28.09	1.506	67	6	22.12	1.418
67	7	30.25	1.682	67	7	23.76	1.632
67	8	32.28	1.807	67	8	25.38	1.778
67	9	34.36	1.933	67	9	26.99	1.961
67	10	36.29	2.057	67	10	28.53	2.113
67	11	38.16	2.237	67	11	30.10	2.301
67	12	40.12	2.447	67	12	31.75	2.536
67	13	42.17	2.765	67	13	33.49	2.833
67	14	44.18	2.809	67	14	35.18	2.865
67	15	45.69	2.512	67	15	36.38	2.616
67	16	46.66	2.224	67	16	37.04	2.412
67	17	47.07	2.051	67	17	37.22	2.316
67	18	47.23	1.958	67	18	37.29	2.254

Source: (adapted) [29]

Another regular clinical measurement is limb length. It is essential information to identify possible asymmetries. Usually two measures are executed, the apparent limb length (measured from the umbilicus to the medial malleolus), and the actual limb length (measured from the anterior superior iliac spine to the medial malleolus). Pelvic obliquities related to shortened adductors or abductors, knee or hip flexion contractures often create the illusion of a shorter limb, and the apparent limb length will indicate the presence of an asymmetry (see Figure 33). It's a functional asymmetry, observable while standing or during gait. The presence of structural abnormality is confirmed when the actual limb length measure reveals asymmetry.



Source: (adapted) [29]
Figure 33. – Actual limb length (ASIS to medial malleolus) and apparent limb length (umbilicus to medial malleolus). A – Symmetrical measures; B – Right adductor contracture, creating apparent shortening; C – Right abductor contracture, creating apparent lengthening. ASIS – Anterior Superior Iliac Spine

As every other assessment methods, all of these goniometric and anthropometrics methods described above have associated errors reported up to +/- 10-14º [46]. This varies with number of assessors (one of the sources that creates higher variability; the adoption of one single assessor shows reductions in the associated error of +/- 5-7º), joint assessed, or presence of specific pathologies[46] (see Table 8). These methods consist, despide of the implied error, in practical and accessible techniques for the regular demanding clinical practice[33].

Table 8. – Estimated standard errors of measurement (SEM.)

Joint Motion	S.E.M. (º)
Hip Internal Rotation	+/-3.5
Foot-thigh angle	+/-2.1

Source: (adapted)[44]
Data collected by 1 assessor

It is expected that children begin to walk around 12 months[76], although presenting an immature gait pattern[76], which is identifiable by an enlarged base of support, with no reciprocal arm swing, increased cadence, reduced step length and the reduction of single support time. As the child development progresses, the maturation of musculoskeletal and neurologic systems occur, allowing, in healthy conditions, a walking pattern progressively mature and functional. There are biomechanical gait data, some of global reference[76], others collected for specific purposes at local laboratories. Because the pediatric population has a specific maturation and behavioral particularities, which naturally represents a challenge for reproducible data collections, the literature strongly suggests that the reference data should be collected in each laboratory. This way, all the differences attributable to protocol procedures can be eliminated. "All gait laboratories should have their own normal adult and child databases for comparison with pathological gait, and inter-trial consistency of an individual's gait pattern is evaluated prior to interpretation of data." [58(p 40)]. Although it is overall accepted that the mature gait pattern is established by the age of 5[76,52], there are still some authors that defend that only around 8 years old, the child completely acquires a mature gait pattern[39]. That is probably one of the reasons why some studies are still focusing on describing the normality of biomechanical parameters on children of this age[30,39,40,69]. Moreover, a considerable number of conditions, namely the ones implying surgical approaches, can only be solved when the children reaches 8/10[29,35,53] years old. Regarding the necessity of a pre-surgical evaluation which allows the comparative studies afterwards, the collection of reference data becomes relevant at age 7.

On the long term, the LBMF from FMH expects to develop an enlarged, heterogeneous data base that gathers information about gait parameters on several ages, including adulthood. Hopefully this database will include all of the accepted variability occurring on healthy subjects of a certain age. As the existence of discrepancies between pediatric and adult gait[5,7,39,75] are fully explored and described on the literature, this study will focus on an healthy pediatric sample, with ages between 7 and 9 years old. Variables as walking cadence[16] and selected shoes[39,51,80] have been reported as confounding sources and they are addressed here, by asking all of the children to walk barefoot at their self selected speed. Cadence should be considered while examining the results. Furthermore, the specific study of complex feet movements, where some pathological alterations are reflected, is better accomplished with a multisegmented foot model, which is only available for the barefoot.

METHODS

To better understand and describe the regular/ healthy pediatric gait, a diverse pool of data was gathered. Besides the anthropometrics and goniometric measures, taken primarily for selection purposes, kinematics, kinetics and electromyography data were among the information collected for each subject.

PARTICIPANTS

We opted for a convenience sample from a private school - "colégio Torre" – that already had a protocol with the Faculty. After the consent from the school (Appendix II), the education guardians from the children between 7 and 9 years old were invited to join this study. Copies of the free and informed consent form (Anexo III), approved by the Ethics Committee of the Faculty, and the Health Form (see Appendix IV) were delivered to the guardians whose children have shown interest to participate in the study. After a thorough analysis of the returned health forms, 34 children were cleared for further assessment. For that, they were assessed with the Orthopedic and Neurologic Screening Protocol[20,76] (Appendix V), apllied to rule out any neurologic and orthopedic impairments, the latter mainly concerning the torsional patterns of the lower limbs. Anthropometric and Goniometry data were the basic measures for this assessment.

Thirty-four children were considered healthy, and cleared for the laboratory data collection.

STUDY DESIGN

Anthropometric and Goniometry data were collected as a selection pprocedure, to assess and rule out any orthopedic impairment . The Anthropometric measurements were accomplished using a *Rosscraft Innovation* Kit (Rosscraft Innovations, Canada), which includes a stadiometer, a segmometer and an anthropometric tape. We have collected each subject's mass (in kilograms, using a digital weighting scale (SECA – Medical Measuring Systems and Scales, USA)), standing height (according to ISAK – International Society for the Advancement of Kinanthropometry, consisting in the distance between the vertex – the highest point in the head – and the ground), in meters, using a stadiometer, the trochanteric height (according to ISAK, consisting in the distance between the trochanteric point (superior point of the great trochanter) and the ground), in meters, using a segmometer. In order to better detect any assymetries in the lower limbs, three measurements were obtained: true length (from Anterior Superior Iliac Spine – ASIS – to Medial Malleolus – MM), apparent length (Navel to MM) and trochanteric height (great trochanter to Lateral Malleolus – LM). The goniometric measurements were performed with a Therapeutic Goniometer, which is a measuring device conceived for quantifying the range of movements of body joints, mainly in the clinical context. It can be made either of plastic or metal, in this case, we used a plastic one. Several measurements using this device were collected in order to study the available passive and active joint movements of the children in this study.

A 14 camera-based system (*Qualisys Oqus 300, Qualisys AB, Gothenburg, Sweden)*, was used for the motion capture, operating at 100Hz (Figure 34). Each of these cameras is equipped with *Light-Emitting Diodes (LED)* surrounding the lens. This light, when reflected for passive markers – spherical pearls of different diameters wrapped with retro-reflective tape, placed on the subject's anatomic key points (see Appendix VI) – is captured by the cameras. The cameras also have specific filters that allow it to differentiate the light from different sources, namely the one reflected from the markers. Through determined algorithms, the centroid position of the spheres is calculated, given that all diameters are previously entered into the motion capture software *QTM (Qualisys Track Manager, version 2.9- build 1697 Qualisys Inc., Gothenburg, Sweden).* Each camera calculates the 2-dimension (2D) coordinates of each reflective marker in the previously calibrated volume, and gathering the information of all cameras, the software processes the 3-dimension (3D) coordinates of those points. Once the markers' trajectories are identified (digitizing), the data is exported to a 3D modeling *software, Visual 3D* (*Visual 3D™ Professional v5.01.18*.C_Motion, Inc), which allows the virtual analysis of any human motion task with a 6 degrees of freedom (DoF) modeling technique.

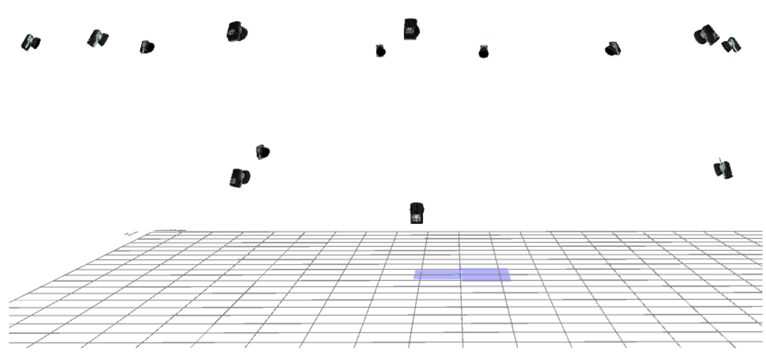


Figure 34. – Model of the 14 cameras from the Motion Capture System (LBMF, FMH). Image from QTM

For the dynamic calibration of the motion capture volume, a specific “L” shaped structure, with 4 embedded reflective markers with a known distance, was placed on a predetermined corner of one of the Force Platforms in the laboratory floor, defining the Laboratory Coordinate System (Global Coordinate System) (Figure 35). In this case, the X axis was aligned with the progression of the movement, the Y axis had a medio-lateral orientation, and the Z axis was the vertical one. Each camera is adjusted so that each reflective marker of the “L” shaped structure is clearly seen. To provide the information concerning the volume on which the action will take place – capture volume – it was used a calibration wand, with 2 embedded reflective markers (also with a known distance between them). The wand is moved in order to be seen in as many positions as possible for all the cameras, so that all the needed volume is swept, and no more than that. This process takes about 60 seconds and the resulting estimated standard deviation error was always below the 0.5 millimeters.

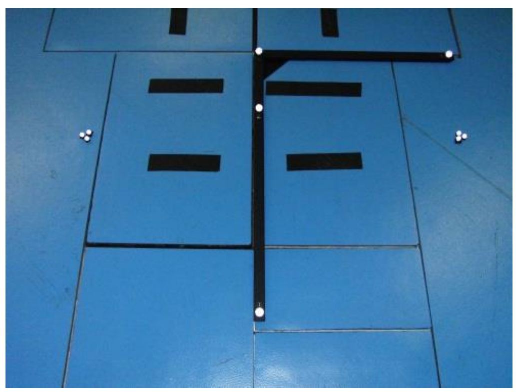


Figure 35. – Photograph of Kistler platforms, with the “L” shaped structure (LBMF, FMH).

This is the process through which we gathered the kinematics. Besides the kinematic curves, key kinematic events were also selected, to better understand the gait normal patterns.

For the force data collection (GRF), we relied on 3 Force Platforms (2 *Kistler type: 9865B* and 1 *AMTI)* (Figure 35), operating at 1000Hz. All three platforms are subtly placed on the laboratory floor, on a built-in manner to avoid *Targeting* (deliberately stepping on the platform center, changing the individual pattern). The Kistler platforms are fitted with piezoelectric crystals such as quartz, 3 at each corner, orthogonally oriented. These crystals detect the deformation caused by the applied force (mechanical stress) and generate an electric dipole moment, which generates an electric signal (Piezoelectric Effect). Due to its capability of generating electric energy, this platform has no need for electric supply. The AMTI is a strain gauge (resistors) platform. Thought it relies on the deformation of specific materials that constitute the strain gauges, (arranged in triplets in the corners of the platform), it uses a different process to quantify that force. Instead of generating an electric signal, it offers resistance to the electric current, necessarily supplied. Usually the difference of resistances is quite small, so an amplifier is required, in this case, an external one. Prior to each data collection, the 3 components of the force vector signal and the center of pressure (CoP) of each force plate were verified. With these platforms we gathered information about the 3 components of the Ground Reaction Force (GRF – the force of equal magnitude and direction, but inverse sense, according to Newton's third law, of the one the individual applies to the ground, through the area of contact to that floor), anterior-posterior, medio-lateral and vertical. Together with the kinematic information, and through inverse dynamics, the internal joint moments were calculated using the Visual 3D software (Figure 36).

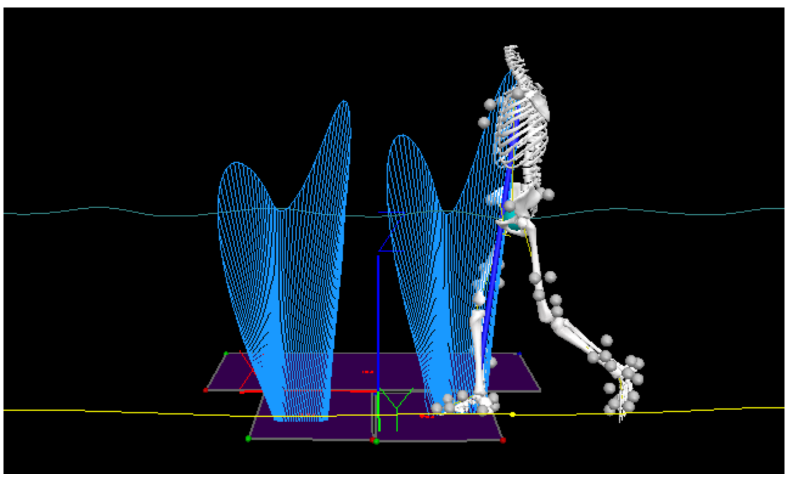


Figure 36. – Avatar of modeled segments walking on the LBMF Force Platforms.
Pedotti diagrams (sagittal view). Image from Visual 3D™ Professional v5.01.18.C_Motion, Inc software.

The natural frequency of the EMG signal is accepted to occur under 500Hz (and little under 30Hz). In order to sample the EMG signal correctly, one is advised to sample it at a frequency that is twice the maximum frequency of the signal (Nyquist Theorem). So, for the EMG data collection, we chose the surface EMG, using the Trigno™ Wireless EMG from Delsys® (Figure 37), with 12 hybrid sensors, operating at 1000Hz, and with a Bandwidth filter frequencies fixed at 20-450Hz. Before placing the electrodes, each baseline's smoothness was examined and the skin was prepared. For that, the area of interest was shaved with disposable razor blade and cleaned afterwards with alcohol, following SENIAM (Surface Electromyography for the Non-Invasive Assessment of

Muscles)[89] recommendations. After the alcohol has vaporized, the 12 fully charged sensors were placed and tested. The muscles' selection was based on the relevance for the elected tasks, how frequently they appeared on similar studies, as well as the opinion of the clinical team enrolled on the process, namely the selection of the adductors muscles, less frequently chosen on the healthy pediatric population[44], but often targets of surgery. Six muscles were analyzed, bilaterally: *Medius Gluteus* (abductor and stabilizer of the coxofemoral joint), the *Adductor Longus* (aductor of the coxofemoral joint), the *Retus Femoris* (extensor of the knee joint, flexor of the coxofemoral joint), the *Semitendinosus* (extensor of the coxofemoral joint, flexor of the knee joint), the *Tibialis Anterior* (dorsiflexor and inversor of the tibio tarsal joint), and the *Gastrocnemius* (plantarflexor of the tibio tarsal joint). The electrodes were placed following the SENIEM and bibliographic[12] anatomical recomendations, as suggested by peers[59 (p 185)] (See Appendix VII).

Figure 37. – EMG Trigno™ Wireless EMG from *Delsys®*

Resorting to analog plates, the *Qualisys Track Manager* software gathers and synchronizes all the data from the camera-based motion capture system, force platforms and EMG.

Collection Procedures

The collection of gait data took place at the LBMF of FMH, during the periods in which the children should attend the gymnastic classes, protocolarly predicted. Therefore, no extra concern or logistics for guardians existed, and all of the safety and responsibility issues were already addressed. The LBMF is a restricted area and has all the necessary conditions for the required procedures, such as walking barefoot and wearing light clothes. The collection room was ready prior to the child arrival in order to shorten the time of permanence of the children. For the prior preparation, besides warming up the space, it was also calibrated, the force platforms checked, markers were prepared and EMG was tested. On child arrival, they changed to proper clothes and took shoes off, also on a restricted area. Fifty-three passive reflective markers were placed on specific anatomic key places to created 8 body segments, according to CAST protocol (Calibrated Anatomical System Technique), CODA pelvis, and a modified Oxford Foot Model (Anexo VI): 37 individual markers, 12 for each foot (1,3cm diameter) and 13 for the rest of the body (1,6cm diameter), and 4 clusters of 4 embedded markers each (1,6cm diameter). The CAST method implies the 3D reconstruction of each segment using both lateral and medial, proximal and distal markers, and also 1 cluster per lower limb segment (in this case, 4 clusters of 4 markers each, for each shank and thigh), to assure the redundant segment tracking (a minimum of three detectable markers was accepted for tracking each segment). The child was then placed on the force plates (each foot on a force platform), facing toward the positive y-axis of the LAB segment. The child was advised to stand on an orthostatic position, as still as possible. This static capture allowed the 3D reconstruction of the biomechanical model, assuming these orthostatic joint positions as neutrals. Afterwards, the child was instructed to walk along an indicated 10m corridor. The walking speed was self-selected (not imposed). In order to help the child adaptation to the space and personnel, he/ she was allowed to make several walking trials before the capture start. With these procedures we expected to obtain data that better reflect their actual walking pattern. The dynamic recorded trials ended when the child successfully achieved a minimum of 10 kinetic walking cycles for each side (meaning that he/ she stepped on the force platform, generating an acceptable GRF vector). Four postural pictures were taken from the frontal, back and lateral perspectives with the child in the orthostatic position, as still as possible for verification purposes.

Overall, each child data collection took approximately 1 hour. Summing up, 1 child couldn't perform the minimum requirements during the laboratory collection and 6 others couldn't be assessed due to time restrictions. The final sample contained 27 children, 13 females and 14 males, a common sample size in similar studies[45]. Eleven children were brought back to the laboratory within a time period of 5 to 7 days in order to reassess gait parameters and conclude about the associated error (technical). The children's guardians, who have shown interest, received a brief report with some of the collected data and respective analysis.

Data Processing

After an automatic and manual digitizing (process through which markers are identified according to the body regions they represent), executed on QTM software, all data processing and model building were concluded with Visual 3D. Ten left and right kinetic trials (GC) from each child were selected to assess the gait data. The gait events were automatically created and adjusted manually for each GC.

FILTERS

Whenever data is collected, there's surely an associated error. Whether it is related to skin movement, digital processing, electric interference, moving wires, one must chose the most adequate way to deal with it, so that the final data reflects the actual signal without the noise. This process is known by smoothing the signal, and is accomplished by submitting the signal to a particular filter, or filters, according to the signal's nature. Our specific collected signals we treated with digital filters: 1) Low-Pass Filter, low frequency remain unchanged while higher than the determined cut frequency are attenuated (applied on kinematic data, where the usual noise is of hight frequency[59]), and/or, 2) High-Pass Filter, high frequency remain unchanged while low frequency are attenuated (applied to the electromyographyc data to eliminate, for example, low frequency movement artifact from low-voltage signals in wires attached to the body), and/ or, 3) Moving RMS, which generates a linear envelope of the EMG signal by calculating the Root Mean Square (RMS) of a moving window. The Kinematic data was processed with a Low-pass Butterworth filter with a cut off frequency of 6 Hz. The Kinetic data was processed with a Low-pass Butterworth filter with a cut off frequency of 6 Hz. Regarding the EMG signal, before applying any filters, the frames were shifted in 48, according to fabricants' specificities. The signal was then processed with an High-pass Butterworth filter with a cut off frequency of 30Hz, a Low-pass Butterworth filter with a cut off frequency of 6 Hz and a linear envelope of 51 moving frames was applied[91].

All cut-off frequency values were selected based on the knowledge of the signal, and often associated noise, already studied and reported[59].

3D MODELING RECONSTRUCTION

To perform a 3D motion analysis, three coordinate systems are required, all orthogonal right-handed systems, with the origin fixed in the lab. With the references, global/laboratory coordinate system (GCS), a segment/local coordinate system (LCS) and a FP (Force Platform) coordinate system, all relative positions in a calibrated volume can be determined. The LCS is defined during the static calibration, where tracking markers (used to track the pose of the segment) and calibration/anatomical markers (used to build each segment) are recorded, and the GCS is defined during the dynamic calibration process. Anatomical and tracking markers are placed for the standing (/static) trial and only the tracking ones remain afterwards. The tracking markers are placed redundantly and in areas with minimal fat tissue to help minimize soft tissue artifact (usually, in the third distal part of the body segments, avoiding belly muscles).

Segment 3D reconstruction requires a minimum of 3 noncolinear markers and, as it is based on the assumption that segments are rigid, a fixed right handed orthogonal coordinate system (LCS) can define its position, together with its inertial properties (mass – Dempster's data –, center of mass location and principal moments of inertia – Hanavan's[60] geometrical model). Eight body segments were reconstructed, each exhibiting its own local coordinate system (LCS), converted from the laboratory coordinates or global coordinate system (GCS). Segments were processed with a 6 DoF technique (segment optimization), which implies tracking each segment independently, with no implicit linkage. Thus, each segment is allowed to move translationally – vertical, mediolateral and anterior-posterior – and angularly – in the saggital, coronal or transverse planes. The segments created were, one trunk, one pelvis, 2 thighs (left and right), 2 shanks (left and right), and 2 feet (left and right). The trunk was created with AC markers as proximal references, ASIS and ASIS as distal; the selected pelvis was the CODA, created with the markers LASIS, RASIS, LPSIS and RPSIS; the tight was created with the virtual marker Great Trochanter, (virtual hip joint center, acquired with the regression equations of Bell and Colleagues 1989), as the proximal reference joint, and LK and MK markers, as the distal references; the segment shank was created in two distinct ways, one (L/RSK_PROX) with L/RLK and L/RMK markers as the proximal references, and the joint center of the ankle (L/RANK, landmark), calculated as the midpoint between L/RLA and L/RMA (malleoli) as the distal reference, and another (L/RSK) with the joint center of the knee, calculated as the midpoint between L/RLK and L/RMK (femoral condyles) as the proximal reference, and the L/RLA and L/RMA as distal references. The L/RSK_PROX segment was used in the calculation of knee angles, and the L/RSK segment was used in the calculation of ankle angles. The foot segment (L/RVFT) was constructed with the midpoint between L/RLA and L/RMA (L/RANK, landmark) as the proximal reference, and L/RANK_DISTAL, a landmark projected from the L/RANK landmark, contained between the L/RD1MT and L/RD5MT markers, as the distal reference (see Table 9). Also, for referencing purposes (to the GCS created with calibration), two other segments were created, VIRTUAL_LAB_longo and VIRTUAL_LAB_curto. Each of these orthogonal coordinate systems is oriented in a way that allow us to perform the gait analysis along two perpendicular corridors.

Table 9.– Segments properties.

Segment	Segment Code	Proximal references	Distal references
Trunk	Thorax/Ab	RAC ; LAC	RASIS ; LASIS
Pelvis	PV	LASIS ; RASIS	LPSIS ; RPSIS
Tight	TH	Great Trochanter (virtual hip joint center)	LK ; MK
Shank	SK_PROX	LK ; MK	joint center of the ankle midpoint between LA and MA
	SK	joint center of the knee midpoint between LK and MK	LA ; MA
Virtual Foot	VRFT	Landmark ANK joint center of the ankle midpoint between LA and MA	landmark ANK_DISTAL (starts on HEE, ends on D1MT; laterally oriented with D5MT)

To understand the relative behavior of the segments throughout the gait cycle, we studied their interactions through the analysis of Joint Angles (angular kinematics), with the proximal segment as reference (see Table 10).

Table 10. – Joint Angles and respective segments.

Joint Angle	Segment	Reference Segment
PELVIS_ANG	PV	VIRTUAL_LAB
HIP_ANG	TH	PV
KNEE_ANG	SK_PROX	TH
VFT_ANG	VRFT	SK
FT_PROG_ANG	VRFT	VIRTUAL_LAB

We chose to calculate the joint angles using the XYZ Cardan sequence (equivalent to the joint coordinate system) so that the calculated joint angles have an anatomical meaning (i.e., x represents flexion/extension, y represents abduction/adduction, and z represents internal/external rotations). (See Table 11)

Table 11. – Joint Angles properties.

JOINT ANGLE	AXIS	FUNCTIONAL MOVEMENT	NOTATION
PELVIS_ANG	X	Tilt	Retroversion/ Anteversion (-) / (+)
	Y	Obliquity	Down/ Up (-) / (+)
	Z	Rotation	Backward/ Forward (-) / (+)
HIP_ANG	X	Extension/ Flexion	Extension/ Flexion (-) / (+)
	Y	Abduction/ Adduction	Abduction/ Adduction (-) / (+)
	Z	Rotation	External/ Internal (-) / (+)
KNEE_ANG	X	Extension/ Flexion	Extension/ Flexion (-) / (+)
	Y	Valgus/ Varus	Valgus/ Varus (-) / (+)
	Z	Rotation	External/ Internal (-) / (+)
VFT_ANG	X	Plantarflexion/ Dorsiflexion	Plantarflexion/ Dorsiflexion (-) / (+)
	Z	Rotation	External/ Internal (-) / (+)
FT_PROG_ANG	Z	Foot Progression Angle	Toe out/ Toe in (-) / (+)

VARIABLES

CLINICAL MEASUMENTS VARIABLES

ANTHROPOMETRIC AND GONIOMETRIC DATA

Prior to the laboratory collection, several measurements were conducted in order to assess the musculoskeletal and neurological condition. The selection of the variables was based on their clinical relevance[57]. The value of the following variables was registered: Mass, Height, Intercondylar Distance, Intermalleolar Distance, the distance between the Umbilicus and the Medial Malleolus (Apparent Leg Length), the distance between the ASIS (Anterior Superior Iliac Spine) and the Medial Malleolus (True Leg Length), the distance between the Great Trochanter and the Lateral Malleolus, Knee Active Extension, Internal and External Hip Rotations, Hip Rotation Range of Motion as a result of adding the previous two, Femoral Anteversion and Tibial Torsion (see Table 12).

Table 12. – Variables selected for the Anthropometric and Goniometric profiles.

	VARIABLE DESCRIPTION	VARIABLE CODE
Mass (kg)	Obtained on an analogical scale, respecting I.S.A.K. recommendations.	M
Height (m)	Measured with a stadiometer, respecting I.S.A.K. recommendations.	H
Intercondylar Distance (cm)	Measured with a caliper, represents the distance between the most prominent aspect of the two medial femoral condyles.	DIST IC
Intermalleolar Distance (cm)	Measured with a caliper, with the children standing on an orthostatic positions, holding the feet as close as possible; often quoted as a quantitative way of classifying the presence of knee Varus/ Valgus[38]. Represents the distance between the most prominent aspect of the two medial malleolus.	DIST IM
Umbilicus – Medial Malleolus (cm)	Measured with an anthropometric scale, represents the distance between the umbilicus and the medial malleolus.	UMB-MM
ASIS – Medial Malleolus (cm)	Measured with an anthropometric scale, represents the distance between the anterior superior iliac spine and the medial malleolus.	ASIS-MM
Great Trochanter – Lateral Malleolus (cm)	Measured with an anthropometric scale, represents the distance between the trochanter and the lateral malleolus.	TROC-LM
Knee Active Extension (º)	Measured with a goniometer, represents the degrees of active knee extension (degrees missing to full extension are - , degrees beyond full extension – 0 – are +)	K EXT
Hip Internal Rotation (º)	Measured with a goniometer, represents the degrees that a hip joint can be internally rotated on a prone lying position.	IR

Hip External Rotation (º)	Measured with a goniometer, represents the degrees that a hip joint can be externally rotated on a prone lying position.	ER
Hip Rotation Range of Motion (º)	Represents the entire available range for a rotation like motion. Obtained by adding both internal and external rotations.	ROT ROM
Femoral Anteversion (º)	Measured with a goniometer, represents the degrees one has to internally rotate the hip joint, so that the femoral neck becomes horizontal. Also on a prone lying position.	F ANT
Tibial Torsion (º)	Measured with a goniometer, with the foot/ thigh angle method.	TI TORS

GAIT PARAMETERS VARIABLES

To describe the gait pattern, variables of distinct nature were selected. This selection was based on the clinical relevance given to these variables, which integrate renowned Gait Indexes[66,68]. Several of these kinematic events are reported as good indicators of the gait pattern[62,66,68]. Spatial and time parameters selected were Cadence (steps/m), Speed (m/s), Step Length (m), Mean Cycle Time (s), Time of Unipodal support (%), Vertical Displacement of the Center of Mass (CoM) (cm), and also Ratio ASIS/ Calcaneus (ratio pelvic span/ankle spread), and "Step Factor" (step lenght/limb lenght), both normalized measures. The selected variables concerning Gait Events were Time of Loading Response (% of GC),Time of Mid-Stance (% of GC), Time of Terminal Stance (% of GC), Time of Pre-Swing (% of GC), Time of Initial Swing (% of GC), Time of Mid Swing (% of GC), and Time of Terminal Swing (% of GC). The selected variables of Key kinematic Events were Sagittal pelvic ROM (º), Mean value of pelvic Sagittal Motion (º), Mean value of pelvic Transverse Motion (º), Sagittal hip ROM (º), Sagittal hip maximum angle (º), Time of the Sagittal hip maximum angle (%),Sagittal hip minimum angle (º), Time of the Sagittal hip minimum angle (%), Mean value of hip Transverse Motion during Stance Phase (º), Hip maximum angle during Swing Phase, on the frontal plane (º), Sagittal knee ROM (º), Sagittal 1st maximum knee angle (º), Sagittal 2nd maximum knee angle (º) Time of the Sagittal 1st maximum knee angle (%), Time of the Sagittal 2nd knee maximum angle (%), Sagittal 2nd knee minimum angle (º), Time of the Sagittal 2nd knee minimum angle (%),Knee angle at Initial Contact (º), Sagittal tibiotarsal ROM (º), Maximum dorsiflexion during Stance Phase, on the sagittal plane (º), Maximum dorsiflexion during Swing Phase, on the sagittal plane (º), and Mean Foot Progression Angle during Stance Phase (º). (see Table 13).

Table 13. – Variables selected to describe the kinematic gait pattern.

	VARIABLE DESCRIPTION	VARIABLE CODE
SPATIAL AND TEMPORAL PARAMETERS		
Cadence (steps/min)	Number of steps per minute.	Cadence
Speed (m/s)	Walking speed	Speed
Step Length (m)	Horizontal distance between two consecutive heel strikes.	L_step
Cycle Time (s)	Time of duration of one GC/stride/two consecutive steps.	Cycle_time
Time of Unipodal support (%)	Percentage of total unipodal support (duration of SW).	dT_unipodal
Displacement of the Center of Mass (CoM) (cm)	CoM ROM on the sagittal plane (vertical motion).	Displace_CoM
NORMALIZED to ANTHROPOMETRICS		
Ratio ASIS/ Calcaneus	Ratio between ASIS span, and heels distance during walking.	Rt_ASIS_Calc
Step Factor	Ratio between step length and leg length.	StepFactor
GAIT EVENTS		
Time of Loading Response (%)	Moment of the beginning of LR, as a % of the GC. Identified with the tibiotarsal minimum angle (plantarflexion), between the ipsilateral heel strike and toe off.	t_LR
Time of Mid-Stance (%)	Moment of the beginning of MST, as a % of the GC. Identified with the moment of each side contralateral toe off.	t_Mid_St
Time of Terminal Stance (%)	Moment of the beginning of TST, as a % of the GC. Identified with the contralateral SK angular velocity maximum value, between an ipsilateral heel strike and toe off.	t_Term_St
Time of Pre-Swing (%)	Moment of the beginning of PSW, as a % of the GC. Identified with the moment of heel strike of the contralateral limb.	t_PSw
Time of Initial Swing (%)	Moment of the beginning of ISW, as a % of the GC. Identified with the moment of each side ipsilateral toe off.	t_Init_Sw
Time of Mid Swing (%)	Moment of the beginning of MSW, as a % of the GC. Identified with the CoM maximum value on the sagittal plane, between a toe off and ipsilateral heel strike.	t_Mid_Sw
Time of Terminal Swing (%)	Moment of the beginning of TSW, as a % of the GC. Identified with the ipsilateral SK angular velocity maximum value, between an heel strike and toe off.	t_Term_Sw
KEY KINEMATIC EVENTS		
Sagittal pelvic ROM (º)	Pelvic ROM on the sagittal plane.	Sag_Pelvis_ROM
Mean value of pelvic Sagittal Motion (º)	Mean value of the pelvic motion (tilt) on the sagittal plane.	PELVIS_Sag_MidV
Mean value of pelvic Transverse Motion (º)	Mean value of the pelvic motion (rotation) on the transverse plane.	PELVIS_Trans_MidV
Sagittal hip ROM (º)	Hip ROM on the sagittal plane.	Sag_Hip_ROM
Sagittal hip maximum angle (º)	Hip maximum angle (flexion) on the sagittal plane, occurring 2^{nd}.	Sag_Max_HipA

Time of the Sagittal hip maximum angle (%)	Moment of the 2nd maximum hip angle on the sagittal plane, as a % of the GC.	Sag_t_Max_HipA
Sagittal hip minimum angle (º)	Hip minimum angle (extension) on the sagittal plane.	Sag_Min_HipA
Time of the Sagittal hip minimum angle (%)	Moment of the minimum hip angle on the sagittal plane, as a % of the GC.	Sag_t_Min_HipA
Mean value of hip Transverse Motion during Stance Phase (º)	Mean value of the hip motion (rotation) during ST on the transverse plane.	Trans_MedV_Hip_STph
Hip maximum angle during Swing Phase (º)	Hip maximum angle (abduction) on the frontal plane, during the SW.	Front_Max_Hip_SWph
Sagittal knee ROM (º)	Knee ROM on the sagittal plane.	Sag_Knee_ROM
Sagittal 1st knee maximum angle (º)	Knee maximum angle (flexion), occurring 1st.	Sag_Max_stKneeA
Sagittal 2nd knee maximum angle (º)	Knee maximum angle (flexion), occurring 2nd.	Sag_Max_ndKneeA
Time of the Sagittal 1st knee maximum angle (%)	Moment of the 1st maximum knee angle, as a % of the GC.	Sag_t_Max_stKneeA
Time of the 2nd knee maximum angle (%)	Moment of the 2nd maximum knee angle in the sagittal plane, as a % of the GC.	Sag_t_Max_ndKneeA
Sagittal 2nd knee minimum angle (º)	2nd minimum knee angle (extension) on the sagittal plane.	Sag_Min_ndKneeA
Time of the Sagittal 2nd knee minimum angle (%)	Moment of the 2nd minimum knee angle, as a % of the GC.	Sag_t_Min_ndKneeA
Knee angle at Initial Contact (º)	Knee angle value at IC.	Sag_KneeA_CI
Sagittal tibiotarsal ROM (º)	Tibiotarsal ROM on the sagittal plane.	Sag_TT_ROM
Maximum dorsiflexion during Stance Phase (º)	Tibiotarsal maximum angle (dorsiflexion), during ST, on the sagittal plane.	Sag_TT_MaxDf_STph
Maximum dorsiflexion during Swing Phase (º)	Tibiotarsal maximum angle (dorsiflexion), during SW, on the sagittal plane.	Sag_TT_MaxDf_SWph
Foot Progression Angle (º)	Mid value of the foot progression angle (angle formed by the foot and line of progression of motion axis) during ST.	FPA_MedV_STph

Statistical Analysis

All statistical procedures were executed on the software IBM SPSS Statistics V22.0, (IBM Corporation, Armonk, NY, USA).

The Gait Variables were first examined for symmetry, for both of the collection days. The Paired-Samples T Test was applied for the variables following a Normal distribution, and the Wilcoxin for the ones not following a Normal distribution.

To understand the behavior according to gender (k=2), the variables were tested for statistical significant differences using the Independent-sample T Test, or the Mann-Whitney U Test, according to the Normality Tests. When the variances homogeneity wasn’t verified (tested with Levene’s Test), we resorted to the Welch correction.

The One_Way ANOVA was applied to study the variables behavior according to Age Group (k=3) to the variables following a Normal distribution, or the nonparametric alternative Kruskal-Wallis. When variance homogeneity was verified (tested with Levene’s Test), we used the p_value from ANOVA, or Welch for the ones with no homogeneity of variances. For the subsequent study of the significant differences among specific groups, the multicomparisons test used was the Scheffé or Tamhanes (or the LSD, when the Tamhane wasn’t enough) with Normal distribution, according to the verified variance homogeneity, or not, respectively. And with the variables not following a Normal distribution (previously tested with Kruskal-Wallis) we applied the Dunn Test.

The reproducibility between the two days of collection was studied to determine the technical error associated with the laboratory pediatric data collection. For that, the reliability of the measures was assessed through the Interclass Correlation Coefficient (ICC; two-way mixed ICC 3.1[85]), and the agreement (/consistency) through the Standard Error of Measurement (SEM; $SEM = SDdif/\sqrt{(2)}$). The Interclass Correlation Coefficient was acquired to understand if the measurement error compromises the discrimination of individuals.

The differences of the mean values for each day, as well as the SD values of each mean were also considered when assessing the variability between days, as they express variability between and within session, respectively.

Afterwards, both groups of variables (Clinical Measurements and Gait Parameters) variables were assessed for eventual correlations, using the Pearson Correlation Coefficient.

Presentation and Discussion of the Results

The examined data will be presented and discussed in this section. Firstly, the Joint Displacement (kinematic) and kinetic curves (moments, powers and GRF) will be analyzed, in a comparative manner, to world refrence data. Then, the specific statistical work operated on the Clinical Measurements and Gait variables will be fully analyzed.

Kinematic Data

Joint Angular Displacement

The joint angular displacement was obtained for the 27 children. Besides the specific kinematic events, the overall pattern of the joint angular displacement curves was also considered, as it also constitutes an important and pertinent approach. The kinematic curves presented on Figure 36 represent the mean values for all subjects' each side, both indistinguishably represented by green lines, as symmetry related aspects are not targeted in the present study. The data representing the Pelvic motion, and the Foot Progression Angle, particularly, are represented by four green lines, fact related to the fact that these angles were obtained with the reference segment "Virtual_Lab". Also, a shadow is shown, representing the value of the mean, added to one standart deviation, as suggested by the literature[56]. The moments of foot-off are represented on top of the curves by top sticks, the red representing the left foot-offs, and the blue representing the right foot-offs. All data is shown with reference to one GC (X axis).

About the Pelvic angles, on the sagittal plane we expected a mean value of 10º, with an oscillating value of 4º during the gait cycle[56], and we obtained a mean value of 10.37º (see Table 19: mean_PELVIS_Sag_MedV_L_R = 10.37 ± 3.28 (9.07 - 11.67)) along the GC, with a range of motion of 4.37º (see Table 19: mean_Sag_Pelvis_ROM_L_R= 4.37º ± 0.60 (4.13 - 4.60)) (see Figure 38). Regarding the graphic that displays the motion on the Frontal plane, it's observable a value around 6/7º during the maximum and minimum drops, when the reported value is around 4º [56] (see Figure 39). In the transverse plane we expected a range of motion of 10º, 5º corresponding to the forward movement, and 5º to the backwards movement, with 0º representing the neutral position. The mean value obtain was around zero degrees, -0.028, (see Table 19: mean_PELVIS_Trans_MedV_L_R = -0.028 ± 0.449 (-0.206 - 0.149))and the range of motion was of 18.29º (see Table 19: mean_Trans_Pelvis_ROM_L_R = 18.29 ± 4.78 (16.40 - 20.18)) (Figure 40).

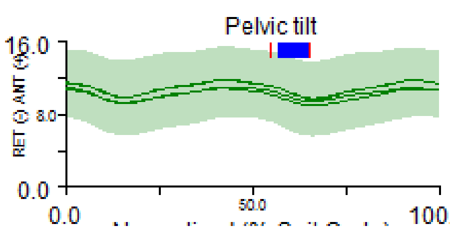


Figure 38.– Pelvic motion on the sagittal plane normalized to percentage of GC.

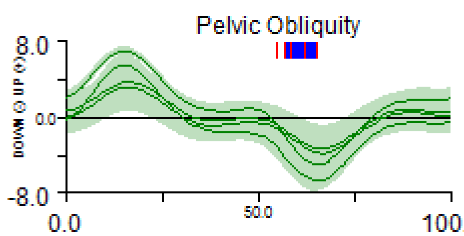


Figure 39.– Pelvic motion on the sagittal plane normalized to percentage of GC.

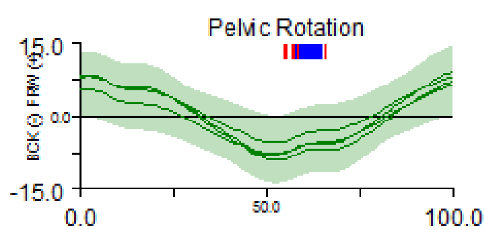


Figure 40.– Pelvic motion on the transverse plane, normalized to percentage of GC.

When analyzing the Hip kinematics, on the sagittal plane we expected a ROM of approximately 40º, with a minimum value of approximately -10º, and a maximum value of approximately 30º [56]. We obtained a ROM of 42.28º (see Table 19: mean_Sag_Hip_ndmax_ROM_L_R = 42.28 ± 9.24 (38.62 - 45.93)), with a minimum value of -7.28º (extension) (see Table 19: mean_Sag_Min_HipA_L_R = -7.28 ± 5.90 (-9.61 - -4.94), and a maximum of 35.85º (see Table 19: mean_Sag_ndMax_HipA_L_R = 35.85 ± 4.39 (34.11 - 37.58) (Figure 41). When analyzing the frontal plane we expected a maximum value of 10º (adduction) and a minimum of -5º (abduction)[56]. We obtained a minimum value of -6.58º (see Table 19: mean_Front_Max_Hip_SWph_L_R = -6.58 ± 1.72 (-7.26 - -5.90)), and the graphic indicates a maximum around 9.75º (Figure 42). Regarding the transverse plane, we expected a ROM of 15º [56], and obtained one of 19.82º (see Table 19: mean_Trans_Hip_ROM_L_R = 19.82 ±4.36 (18.09 -21.54)) (Figure 43).

Figure 41. – Hip motion on the sagittal plane, normalized to percentage of GC.

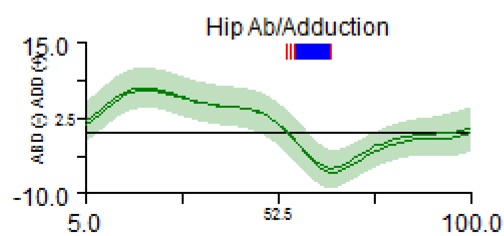


Figure 42. – Hip motion on the frontal plane, normalized to percentage of GC.

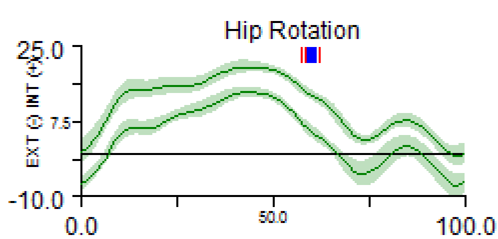


Figure 43. – Hip motion on the transverse plane, normalized to percentage of gait cycle.

Regarding the knee angles, on the sagittal plane we expected a ROM of 60º, oscilatting from 0º to 60º [56], and we obtained a ROM oscilatting from 0.40º (see Table 19: mean_Sag_KneeA_CI_L_R = 0.40 ± 3.40 (-.94 - 1.74)) to 65.28º on the left side, and 66.62º on the right side (see Table 19: Sag_L_Max_ndKneeA = 65.28 ± 3.97 (63.71 - 66.85); Sag_R_Max_ndKneeA = 66.62 ± 3.81 (65.11 - 68.13)) (Figure 44). When looking at the frontal motion, we expected the value of varus to be 4º or less during stance phase, and a ROM up to 10º during swing phase[56]. The obtained graphic shows values within the expected ranges. The reference values on the transverse plane range approximately between 25º and -10º [56]. At the end of ST, the external rotation is expected to be maximal. At TO, the internal rotation begins and remains through SW and LR. The obtained curves reproduce the TO turn point, from external to internal rotation, however, the internal rotation is not preserved until LR, as reported in the literature. The rotation curve of the knee has been associated with higher levels of error (variability) in the literature[45], which probably justifies these findings (Figure 46).

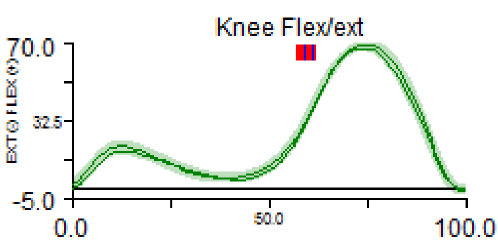


Figure 44. – Knee motion on the sagittal plane,normalized to percentage of GC.

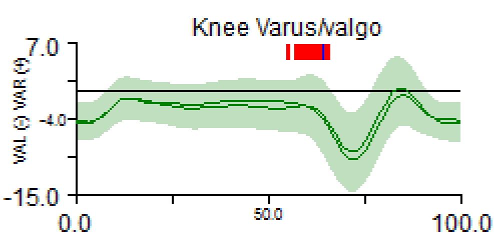


Figure 45. – Knee motion on the frontal plane, normalized to percentage of GC.

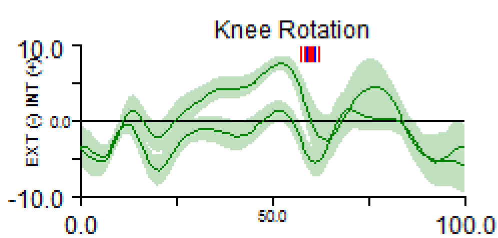


Figure 46. – Knee motion on the transverse plane, normalized to percentage of GC.

Regarding the Ankle kinematics, on the sagittal plane we expected a ROM of approximately 25º, 10º of dorsiflexion to 15º of plantarflexion[56]. We obtained a ROM of 27.70º for the left side, and 29.62º for the right side (see Table 19: Sag_L_TT_ROM = 27.70 ± 4.49 (25.93 - 29.48); Sag_R_TT_ROM = 29.62 ± 4.62 (27.80 – 31.45)). The maximum dorsiflexion registered occurred during ST, with the value of 12.49º (see Table 19: mean_Sag_TT_MaxDf_STph_L_R = 12.49 ± 2.89 (11.34 - 13.63)) (Figure 47). The Foot Progression Angle is also presented as it is among the regular information reported on gait analysis. The obtained mean value during ST is -5.92º (see Table 19: mean_FPA_MedV_STph_L_R = -5.92 ± 3.02 (-7.11 - -4.72)), and the literature reports an healthy reference value of -10º(healthy acceptable values ranging from -3º to -20º)[8]. The overall curve pattern is similar to the reference one[4].

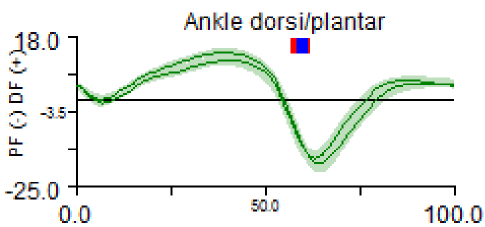


Figure 47. – Ankle motion on the sagittal plane, normalized to percentage of GC.

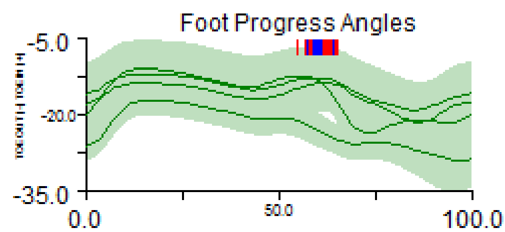


Figure 48. – Angle between the axis of the foot and the line of walking direction (transverse plane). Normalized to percentage of GC.

When considering the overall behavior of the curves, small differences occur amongst sides, with a good visible overlapping of the curves. All of the obtained curves (see Figure 49) show a similar pattern to that presented in the literature as the reference for the healthy population (see Figure 50), the exception being the knee rotation curve.

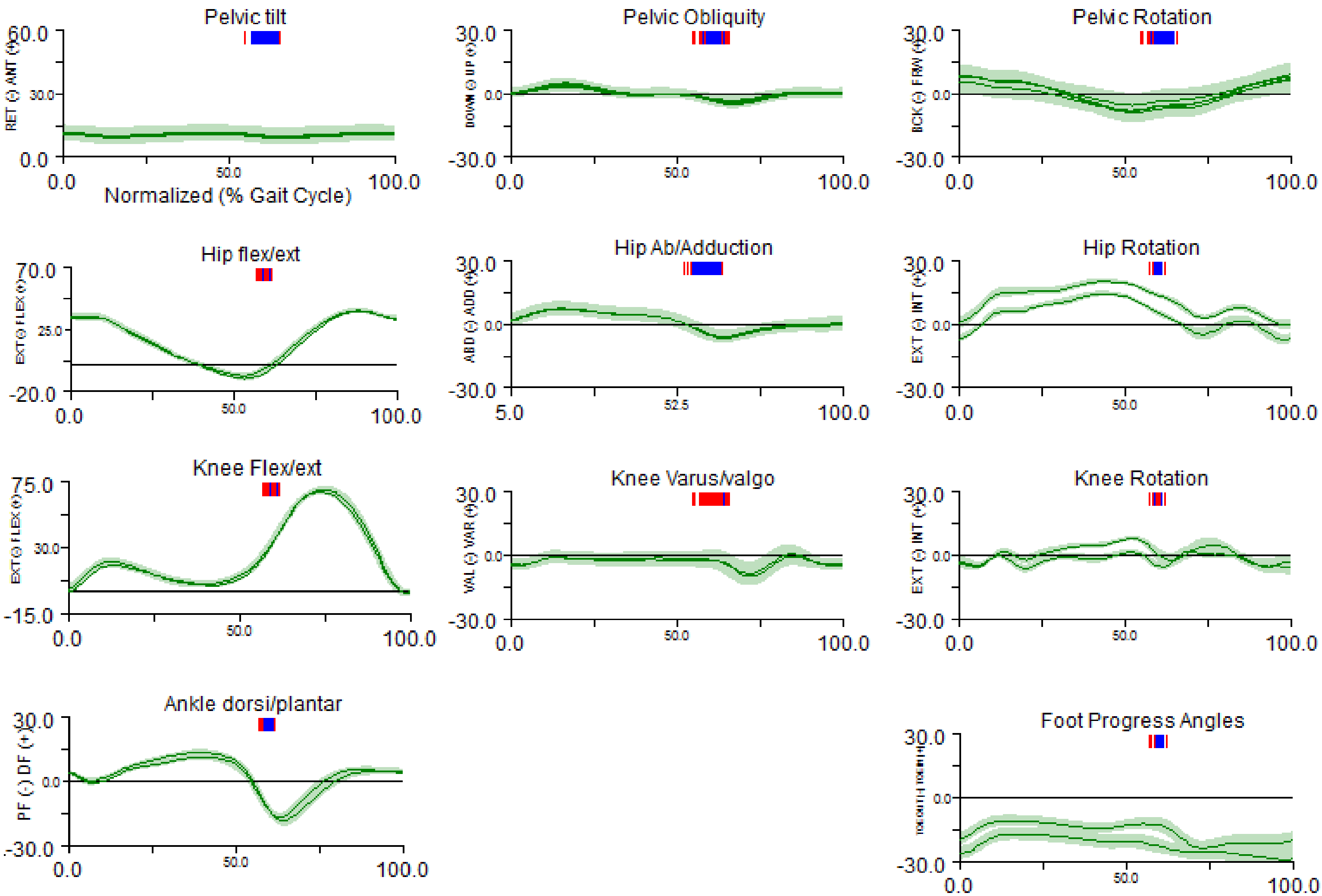
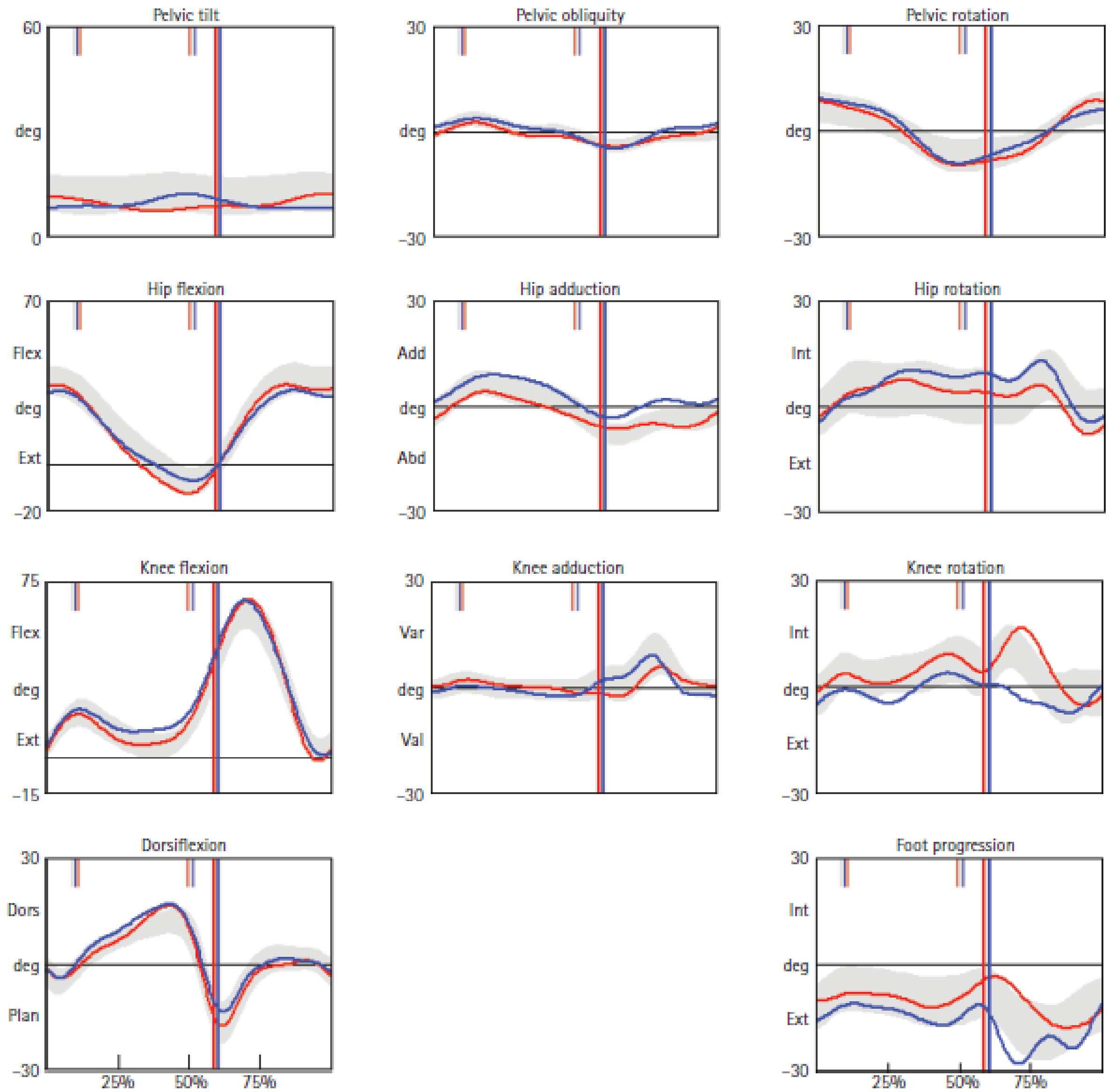


Figure 49.- Joint Angle Displacement curves obtained from the 27 children of this study. All data presented is referred to GC %. The green lines represent the mean of the data for the left and right sides of the subjects. The shadow represents the sum of the mean plus 1SD.



Source: (adapted) [4]

Figure 50. – Reference Joint Angle Displacement curves.

Kinetic Data

Moments and Power

Kinetic data was collected for all 27 subjects. The curves representing moments and power are presented on Figure 40 for all subjects, the left side being represented by the red lines, and the right by the blue. The curves show the reunion of all of the valid kinetic motion trials. The moments of foot-off are represented on top of the curves by top sticks, the red representing the left, and the blue representing the right. All data is shown with reference to one GC (X axis). The overall kinetic curves pattern (regarding moments and power of the joints) was analized, mainly on a comparative manner, to the previously published work. The analysis of moment and power is presented together, as they are functionally related.

When analyzing the behavior of the curves we observe small differences among sides, with a good overlapping of the curves. All of the graphs show a similar pattern to that presented in the literature as the reference for the healthy population (see Figures 51 and 52).

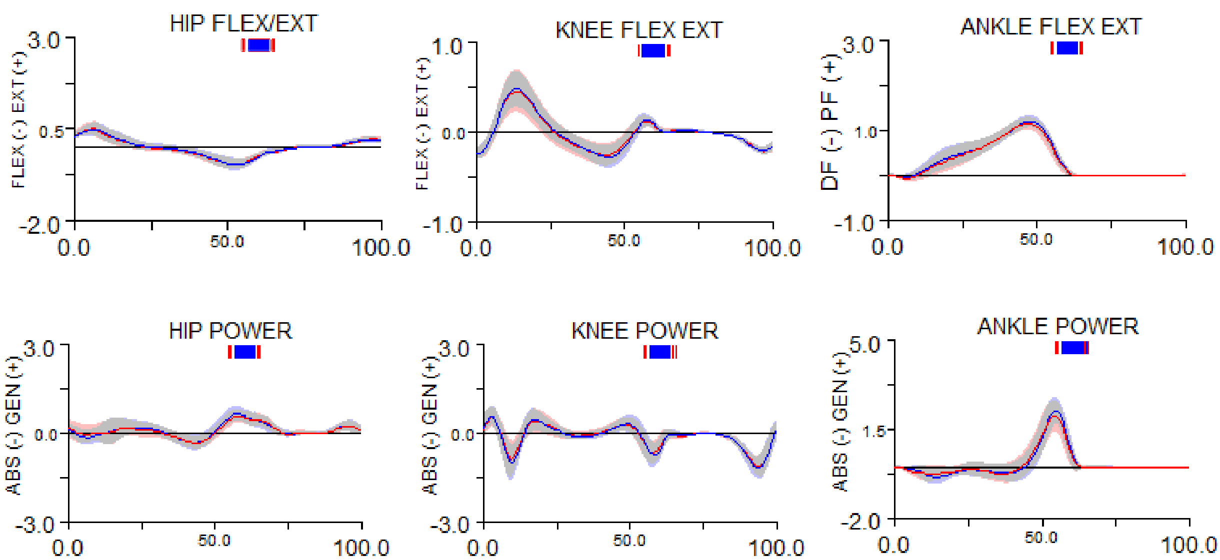
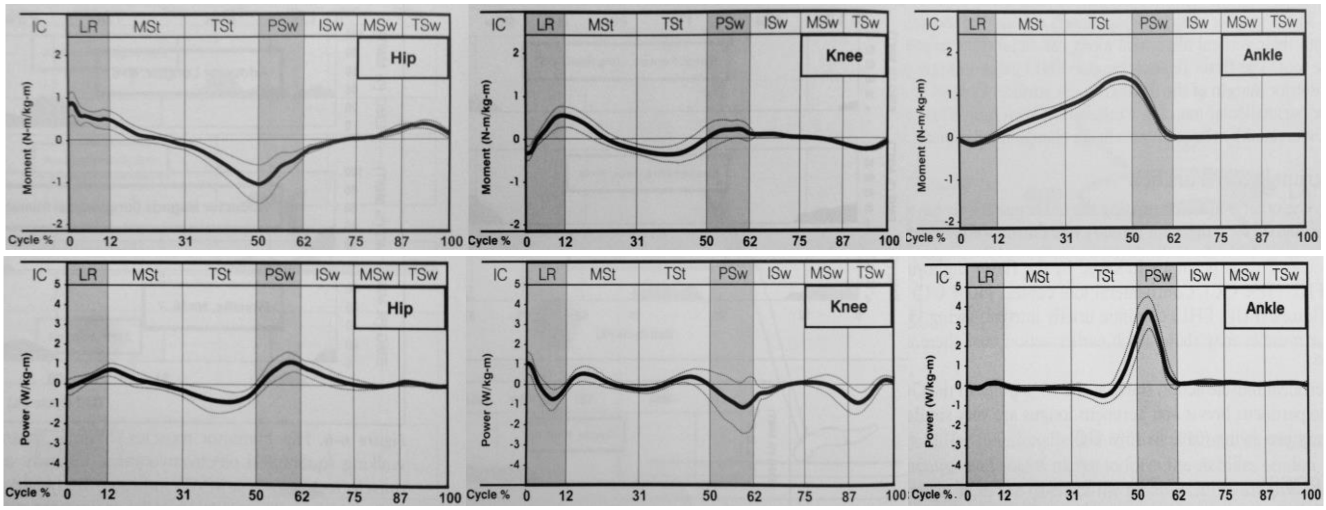


Figure 51.– Moments and Power graphs obtained from the 27 children of the present study. All data is presented according to one GC. The red lines represent the mean of the data values regarding the left side of the subject, and the blue lines the right one. The shadow represents the sum of the mean plus 1SD.



Source: [56]
Figure 52.– Reference Moments and Power graphs.

Regarding the moments of the Hip, it is expected that the curve begins with an extensor moment of approximately 0.84N.m/kg, slightly after the beginning of the GC, with a descent, as the force vector approximates itself to the Hip joint, until a flexor moment peak occurs at the beginning of PSW (approximately 1.06N.m/kg). Meanwhile, a power generation peak occurs, contributing to hip extension during LR and MST (0.72W/kg.m). As the flexor moment is declining (with load shifting), another power generation peak occurs by the end of PSW (1.14 W/kg.m), contributing to hip flexion. A small extensor moment occurs at the end of GC (MSW and TSW) to prepare the imminent heel strike. Both curves, moments and powers are consistent with published work.

About the Knee joint moments, it is expected that the GC beggins with a small and brief flexor moment (0.35 N.m/kg), as power is generated (1.0W/kg.m), reflecting the quadriceps muscles concentric action to prevent knee hyperextension. An extensor moment (0.52N.m/kg) should follow, during LR, while power is absorbed (0.8W/kg.m), as a result of the eccentric activity of the quadriceps to stabilize the knee joint. Power generation must occur at the beginning of MidST, from the muscles concentric contribution to knee extension (0.5W/kg.m). The previous extensor moment is then suppose to decline, and swift to a flexor one by the end of MidST (0.36 N.m/kg), until it changes again in PSW to an extensor moment (0.21N.m/kg), with a peak power absorption (1.2W/kg.m) to control knee flexion. By the end of swing, a flexor moment (0.26N.m/kg) with power absorption (0.9W/kg.m), shows the eccentrical action of the hamstrings muscles, controlling the rate of knee extension, when preparing for a new GC. Both graphs respect the published literature.

Regarding the Ankle joint moments, we expected the curve to begin with a small dorsiflexor moment that controls foot descent (0.18N.m/kg), a control made eccentrically and therefore generating a power absorption peak (0.15W/kg.m) (see Figure 53). When LR is through, the dorsiflexor moment is reduced to zero, as the force vector crosses the joint, to an aterior position, and a small power is generated, reflecting the concentric control of the pre-tibials (drawing the tibia fowardly) (see Figure 54). When the opposite foot off occurs, the force vector progressivelly crosses the joint, forwardly, creating a rising plantarflexor moment, which peaks just before the opposite foot strike (end of TST) (1.40N.m/kg). The eccentric controling action of the plantarflexors should generate a power absorption until the final half of TST (0.54W/kg.m). During PSW, as the unloading of the limb occurs, the posterior muscles of the leg, that had been lenghten through this entire process, suffer an elastic recoil of the respective tendon, contributing to the occurrence of a plantarflexion (pusf-off), with a strong power generating peak of 3.7W/kg.m[56]. Both moments and power graphs respect the published literature.

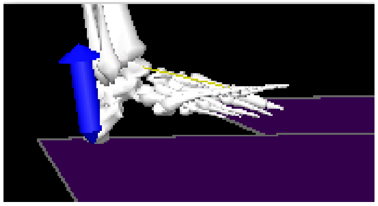


Figure 53.– Ground Reaction Force vector.
Here the force vector is posterior to the Ankle joint, generating an external plantarflexion moment (equivalent to an internal dorsiflexor moment). Image from Visual 3D™ Professional v5.01.18.C_Motion, Inc software.

Figure 54. – Ground Reaction Force vector.
Here the force vector is anterior to the Ankle joint, generating an external dorsiflexion moment (equivalent to an internal plantarflexor moment). Image from Visual 3D™ Professional v5.01.18.C_Motion, Inc software.

GROUND REACTION FORCE

The figures 55, 57, and 59 represent the curves obtained for the vertical, anterior-posterior and medio-lateral components of the GRF. All graphics' X axis represent the percentage of ST, while the Y axis corresponds to the registered magnitude of Force (N), normalized to body weight (BW; as Mass, measured in kg). Differences when comparing to the reference values may occur related to walking speed, with higher magnitudes registered for higher speeds[59].

Regarding the vertical component, we expected the presence of two peaks, each reaching approximately 1.2 times the BW, and the dip trough reaching 0.7 of BW. The 1st peak should occur around the 22% of the stance phase, the 2nd around the 78%, and the the time to trough should be around 51%. For our sample, of mean Mass of 27.90kg, we obtained peaks reaching approximately 1.13 times the BW, and with the trough reaching 0.75 times the BW, occurring within the expected times (see Figures 55 and 56).

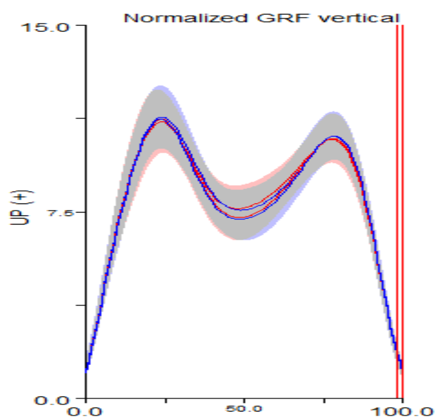
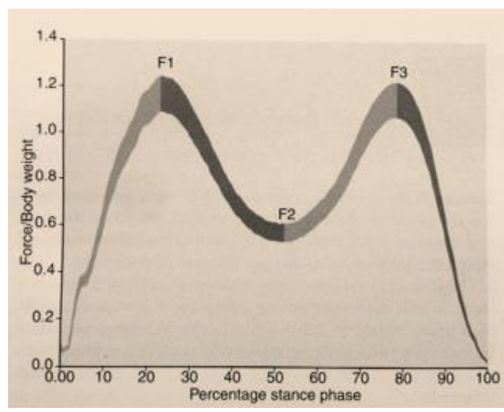


Figure 55.– Vertical component of the GRF. Data from the present study



Source: (adapted)[59]
Figure 56.– Vertical component of the GRF. Reference data.

The anterior-posterior component of the GRF is expected to reach a maximum posterior loading force around 0.2 the value of BW, and a maximum anterior thrusting force around 0.2 the value of BW. The expected timings of these events are 20% of ST, regarding the maximum posterior loading force, and 85% of ST for the anterior thrusting force, with the crossing over (moment where no anterior or posterior forces are acting – time of midstance) happening around 55% of ST[59]. Our sample registered similar values (approximately 0.2 times the BW for the maximum posterior loading force; approximately

0.22 for the maximum anterior thrusting force). The timings of the mentioned events are also similar (see Figures 57 and 58).

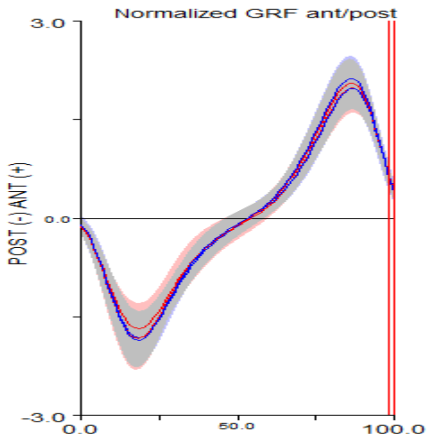
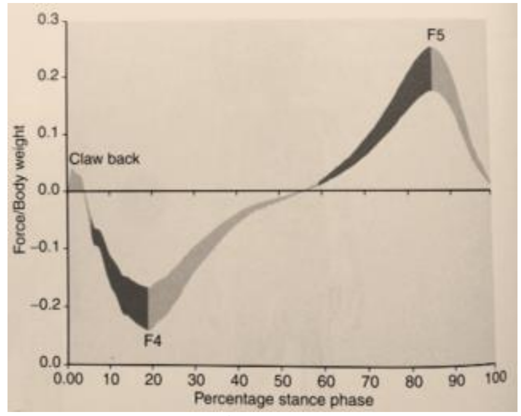


Figure 57.– Anterior-posterior component of the GRF. Data from the present study



Source: (adapted)[59]
Figure 58.– Anterior-posterior component of the GRF. Reference data.

Considering the medial-lateral component of the GRF, a maximum medial force between 0.05 and 0.1 of the BW is the expected behaviour, with the maximum lateral force usually registering a smaller value then the medial[62]. We obtained approximately 0.08 of the BW for the maximum medial force values, which is in accordance with the literature (see Figures 59 and 60).

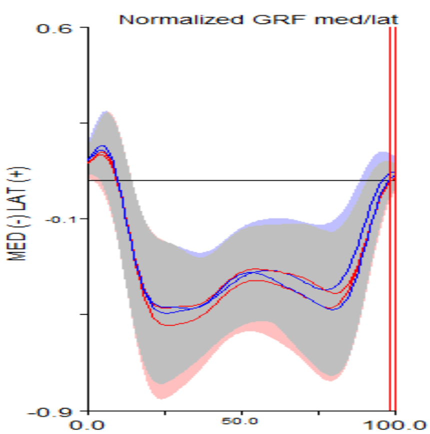
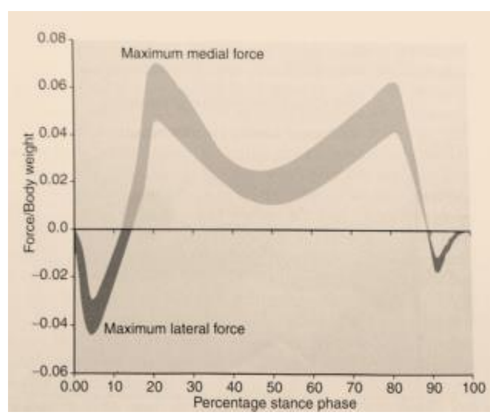


Figure 59.– Medial-lateral component of the GRF. Data from the present study.



Source: (adapted)[59]
Figure 60.– Medial-lateral component of the GRF. Reference data.

Electromyographic Data

The EMG analysis is focused on activation timings, as it is not normalized to a maximum value of force.

Regarding symmetry, we observe a very similar signal behavior for each side, with similar peaks, occurring on the same moments of GC.

When comparing the activity of Gluteus Medius to world reference data, we see a similar activation pattern of (Figure 61 and 62), with a peak of activity since late TSW until the end of MST. Concerning the Adductor Longus, the signal is less clear. It shows its greater activity between late TST and initial MSW, as expected, but more then just the expected peak in late PSW (see Figure 61 and 62). We admit the possibility of cross talk on this small muscle, as well as tissue wobbling, due to its specific location.

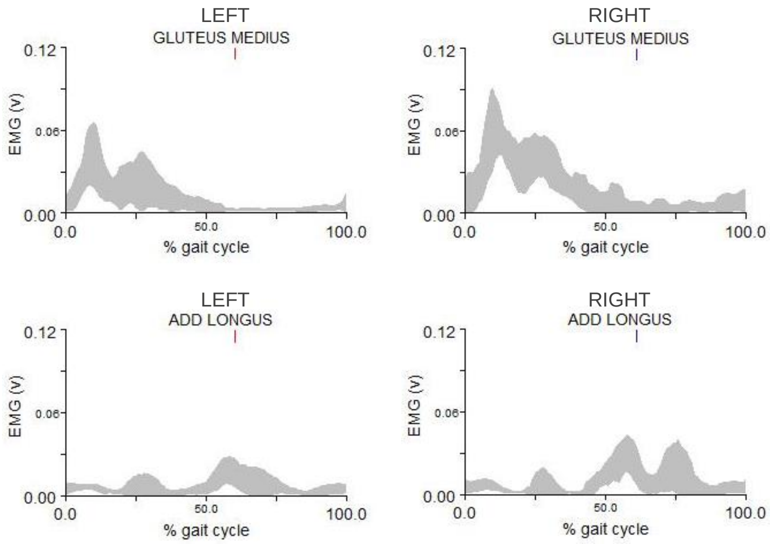
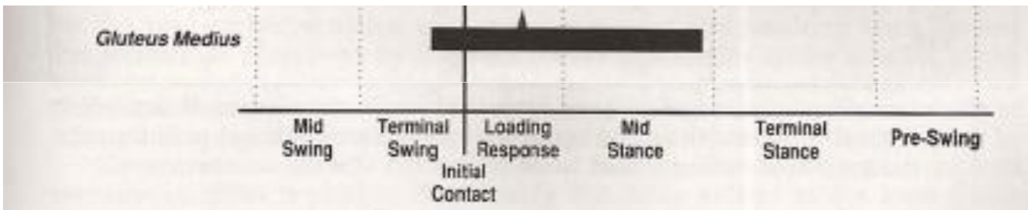
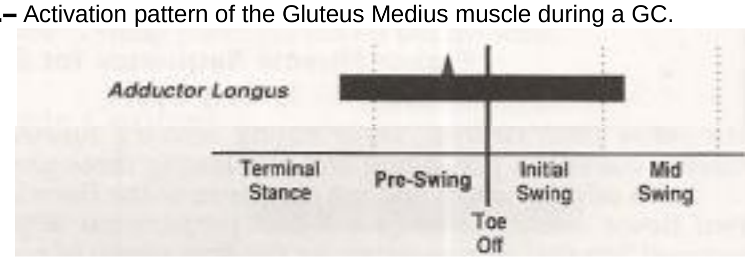


Figure 61.– EMG signal obtained from the present study (n=27). Mean +/- 1SD (shadow).



Source: (adapted) [56]

Figure 62.– Activation pattern of the Gluteus Medius muscle during a GC.



Source: (adapted)[56]

Figure 63.– Activation pattern of the Adductor Longus muscle during Swing Phase.

Concerning the Semitendinosus, it is possible to detect a peak between TSW and through LR (see Figure 64). This signal behavior is in accordance to the previously published reference data (see Figure 65). Regarding the Rectus Femoris activity, it is detectable a peak around foot-off, in accordance with reference data (see Figures 64 and 66). The augmented activity during TSW and through LR is probably attributable to cross-talk, namely with the Vastus muscles, all active in this period (see Figure 12).

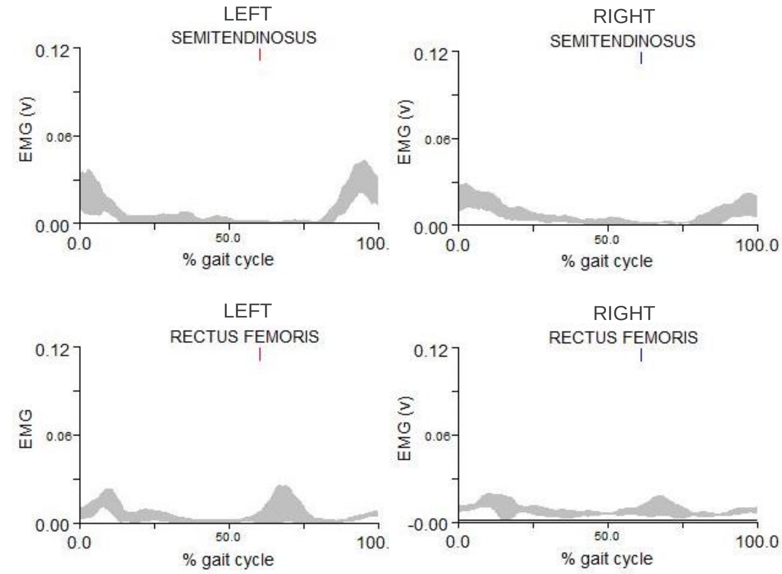
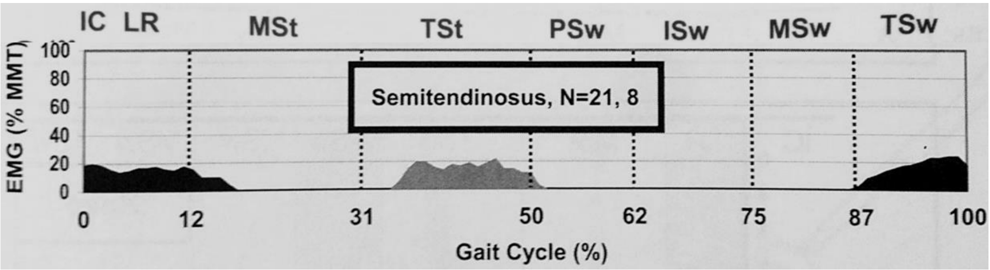
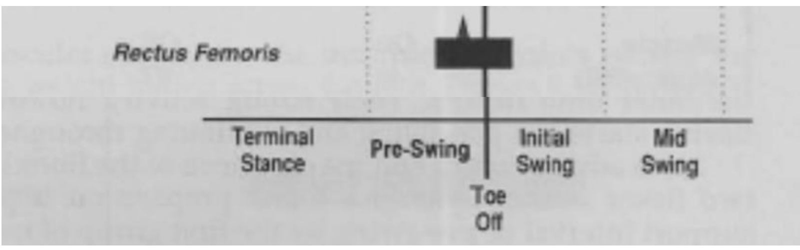


Figure 64.– EMG signal obtained from the present study (n=27). Mean +/- 1SD (shadow).



Source: (adapted)[56]

Figure 65.– Normal mean intensity and timing of the semitendinosus muscle during a GC.



Source: (adapted)[55]

Figure 66.– Activation pattern of the Rectus Femoris muscle during Swing Phase.

Regarding the Tibialis Anterior, we observe a signal continuously active, with higher peaks around the IC and slightly after foot-off (see Figure 67). About the Gastrocnemius, we observe a peak on the latest half of the ST (Figure 67). The data of both graphics is in accordance with the published reference data (see Figures 68 and 69).

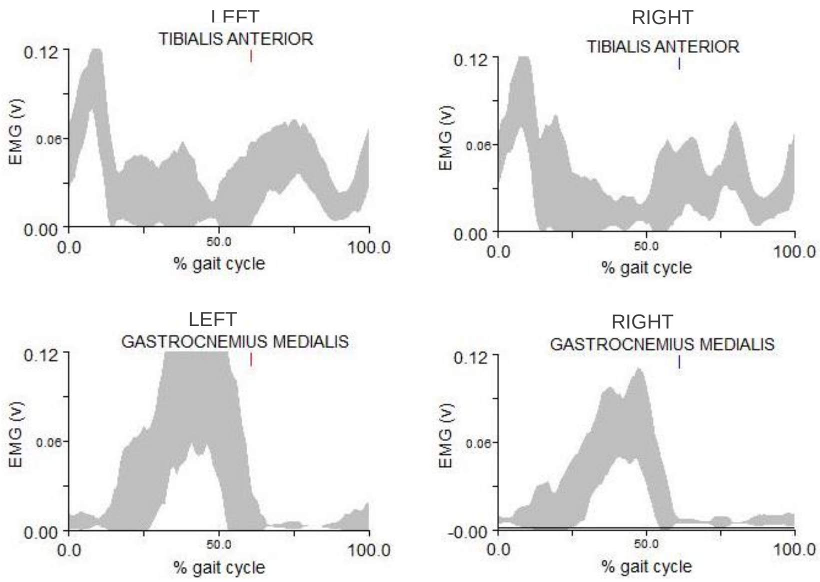
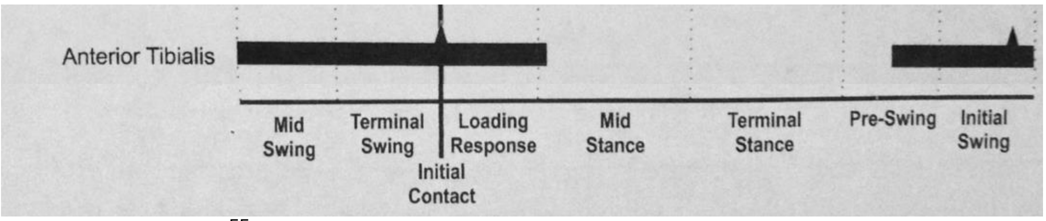
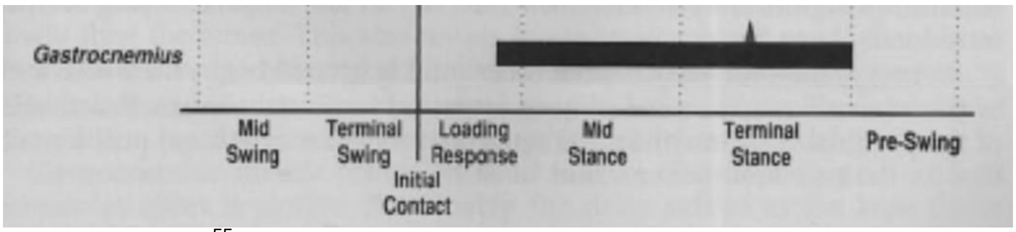


Figure 67.– EMG signal obtained from the present study (n=27). Mean +/- 1SD (shadow).



Source: (Adapted)[55]

Figure 68.– Activation pattern of the Anterior Tibialis muscle during a GC.



Source: (adapted)[55]

Figure 69.– Activation pattern of the Gastrocnemius muscle during a GC.

Clinical Measurements Variables

The Clinical Measurements Variables, concerning Anthropometric and Goniometry data, will be presented according to the applied statistics. The Frequency tables are presented on Appendix VIII.

Descriptive Statistics Of The Sample (n=27)

As part of the selection process, a protocol of Anthropometric and Goniometric measures (Appendix V) were developed to rule out any musculoskeletal involvements. Those registered variables (Frequency Table: Appendix VIII) were studied, in order to better describe the subjects, by age and gender.

The descriptive statistics obtained for these variables are presented on the Table 14. We chose to report the value of the Mean, Standard Deviation (SD), and the 95% Confidence Interval (CI = ± 2SEM), which is calculated by adding and subtracting 2 times the value of the Standard Error of the Mean (SEM= SD / $\sqrt{n}$)[4,57].

Table 14.– Descriptive statistics of the Clinical Measurements variables for all individuals.

	Mean ± SD (95% CI) **n= 27**
Anthropometrics	
M	27.90 ± 4.67 (26.056 - 29.75)
H	1.313 ± 0.057 (1.290 - 1.336)
N.º geno varus	10
N.º geno valgus	12
N.º neutral (0 cm)	5
UMB-MM	72.98 ± 3.76 (71.50 - 74.47)
ASIS-MM	68.30 ± 3.26 (67.01 - 69.58)
TROC-LM	62.15 ± 3.02 (60.96 – 63.34)
Goniometry	
K EXT	0.30 ± 1.07 (-0.13 - 0.72)
IR	46.07 ± 7.24 (43.21 - 48.92)
ER	18.96 ± 5.18 (16.91 - 21.01)
ROT ROM	65.04 ± 8.20 (61.79 - 68.28)
F ANT	17.78 ± 5.85 (15.47 - 20.09)
TI TORS	5.89 ± 3.25 (4.60 - 7.17)

As the children were selected according to health status, it is expected that the data reflects that, with values within normal healthy ranges. Regarding the mean values of Mass and Weight, 27.90 Kg and 1.313 m respectively, they are in accordance with the Portuguese Directorate-General of Health (DGS) published data (see Table 15).

Table 15. – Values of height and mass referring to the 50th percentile of the National Programme for Infantile and Juvenile Health DGS 2013.

	MALE			FEMALE		
AGE GROUP	7	8	9	7	8	9
HEIGHT (m)	122	127	132.5	121	127	132.5
MASS (Kg)	23	25.5	28	22.5	25	28

Source: National Programme for Infantile and Juvenile Health DGS 2013.[87]
The data is in accordance with the new Growth Curves adopted by the World Health Organization[81].

From the 27 assessed children, 12 presented valgus, 10 varus, and the remaining 5 presented no measurable distance between the mentioned bony references (neutral). All of the varus or valgus measures were within the range of normal variability, with DIST IC (intercondylar distance) ranging from 0.5 to 2, and DIST IM (inter-malleolar) ranging from 0.5 to 2.5. Authors refer, for these age groups (7, 8, and 9), healthy DIST IC values as high as 4 cm, and DIST IM as high as 7.5 cm (see Table 16)[72,73].

Table 16. – Intercondylar (IC) and intermalleolar (IM) distance in the healthy developing child.

	7 YEARS OF AGE	8 YEARS OF AGE	9 YEARS OF AGE
IC DIST(/GENO VARUM) (MEAN + 2SD) (cm)	2/3	3	3.5/4
MEAN VALUE	-2/-3	-2	-2
IM DIST (GENO VALGUM) (MEAN – 2SD) (cm)	-6/-7	-7	-7.5

Source: (adapted)[72,73]
Negative (-) values represent IM DIST; Positive values represent IC DIST.

Three measures of the inferior limb were recorded. The apparent limb length (UMB-MM; which measures the distance between the umbilicus and the medial malleolus), the real limb length (ASIS-MM; which measures the distance between the anterior superior iliac spine and the medial malleolus), and the distance between the great trochanter and the lateral malleolus (TROC-LM). This last measure was collected mainly for the modeling process. The reference values concerning inferior limb length and growth are presented for each segment, in this case, femur and tibia. The TROC-LM can be considered as the closest representation of the addition of its segments length, femur and tibia. The mean value for our sample is 62.15 ± 3.02 cm, which falls in the published normal ranges of the addition of femur and tibia length (+/- 1SD) (see Table 16).

Table 16. – Femoral and tibial growth in length.

		7y		8y		9y	
		Segmental Length (cm) ± SD	Total Length (min – max)	Segmental Length (cm) ± SD	Total Length (min – max)	Segmental Length (cm) ± SD	Total Length (min – max)
Female Gender	Femur	30.60 ± 1.83	51.35 – 54.29	32.72 ±1.94	54.88 – 62.34	34.71 ± 2.12	58.16 – 66.38
	Tibia	24.22 ± 1.64		25.89 ± 1.79		27.56 ± 1.99	
Male Gender	Femur	30.25 ± 1.68	50.70 – 57.32	32.28 ± 1.81	54.07 – 61.25	34.36 ± 1.93	57.46 – 65.24
	Tibia	23.76 ± 1.63		25.38 ± 1.78		26.99 ± 1.96	

Source: (adapted)[29]

The mean value for the knee extension (KEXT) was 0.30º, therefore, in accordance with the previously published data that admit few degrees of oscillation around 0º [29]. The mean values for the hip internal (medial) and external (lateral) rotations were 46.07º and 18.96º, correspondingly. Previously reported reference values of the mean hip internal rotation fluctuate from 54º (SD = 17.50º)[31] to 61.20º (SD= 10.70º)[47], with our obtained mean occurring on the lower healthy confidence interval. Previously reported reference values of the mean hip external rotation fluctuate from 43º (SD = 17.50º) to 45º (ẋ +/- 2SD = 25º to 65º), therefore not in accordance with our findings, which are below the expected. The value of mean ROT ROM was 65.04º, when authors advocate it should be close to 100º [29,47,72]. As this is a variable obtained by adding both hip rotations, medial and lateral, the low lateral rotation influenced this finding. The value of the mean for the F ANT variable was 17.78º. It is stablished that this is an angle that should stabilize around 16º by the age of 16 years, decreasing from 32º by the age of 1 year, therefore covering our value of mean. The value of the mean for the TI TORS variable was 5.89º, a little bellow the expected, as described in the literature. It describes the evolution of tibial version starting around 5º, and evolving to 15º by adulthood, but showing little changes after the 6 years of age. It is, however, included in the normal interval of 2SD (- 5º to 30º)[72].

DESCRIPTIVE ANALYSIS OF THE SAMPLE BY GENDER

To understand how differently the variables could behave according to gender, each one was compared among that factor. After the study of the variables' distribution according to gender (Appendix VIII), the Independent-Samples T Test was applied whenever Normal distribution was verified, or the nonparametric alternative Mann Whitney U Test ,whenever it wasn't. When the variances homogeneity (tested with Levene's Test) wasn't verified, for the variables following a Normal distribution, we resorted to the Welch correction. The results are presented on the Table 17.

Table 17. – Descriptive statistics of the Clinical Measurements variables according to gender.

	Female **n= 13**	**Male** **n= 14**
	Mean ± SD (95% CI)	
ANTHROPOMETRICS		
M	27.01 ± 4.48 (24.30 – 29.71)	28.73 ± 4.85 (25.93 – 31.53)
H	1.31 ± .05 (1.28 – 1.34)	1.31 ± .06 (1.28 – 1.35)
N.º GENO VARUS	3	7
N.º GENO VALGUS	8	4
N.º NEUTRAL (0 CM)	2	3
UMB-MM	73.69 ± 3.72 (71.45 – 75.94)	72.32 ± 3.81 (70.12 – 74.52)
ASIS-MM	68.85 ± 2.85 (67.13 – 70.57)	67.79 ± 3.63 (65.69 – 69.88)
TROC-LM	63.12 ± 2.72 (61.47 – 64.76)	61.25 ± 3.09 (59.46 – 63.04)
GONIOMETRY		
K EXT	.31 ± 1.11 (-.36 - .98)	.29 ± 1.07 (-.33 - .90)
IR	48.92 ± 5.87 (45.38 – 52.47)	43.43 ± 7.58 (39.05 – 47.81)
ER	17.38 ± 4.50 (14.66 – 20.10)	20.43 ± 5.50 (17.25 – 23.60)
ROT ROM	66.31 ± 6.73 (62.24 – 70.37)	63.86 ± 9.46 (58.39 – 69.32)
F ANT	18.46 ± 5.09 (15.38 – 21.54)	17.14 ± 6.60 (13.33 – 20.95)
TI TORS	5.85 ± 2.61 (4.27 – 7.42)	5.93 ± 3.85 (3.70 – 8.15)

The analysis of the Clinical Measurements variables according to gender showed little differences regarding the variables M and H, with the males presenting a bigger value of mass (27,01kg and 1.31m for the feminine gender, and 28,73kg and 1.31m for the masculine gender). Regarding the variables related to the angular alignment of the inferior limbs on the Frontal plane, we verified the feminine gender tends to present a geno valgus, while the male gender tends to present a geno varus. From the 27 children of our sample, 8 girls presented geno valgus, 3 presented geno varus, and 2 presented no measurable distance between the bony references. Regarding the male gender, 4 boys presented geno valgus, 7 presented geno varus, and 3 presented no measurable distance between the bony references. This is another result in accordance with previously published work (see Table 16). The value of the mean K EXT was .31º for the female group, and .29º for the male one, which is in accordance with the previously published work. All variables that tell us about the lower limbs length (UMB-MM, ASIS-MM, TROC-ML), revealed higher mean values for the feminine gender (73,33cm for UMB-MM, 68,85cm for ASIS-MM, and 63,12cm for TROC-ML concerning the feminine gender; 72,32cm for UMB-MM, 67,79cm for ASIS-MM, and 61,25cm for TROC-ML concerning the masculine gender), all in accordance with previously published, and mentioned literature (see Table 16). The IR was the only variable that showed significant differences among genders (p_value=.047), with a higher hip internal rotation mean of 48.92º for the females, and a lower one of 43.43º for the males. This is in accordance with the findings of Mudge[47], and against the findings of Staheli[72], that found the female value of the mean for the hip internal rotation lower than the male one. The value of the mean ER found for the female group was 17.38º, and 20.43 º for the male one. This difference is expected since the value of hip internal and external rotation complement each other, so as one augments, the other is expected to diminish. The mean value of ROM ROT showed little difference between genders (66,31º for females, and 63,86º for males), as expected, for the same reason. The value of the mean ANT F was 18,46º for females and 17,14º for males, a little higher for the female gender, in agreement with the significant higher IR, as stated in the literature[29]. The value of the mean TI TORS was 5.85º for the female group, and 5.93º for the male group, with no significant differences found among groups, as expected, in accordance with published work[29].

DESCRIPTIVE ANALYSIS OF THE SAMPLE BY AGE GROUP

As previously reported in the literature, differences regarding anthropometrics and goniometry data may be found across age groups[33,47,72]. For that we decided to study our variables according to that factor, age (see Table 18; see Appendix VIII). Whenever Normal distribution was verified, the One_Way ANOVA was applied, with its p_value or Welch's taken into account, based on the variance homogeneity confirmation (tested with Levene's Test), or not, correspondingly. Whenever the distribution wasn't Normal, we chose the nonparametric alternative Kruskal-Wallis. For the subsequent study of the significant differences among groups, the multicomparisons test used was the Scheffé or Tamhanes (or the LSD, when the Tamhane wasn't enough) with Normal distribution, and according to the verified variance homogeneity, or not, respectively. We applied the Dunn Test as the nonparametric alternative.

Table 18. – Descriptive statistics of the Clinical Measurements variables according to Age Group.

	7 years Group n= 9	8 years Group n= 8	9 years Group n= 10
	Mean ± SD (95% CI)		
ANTHROPOMETRICS			
M	25.15 ± 4.32 (21.83 – 28.47)	30.59 ± 4.47 (26.86 – 34.33)	28.22 ± 4.07 (25.31 – 31.13)
H	1.27 ± .06 (1.22 – 1.32)	1.33 ± .04 (1.30 – 1.37)	1.33 ± .04 (1.30 – 1.37)
N.º GENO VARUS	2	3	5
N.º GENO VALGUS	5	5	2
N.º NEUTRAL (0 CM)	2	-	3
UMB-MM	71.56 ± 5.09 (67.64 – 75.47)	73.81 ± 3.00 (71.31 – 76.32)	73.60 ± 2.78 (71.61 – 75.59)
ASIS-MM	66.61 ± 4.04 (63.50 – 69.72)	69.38 ± 2.34 (67.42 – 71.33)	68.95 ± 2.73 (67.00 – 70.91)
TROC-LM	61.22 ± 4.13 (58.05 – 64.40)	62.94 ± 2.08 (61.20 – 64.68)	62.35 ± 2.51 (60.56 – 64.14)
GONIOMETRY			
K EXT	.44 ± 1.33 (-.58 – 1.47)	.50 ± 1.41 (-.68 – 1.68)	0 ± 0 (0 – 0)
IR	46.89 ± 6.86 (41.61 – 52.16)	45.00 ± 4.66 (41.10 – 48.90)	46.20 ± 9.54 (39.37 – 53.03)
ER	20.22 ± 6.12 (15.52 – 24.93)	17.75 ± 3.62 (14.73 – 20.77)	18.80 ± 5.59 (14.80 – 22.80)
ROT ROM	67.11 ± 8.31 (60.72 – 73.50)	62.75 ± 5.95 (57.78 – 67.72)	65.00 ± 9.81 (57.98 – 72.02)
F ANT	20.44 ± 6.54 (15.42 – 25.47)	16.88 ± 5.59 (12.20 – 21.55)	16.10 ± 5.04 (12.49 – 19.71)
TI TORS	6.56 ± 4.72 (2.93 – 10.18)	5.63 ± 2.26 (3.73 – 7.52)	5.50 ± 2.46 (3.74 – 7.26)

For the analysis of the Anthropometric and Goniometric data according to age, 3 groups were considered, the 7 years old group (n=9), the 8 years old group (n= 8), and the 9 years old group (n= 10). A notable increase in the mean values of M, H, UMB-MM, ASIS-MM and TROC-ML occurs from 7 to 8 years old group. In fact, a statistical significant differences was found on the variable M (p_value=.008), with the Dunn test identifying the 7 and 8 years old group as the meaningful ones (p_value=.006). When compared with the 9 years old group, the variables reach a plateau M, H, UMB-MM, ASIS-MM and TROC-ML, showing no changes or even small decreases (28.22kg for the M, 1.33m for the H, 73.60cm for the UMB-MM, 68.95cm for the ASIS-MM and 62.35cm for the TROC-ML). This is probably the reflection of the rate of growth, in its peak until 7/8 years of age, and decreasing between the ages 7/8 to 9/10[15,29]. Regarding the angular alignment of the inferior limbs on the Frontal plane, we found the number of children presenting geno varus increasing with age group, with 2 children presenting it at 7 years old, 3 at age 8, and 5 at age 9. Also, we found the number of children presenting geno valgus decreasing with age group, with 5 children presenting it at 7 years old, 5 at age 8, and 2 at age 9. Furthermore, 2 children presented geno neutral in the 7 year old group, and 3 in the 9 year old group. The physiological evolution of the angular behavior of the inferior limbs in the frontal plane is described to happen toward the tendency of developing geno valgus[29,35,47], however the forms presented by the 27 children of this sample are predicted within the normal variations. The value of the mean K EXT showed little changes between the age groups, .44º for the 7 year old group, .50º for the 8 year old group, and 0º for the 9 year old group. The variables IR and ER showed little differences among age groups, with the value of mean IR of 46.89º for the 7 year old group, 45.00º for the 8 year old group, and 46.20º for the 9 year old group, and the value of the mean ER of 20.22º for the 7 year old group, 17.75º for the 8 year old group, and 18.80º for the 9 year old group. Necessarily, the mean value of the ROM ROT also showed little variations among age groups, with the 7 year old group showing 67,11º, the 8 year old group showing 62.75º, and the 9 year old group showing 65,00º. The value of the mean ANT F decreased from the 7 years old group to the 8 years old group (20,44º to 16,88º), and showed little change to the 9 years old group (16,10º). This behavior is in perfect harmony with the published literature, with the angle of femoral anteversion decreasing as age increases[29,33,47]. The TI TORS showed a little decrease from the 7 to 8 years old groups (6,56º to 5,63º), and little changes to the 9 years old (5,50º), which is not exactly the physiologically expected evolution, increasing torsion with increasing age, but still is comprised in the normal range of variations.

Gait Parameters Variables

The Gait Parameters Variables concerning Spatial, Temporal, Gait Percentage related variables, and key kinematic events will be presented according to the statistical data treatment. The Frequency tables are presented on Appendix VIII.

We chose to report the value of the Mean, Standard Deviation (SD), and the 95% Confidence Interval (CI = ± 2SEM), which is calculated by adding and subtracting 2 times the value of the Standard Error of the Mean (SEM= SD / $\sqrt{n}$)[4,57].

Descriptive Statistics Of the Sample (n=27)

Along with Spatial, Temporal and Gait percentage related variables, an assortment of key kinematic events was elected as the most fitting to describe the gait pattern[62,66,]. All the Gait Parameters variables, mentioned earlier, were collected for each side of the subject. However, in order to organize and facilitate the management of such data, we analyzed the symmetry among sides, through the Paired-sample T test, or the Wilcoxin for the variables following a Normal distribution, and not following a Normal distribution, respectively. The variables that presented differences were t_Init_Sw (p_value=.026), Sag_Max_stKneeA (p_value=.002), Sag_Max_ndKneeA (p_value=.002), Sag_t_Min_ndKneeA (p_value=.002) and Sag_TT_ROM (p_value=.019). When the test results showed no significant differences at the significance level of 5%, the variable "mean_variable_L_R" was created, with the arithmetic mean of left and right. The descriptive statistics are presented below on Table 19.

Table 19 – Descriptive statistics of the Gait Parameters variables for all subjects.

	Mean ± SD (95% CI) **n=27**
Spatial and Temporal Parameters	
Cadence	128.98 ± 6.14 (126.55 - 131.40)
Speed	1.17 ± .12 (1.12 - 1.22)
mean_L_step_L_R	.543 ± .346 (.134 - .952)
Mean_Cycle_Time_L_R	.934 ± .043 (.918 - .950)
mean_dT_unipodal_L_R	39.45 ± .96 (39.08 - 39.83)
Displace_CoM	3.41 ± .51 (3.21 - 3.61)
Normalized to Anthropometrics	
Rt_ASIS_Calc	2.223 ± .31 (2.103 - 2.343)
mean_StepFactor_L_R	.874 ± .067 (.848 - .900)

Gait Events	
mean_t_LR_L_R	6.45 ± .82 (6.12 - 6.77)
mean_t_Mid_St_L_R	10.46 ± .61 (10.22 - 10.71)
mean_t_TST_L_R	38.37 ± .86 (38.04 - 38.70)
mean_t_PSw_L_R	50.01 ± .14 (49.96 - 50.07)
t_L_Init_Sw/ L_Foot_Off	60.30 ± .83 (59.97 - 60.63)
t_R_Init_Sw/ R_Foot_Off	60.68 ± .68 (60.41 - 60.95)
mean_t_Mid_Sw_L_R	80.75 ± 1.50 (80.16 - 81.35)
Mean_t_TSW_L_R	88.05 ± 2.39 (87.13 - 88.97)
Key Kinematic Events	
mean_Sag_Pelvis_ROM_L_R	4.37 ± .60 (4.13 - 4.60)
mean_PELVIS_Sag_MedV_L_R	10.37 ± 3.28 (9.07 - 11.67)
mean_PELVIS_Trans_MedV_L_R	-.028 ± 0.449 (-.20 - .14)
mean_Sag_Hip_ ROM_L_R	42.28 ± 9.24 (38.62 - 45.93)
mean_Sag_Max_HipA_L_R	35.85 ± 4.39 (34.11 - 37.58)
mean_Sag_t_Max_HipA_L_R	89.02 ±1.61 (88.38 -89.65)
mean_Sag_Min_HipA_L_R	-7.28 ± 5.90 (-9.61 - -4.94)
mean_Sag_t_Min_HipA_L_R	53.28 ±0.85 (52.94 -53.61)
mean_Trans_MedV_Hip_STph_L_R	-.78 ± 5.86 (-3.04 - 1.48)
mean_Front_Max_Hip_SWph_L_R	-6.58 ± 1.72 (-7.26 - -5.90)
mean_Sag_Knee_ROM_L_R	65.56 ± 4.04 (63.96 - 67.16)
Sag_L_Max_stKneeA	18.62 ± 5.21 (16.56 - 20.68)
Sag_R_Max_stKneeA	20.60 ± 5.13 (18.57 - 22.63)
Sag_L_Max_ndKneeA	65.28 ± 3.97 (63.71 - 66.85)
Sag_R_Max_ndKneeA	66.62 ± 3.81 (65.11 - 68.13)
mean_Sag_t_Max_stKneeA_L_R	16.29 ± 4.35 (14.57 - 18.02)
mean_Sag_t_Max_ndKneeA_L_R	74.10 ± .82 (73.78 - 74.42)
mean_Sag_Min_ndKneeA_L_R	5.43 ± 3.75 (3.94 - 6.91)
Sag_t_L_Min_ndKneeA	38.89 ± 2.51 (37.90 - 39.88)
Sag_t_R_Min_ndKneeA	40.43 ± 2.36 (39.50 - 41.36)
mean_Sag_KneeA_CI_L_R	.40 ± 3.40 (-.94 - 1.74)
Sag_L_TT_ROM	27.70 ± 4.49 (25.93 - 29.48)
Sag_R_TT_ROM	29.62 ± 4.62 (27.80 - 31.45)
mean_Sag_TT_MaxDf_STph_L_R	12.49 ± 2.89 (11.34 - 13.63)
mean_Sag_TT_MaxDf_SWph_L_R	5.36 ± 2.38 (4.42 - 6.30)
mean_FPA_MedV_STph_L_R	-5.92 ± 3.02 (-7.11 - -4.72)

Regarding the spatial and temporal parameters we obtained a mean value of cadence of 128.98 steps/min, similar to the published references (112.8[2], 118.4[75], up to 143 steps/min[76]). The mean value of walking speed was 1.17 m/s, comparable to the published references (1.06[2], 1.10[75] m/s). The mean step length (MEAN_L_STEP_L_R) was of .543m, in accordance with previously published data (.55[2], and .56[75] m). The mean Cycle Time (MEAN_CYCLE_TIME_L_R) or this study was .934s, in agreement with previously published data (1.01s[2,75]). The mean total time of unipodal support (MEAN_DT_UNIPODAL_L_R) was 39.45% of the GC, data in harmony with stablished reference[55], which argues that each of the 2 double supports represents 12% of the GC, therefore about 36% remaining for the unipodal support. The mean CoM vertical displacement (DISPLACE_COM) was 3.41cm, also this data in accordance with previously published data (3.2 +/- 0.8 cm[36]). The variables normalized to anthropometrics, the ratio ASIS distance (pelvic width) and calcaneus distance (RT_ASIS_CALC), and the ratio between step length and leg length (MEAN_STEPFACTOR_L_R) revealed mean values of 2.223 and .874, respectively, both in accordance with published work (ratio pelvic width and calcaneus distance of 2.53 for females and 2.48 for males; step factor of .873 for females and .845 for males) [19].

The percentage at which the gait periods and phases occurred was also analyzed for the collected data. The timing of the specific kinematic events that dictate the end and/or the beginning of each phase was calculated and it is presented below. The percentage of occurrence of these gait events is similar to that already published, the largest observable differences being the delay on LR (2% to 6.45%), TST (31% to 38.37%), and the MSW (75% to 80.75%) (see Figure 70).

STANCE PHASE					SWING PHASE			
INITIAL CONTACT	LOADING RESPONSE	MID STANCE	TERMINAL STANCE	PRE-SWING	INITIAL SWING	MID SWING	TERMINAL SWING	
0	6.45	10.46	38.37	50.01	60.30(L)/ 60.68(R)	80.75	88.05	100%

Figure 70. – Percentage of the gait cycle events for the present study (n=27).

The Key Kinematic Events selected to describe the normal gait pattern were gathered, processed and analyzed. The value for the mean range of pelvic tilt (MEAN_SAG_PELVIS_ROM_L_R) was of 4.37º (SD= .60), with the literature reference values ranging from 3.20º (SD= 1.60)[2] to 3.81º (SD= 1.25)[62]. Considering the SD values and ranges of normal variation, it is a value in accordance with the previously published work. The value for the mean pelvic tilt (MEAN_PELVIS_SAG_MEDV_L_R) was 10.37º (SD= 3.28), also in accordance with the published literature that ranges from 8.10º (SD=4.00)[2] to 9.43º (SD=5.20)[62]. The value of mean pelvic rotation (MEAN_PELVIS_TRANS_MEDV_L_R) was of -.028º (SD= 0.449), again in accordance with the literature, that ranges from -.78º (SD= 3.19)[62] to -.04º (SD= 2.52)[2]. The mean value for the range of hip flexion (MEAN_SAG_HIP_ROM_L_R) was of 42.28º (SD= 9.24), within the previously reported reference values, that range from 38.98º (SD= 4.24)[62] to 43.40º+ (SD= 4.50)[2]. Because the hip sagittal kinematic pattern shows little change with age[77], this is information not present in gait indexes that, by definition, intent to describe the gait pattern with as little variables as needed. Here we opted to process the mean value of maximum hip flexion (MEAN_SAG_MAX_HIPA_L_R 35.85º ± 4.39) and its time of occurrence as a % of GC (MEAN_SAG_T_MAX_HIPA_L_R 89.02 ± 1.61). Namely the time of occurrence shows a little SD value, which indicates a good consistency among the 27 subjects. The mean value of minimum hip flexion (MEAN_SAG_MIN_HIPA_L_R) was of -7.28º (SD= 5.90), i.e., the highest mean value of hip extension was of 7.28º, and the mean value for the percentage of GC of its occurrence (MEAN_SAG_T_MIN_HIPA_L_R) was of 53.28% (SD=0.85). Again, this timing variable is not presented in the referred gait indexes, but the small SD denotes a good consistency among the 27 subjects. The published data regarding the mean value of minimum hip flexion ranges from -6.59º (SD=6.00)[62] to -5.10 (SD=6.50)[2], therefore comprising our findings. The value of mean hip rotation in stance (MEAN_TRANS_MEDV_HIP_STPH_L_R) was of -.78º (SD= 5.86), with published reference data ranging from 2.03º (8.98) to 31.90º (14.00). Although our findings seem to distance from the published references, it is important to highlight the fact that hip rotation is amongst the data with higher associated error[45]. The mean value of peak abduction in swing (MEAN_FRONT_MAX_HIP_SWPH_L_R) was of -6.58º (SD=1.72), which is in accordance with published references that range from -8.00º (SD=3.50)[2] to -.16º (SD=3.53). The mean value for the range of knee flexion (MEAN_SAG_KNEE_ROM_L_R) was of 65.56º (SD= 4.04). This is a value a little higher when compared to the published reference data, that ranges from 53.60º (SD=8.00)[2] to 56.34º (SD=4.60)[62]. The typical knee angular displacement curve shows 2 peaks. The initial knee flexion wave happens during loading response and is only well stablished by the age of 4[77]. Both peaks and respective times of occurrence were collected. The mean value for the first knee flexion peak (SAG_L_MAX_STKNEEA) was of 18.62º (SD=5.21) for the left side, and (SAG_R_MAX_STKNEEA) 20.60º (SD=5.13) for the right side. The mean value for the second knee flexion peak (SAG_L_MAX_NDKNEEA) was of 65.28º (SD= 3.97) for the left side, and (SAG_R_MAX_NDKNEEA) 66.62º (SD=3.81). The timings of those 2 peaks were 16.29% (SD= 4.35), for the first one (MEAN_SAG_T_MAX_STKNEEA_L_R), and 74.10% (SD= .82) for the last one (MEAN_SAG_T_MAX_NDKNEEA_L_R). From all these, only the variable “time of the second knee flexion peak” is included on the mentioned gait indexes, with reported values ranging from 70.06º (SD=1.85) to 71.70º (SD=2.30), which are similar to our findings. Regarding the behavior of the knee flexion peaks, the first one, shows higher inconsistencies, with larger SD values for the angle itself, and also for the time of occurrence, therefore not being, probably, a good reference when assessing pathologies.

So it is important that it occurs, as it characterizes the normal behavior of the knee joint, but its specific features are very variable, which constitutes important information per se. Another relevant information regarding the knee joint, and present on gait indexes, is the mean value of knee flexion at initial contact (MEAN_SAG_KNEEA_CI_L_R), which we found to be of .40º (SD= 3.40), a little bellow the data reported by ROMEI[62] (6.24º ± 4.54) and ASSI[2] (8.50º ± 6.50), but in accordance with the normal range of variability proposed by PERRY[56] (0º to 10º, namely when velocity changes are present). We also registered the mean value of knee minimum flexion following loading response (MEAN_SAG_MIN_KNEEA_L_R), that reached 5.43º (SD= 3.75), and its time of occurrence, that was of 38.89% (SD= 2.51) for the left side (SAG_T_L_MIN_NDKNEEA), and 40.43% (SD= 2.36) for the right side (SAG_T_R_MIN_NDKNEEA). Regarding the tibiotarsal joint, we registered its ROM during the entire GC and its peaks (maximum dorsiflexion) during ST and SW. The ROM registered was of 27.70º (SD= 4.49) for the left side (SAG_L_TT_ROM), and 29.62º (SD= 4.62) for the right side (SAG_R_TT_ROM), values in accordance with the literature (ROM ± 25º)[56]. The dorsiflexion peak during registered during ST (MEAN_SAG_TT_MAXDF_STPH_L_R) reached the 12.49º (SD= 2.89), and 5.36º (SD= 2.38) during SW (MEAN_SAG_TT_MAXDF_SWPH_L_R). These values are in accordance with the literature, that states that for the ST the normal dorsiflexion peak is between 11.68º (SD=3.76)[62] and 17.00º (SD=6.80)[2], and during SW, between 3.82º (SD=4.08) and 9.00º (SD=5.60). At last, the mean value of Foot Progression Angle (MEAN_FPA_MEDV_STPH_L_R) was of -5.92º (SD= 3.02), which is comprised within the normal range of variation already published, that ranges from -11.26º (SD=6.50)[62] to -8.40º (SD=6.70)[2].

<u>DESCRIPTIVE ANALYSIS OF THE SAMPLE BY GENDER</u>

To understand how differently the variables could behave according to gender, each one was compared considering that factor. The 27 subjects were distributed between the 2 groups, resulting in 1 Female Group of 13 children, and 1 Male Group of 14 children. After the study of the variables' distribution according to gender (Appendix VIII), the Independent-Samples T Test was applied whenever Normal distribution was verified, or the nonparametric alternative Mann Whitney U Test ,whenever it wasn't. When the variances homogeneity (tested with Levene's Test) wasn't verified, for the variables following a Normal distribution, we resorted to the Welch correction. The statistics of the Gait Parameters Variables are presented on the Table 20.

Table 20.– Descriptive statistics of the Gait Parameters variables according to gender.

	Female n=13	Male n= 14
	Mean ± SD (95% CI)	
SPATIAL AND TEMPORAL PARAMETERS		
CADENCE	129.98 ± 6.72 (125.93 – 134.04)	128.04 ± 5.63 (124.79 – 131.29)
SPEED	1.19 ± .15 (1.10 – 1.29)	1.14 ± .08 (1.09 – 1.19)
MEAN_L_STEP_L_R	.552 ± .056 (.518 – .586)	.535 ± .039 (.513 – .557)
MEAN_CYCLE_TIME_L_R	.93 ± .05 (.91 - .95)	.94 ± 0.4 (.78 - 1.1)
MEAN_DT_UNIPODAL_L_R	39.44 ± 1.17 (38.73 – 40.15)	39.47 ± .75 (39.03 – 39.90)
DISPLACE_COM	3.62 ± .56 (3.29 – 3.96)	3.21 ± .39 (2.98 – 3.43)
NORMALIZED TO ANTHROPOMETRICS		
RT_ASIS_CALC	2.169 ± .262 (2.011– 2.328)	2.272 ± .355 (2.067 – 2.477)
MEAN_STEPFACTOR_L_R	.875 ± .084 (.825 – .926)	.874 ± .049 (.845 – .902)
GAIT EVENTS		
MEAN_T_LR_L_R	6.35 ± .77 (5.88 – 6.81)	6.54 ± .87 (6.04 – 7.04)
MEAN_T_MID_ST_L_R	10.35 ± .59 (9.99 – 10.70)	10.57 ± .64 (10.21 – 10.94)
MEAN_TST_L_R	38.17 ± .80 (37.88 – 38.47)	38.56 ± .89 (38.22 – 38.90)
MEAN_T_PSW_L_R	50.02 ± .11 (49.95 – 50.09)	50.00 ± .16 (49.91 – 50.10)
T_L_INIT_SW	60.07 ± .69 (59.66 – 60.49)	60.51 ± .92 (59.98 – 61.04)
T_R_INIT_SW	60.50 ± .67 (60.10 60.91)	60.84 ± .67 (60.46 – 60.23)
MEAN_T_MID_SW_L_R	80.59 ± 1.28 (79.81 – 81.36)	80.90 ± 1.72 (79.91 – 81.89)
MEAN_T_TSW_L_R	87.45 ± 3.30 (86.17 – 88.73)	88.61 ± .85 (88.29 – 88.93)
KEY KINEMATIC EVENTS		
MEAN_SAG_PELVIS_ROM_L_R	4.19 ± .58 (3.84 – 4.55)	4.52 ± .58 (4.19 – 4.86)
MEAN_PELVIS_SAG_MEDV_L_R	11.69 ± 1.95 (10.51 – 12.87)	9.14 ± 3.83 (6.93 – 11.35)
MEAN_PELVIS_TRANS_MEDV_L_R	-.057 ± .275 (-.223 – .109)	-.002 ± .576 (-.334 – .331)
MEAN_SAG_HIP _ROM_L_R	45.21 ± 4.60 (42.43 – 47.98)	39.56 ± 11.61 (32.85 – 46.26)
MEAN_SAG_MAX_HIPA_L_R	37.64 ± 2.48 (36.14 – 39.14)	34.18 ± 5.16 (31.20 – 37.16)
MEAN_SAG_T_MAX_HIPA_L_R	89.60 ± 1.82 (88.50 – 90.70)	88.48 ± 1.21 (87.78 – 89.17)
MEAN_SAG_MIN_HIPA_L_R	-7.59 ± 4.76 (-10.47 – -4.72)	-6.98 ± 6.96 (-11.00 – -2.96)
MEAN_SAG_T_MIN_HIPA_L_R	53.18 ± .76 (52.72 – 53.74)	53.36 ± .94 (52.82 – 53.91)
MEAN_TRANS_MIDV_HIP_STPH_L_R	1.32 ± 5.34 (-1.91 – 4.54)	-2.73 ± 5.82 (-6.09 – .63)
MEAN_FRONT_MAX_HIP_SWPH_L_R	-6.47 ± 1.84 (-7.59 – -5.36)	-6.67 ± 1.68 (-7.64– -5.71)
MEAN_SAG_KNEE_ROM_L_R	63.54 ± 3.50 (61.43 – 65.66)	67.44 ± 3.67 (65.32 – 69.56)
SAG_L_MAX_STKNEEA	20.49 ± 5.85 (16.96 – 24.03)	16.88 ± 3.97 (14.58 – 19.17)
SAG_R_MAX_STKNEEA	21.82 ± 5.59 (18.45 – 25.20)	19.46 ± 4.57 (16.82 – 22.10)
SAG_L_MAX_NDKNEEA	64.85 ± 3.67 (62.63 – 67.07)	65.68 ± 4.32 (63.18 – 68.17)
SAG_R_MAX_NDKNEEA	66.31 ± 3.41 (64.25 – 68.37)	66.91 ± 4.26 (64.45 – 69.37)
MEAN_SAG_T_MAX_STKNEEA_L_R	16.23 ± 5.99 (12.61 – 19.85)	16.36 ± 2.18 (15.10 – 17.62)
MEAN_SAG_T_MAX_NDKNEEA_L_R	73.90 ± .83 (73.40 – 74.41)	74.28 ± .78 (73.83 – 74.74)
MEAN_SAG_MIN_NDKNEEA_L_R	4.99 ± 3.48 (2.88 – 7.09)	5.84 ± 4.07 (3.49 – 8.19)
SAG_T_L_MIN_NDKNEEA	39.57 ± 2.49 (38.07 – 41.08)	38.25 ± 2.45 (36.84 – 39.67)
SAG_T_R_MIN_NDKNEEA	40.46 ± 2.62 (38.88 – 42.05)	40.40 ± 2.19 (39.13 – 41.67)
MEAN_SAG_KNEEA_CI_L_R	1.92 ± 3.36 (-.11 – 3.95)	-1.01 ± 2.87 (-2.66 – .65)
SAG_L_TT_ROM	27.80 ± 5.26 (24.62 – 30.97)	27.61 ± 3.84 (25.40 – 29.83)
SAG_R_TT_ROM	29.05 ± 5.40 (25.79 – 32.31)	30.16 ± 3.89 (27.91 – 32.40)
MEAN_SAG_TT_MAXDF_STPH_L_R	13.27 ± 2.03 (12.04 – 14.50)	11.76 ± 3.43 (9.78 – 13.74)
MEAN_SAG_TT_MAXDF_SWPH_L_R	5.50 ± 2.60 (3.93 – 7.07)	5.22 ± 2.25 (3.92 – 6.53)
MEAN_FPA_MEDV_STPH_L_R	-5.82 ± 2.33 (-7.22 – -4.41)	-6.01 ± 3.64 (-8.12 – -3.91)

Regarding the behavior of the spatial and temporal parameters according to gender, they showed that females walked a little faster (1.19 m/s versus 1.14 m/s), with a higher number of steps per minute (129.98 steps/min versus 128.04 steps/min) and a larger step length (.552m versus .535m). This difference may be explained by the fact that, although no differences were found between the height of males and females, the variables related to the inferior limbs length showed higher values for the female gender. The mean Cycle Time was also slightly shorter for the female group (.93s for the females, and .94 for the males), which is intimately related to the facts just stated. The mean total time of unipodal support was quite similar, with both groups showing approximately 39% of unipodal support time, in one GC (the female group presented 39.44%, and the male group showed 39.47%). The mean CoM vertical displacement is the only variable that revealed statistically significant differences between gender groups, with the female group showing a higher mean value of 3.62 cm, while the male group showed 3.21 cm. To discard a possible influence of the musculoskeletal system, the variable would have had to be normalized to a measure related to height, in this case, maybe the variables of inferior limbs length, since they seem to be of influence in other variables, previously mentioned. This step of normalization wasn't performed for time related issues. The Rt_ASIS_Calc variable, a normalized base of support value, was inferior for the Female group, which presented a value of 2.169, while the Male group presented a value of 2.272. Both values are below the reference data (ratio pelvic width and calcaneus distance of 2.53 for females and 2.48 for males [19]). This indicates the presence of a narrower base of support, which is a sign of maturity according to Sutherland's determinants of mature gait[76]. No actual differences were recorded for the StepFactor mean value (.875 for the Female group, and .874 for the Male group). As this is a measure of step length, only normalized to musculoskeletal data, it endorses the possibility of influence of this data on the spatial parameters, once the un-normalized step length was slightly higher for the Female Group.

The percentage at which the gait periods and phases occurred for each Gender Group was analyzed. The timing of the specific kinematic events that dictate the end and/or the beginning of each phase was calculated and it is presented on Figures 71 and 72. No statistically significant or even appreciable differences were found.

Stance Phase					**Swing Phase**			
Initial Contact	Loading Response	Mid Stance	Terminal Stance	Pre-Swing	Initial Swing	Mid Swing	Terminal Swing	
0	6.35	10.35	38.17	50.02	60.07(L)/ 60.50 (R)	80.59	87.45	100%

Figure 71. – Percentage of the gait cycle events for the Female Group of the present study (n=13).

Stance Phase					**Swing Phase**			
Initial Contact	Loading Response	Mid Stance	Terminal Stance	Pre-Swing	Initial Swing	Mid Swing	Terminal Swing	
0	6.54	10.57	38.56	50.00	60.51(L)/ 60.84(R)	80.90	88.61	100%

Figure 72. – Percentage of the gait cycle events for the Male Group of the present study (n=14).

The key kinematic events were compared between genders. The mean value for the range of pelvic tilt showed very similar values for the Female and Male Groups, with the males showing a slightly superior ROM (4.19º for the Female Group and 4.52º for the Male Group). The value for the mean pelvic tilt revealed statistically significant differences among Gender Groups (p_value=.040). The Female Group registered 11.69º and the Male Group 9.14º. Both values are within the normal ranges of variability, and the higher value of anterior pelvic tilt for the females is in accordance with the literature[41]. The value for the mean pelvic rotation was very similar between the Gender Groups, with the Female Group registering a mean value of -.057º, and the Male Group a mean value of .002º. The mean value for the range of hip flexion was higher for the Female Group that reached the 45.21º, while the Male Group only registered 39.56º. The mean value of maximum hip flexion was statistically significant different between groups (p_value=.037), with the Female Group registering a higher value of 37.64º, while the Male Group registered 34.18º. The timing of this event was very similar among the Gender Groups, occurring at 89.60% and 88.48% of the GC, for the Female and Male Groups, respectively. The mean value of minimum hip flexion was similar among Gender Groups, with values of -7.59º for the Female group, and -6.98 for the Male group, as was its occurrence timing, at 53.18% of GC for the Female Group and 53.36% of GC for the Male group. The value of mean hip rotation during ST was quite different among the Gender

Groups, with 1.32º (SD=5.34) for the Female Group and -2.73º (SD=5.82) for the Male Group. It is important to highlight the fact that this is a measure with high error associated[45], in fact, it is noticeable the low consistency given the SD values. The mean value of peak abduction during SW was similar among groups, with -6.47 for the Female Group and -6.67 for the Male group. The mean value for the range of knee flexion showed statistically significant differences between groups (p_value=.009), with a higher mean value for the Male Group that registered 67.44º, while the Female group reached the 63.54º. Probably the small differences occurring in an inverted way for the measures of hip and knee flexions are reflecting the compensatory relation between these two articulated joints. The mean value for the first knee flexion peak was 20.49º for the Female Group and 16.88º for the Male Group, for the left side, and 21.82º for the Female group and 19.46º for the Male group, for the right side. Generally, the females showed a slightly superior first maximum knee flexion value. The mean value for the second knee flexion peak was 64.85º for the Female Group and 65.68º for the Male Group, for the left side, and 66.31º for the Female Group and 66.91º for the Male Group, for the right side. This second maximum flexion peak, the actual maximum in the entire curve, showed no appreciable differences among Gender Groups. The timing of occurrence of the first peak showed no differences between the groups, with 16.23% for the Female Group and 16.36% for the Male Group. The timing of occurrence of the second peak was also quite similar among the groups, with 73.90% for the Female Group and 74.28% for the Male Group. The mean value of knee minimum flexion following loading response was 4.99º for the Female Group and 5.84º for the Male Group, with the females showing a smaller minimum value. The timing of occurrence of this event was similar among the groups, with a value of 39.57% for the Female Group and 38.25% for the Male Group for the left side, and 40.46% for the Female Group and 40.40% for the Male Group, for the right side. The mean value of knee flexion at initial contact revealed statistically significant differences between groups (p_value=.022), with the males showing an inferior mean value (-1.01º for the Male Group and 1.92º for the Female Group) that reaches the inferior boundary of the published normal range of variability (0º to 10º, namely when velocity changes are present)[56]. The mean value for the tibiotarsal ROM was 27.80º for the Female Group and 27.61º for the Male Group for the left side, and 29.05º for the Female group and 30.16º for the Male group for the right side. Although the mean ranges are slightly superior for both gender groups' right side, the differences between Gender Groups are insignificant. The dorsiflexion peak during registered during ST was 13.27º for the Female Group and 11.76º for the Male Group, and 5.50º for the Female Group and 5.22º for the Male Group during SW. The peak during ST registered a little higher mean value for the females, and the peak during SW was similar for the Gender Groups. It is, once again, relevant to highlight the harmonic behavior observed in the chain of joints of the inferior limb. A smaller knee ROM presented by the females, now combines with a higher tibiotarsal ROM when the kinetic chain is closed (contacting foot). The mean value of Foot Progression Angle was -5.82º for the Female group and -6.01º for the Male group, with no appreciable differences among groups.

DESCRIPTIVE ANALYSIS OF THE SAMPLE BY AGE GROUP

The existence of differences across age groups has already been reported on the literature[7]. For that, we decided to study our variables according to the factor age (see Tables 21 and 22). The 27 subjects were distributed by the groups according to age at collection day (9 children for the 7 years old Group, 8 children for the 8 years old Group, and 10 children for the 9 years old Group). Whenever Normal distribution was verified the One_Way ANOVA was applied, and the p_value given by it or Welch was selected, based on the verified variance homogeneity (tested with Levene's Test), or not, respectively. Whenever the distribution wasn't Normal, we chose the nonparametric alternative Kruskal-Wallis. For the subsequent study of the significant differences among groups, the multicomparisons test used was the Scheffé or Tamhanes (or the LSD, when the Tamhane wasn't enough) with Normal distribution, and according to the verified variance homogeneity, or not, respectively. We applied the Dunn Test as the nonparametric alternative.

Table 21. – Descriptive statistics of the Gait Parameters variables for the Age Groups 7 and 8.

	7 Years Old Group n= 9	**8 Years Old Group n= 8**
	Mean ± SD (95% CI)	
SPATIAL AND TEMPORAL PARAMETERS		
CADENCE	132.47± 7.40 (126.48 – 138.15)	129.39 ± 4.75 (125.42 – 133.36)
ICC	1.16 ± .16 (1.04 – 1.28)	1.15 ± .08 (1.08 – 1.22)
MEAN_L_STEP_L_R	.527 ± .044 (.494 – .561)	.535 ± .044 (.498 – .572)
MEAN_CYCLE_TIME_L_R	.91 ± .02 (.90 - .92)	.92 ± .02 (.91 - .93)
MEAN_DT_UNIPODAL_L_R	39.17 ± 1.24 (38.21 – 40.12)	39.33 ± .63 (38.80 – 39.85)
DISPLACE_COM	3.39 ± .57 (2.95 – 3.82)	3.33 ± .43 (2.97 – 3.69)
NORMALIZED TO ANTHROPOMETRICS		
RT_ASIS_CALC	2.24 ± .35 (1.97 – 2.51)	2.04 ± .25 (1.83 – 2.25)
MEAN_STEPFACTOR_L_R	.863 ± .063 (.814 – .911)	.849 ± .053 (.805 – .893)
GAIT EVENTS		
MEAN_T_LR_L_R	6.50 ± .75 (5.92 – 7.07)	6.42 ± 1.08 (5.52 – 7.32)
MEAN_T_MID_ST_L_R	10.47 ± .592 (10.02 – 10.93)	10.71 ± .414 (10.36 – 11.06)
MEAN_T_TST_ST_L_R	38.08 ± .32 (37.96 – 38.20)	38.62 ± .44 (38.46 – 38.78)
MEAN_T_PSW_L_R	49.97 ± .167 (49.84 – 50.09)	50.04 ± .171 (49.91 – 50.20)
T_L_INIT_SW	60.45 ± .70 (59.91 – 60.98)	60.60 ± .58 (60.11 – 61.09)

t_R_Init_Sw	60.54 ± .70 (60.00 – 61.07)	61.14 ± .47 (60.74 – 61.53)
mean_t_Mid_Sw_L_R	80.47 ± 1.47 (79.34 – 81.60)	81.62 ± 1.35 (80.50 – 82.75)
Mean_t_TSW_L_R	87.07 ± 1.32 (86.57 – 87.57)	88.66 ± .40 (88.50 – 88.82)
Key Kinematic Events		
mean_Sag_Pelvis_ROM_L_R	4.40 ± .55 (3.98 – 4.82)	4.11 ± .464 (3.72 – 4.50)
mean_PELVIS_Sag_MedV_L_R	8.91 ± 3.24 (6.42 – 11.41)	10.13 ± 3.03 (7.60 – 12.67)
mean_PELVIS_Trans_MedV_L_R	-.093 ± .309 (-.330 – .145)	-.011 ± .470 (-.404 – .382)
mean_Sag_Hip_ROM_L_R	40.05 ± 14.86 (28.62 – 51.47)	41.05 ± 3.78 (37.89 – 44.22)
mean_Sag_Max_HipA_L_R	34.91 ± 3.79 (32.00 – 37.83)	34.31 ± 5.14 (30.01 – 38.60)
mean_Sag_t_Max_HipA_L_R	88.26 ± 1.50 (87.11 – 89.41)	89.67 ± 1.84 (88.13 – 91.21)
mean_Sag_Min_HipA_L_R	-9.97 ± 3.96 (-13.02 – -6.93)	-6.75 ± 5.37 (-11.24 – -2.26)
mean_Sag_t_Min_HipA_L_R	53.05 ± .81 (52.43 – 53.67)	53.29 ± 1.10 (52.37 – 54.21)
mean_Trans_MidV_Hip_STph_L_R	-.069 ± 4.91 (-3.84 – 3.70)	-3.04 ± 7.09 (-8.97 – 2.89)
mean_Front_Max_Hip_SWph_L_R	-6.25 ± 1.52 (-7.42 – -5.08)	-6.38 ± 1.63 (-7.75 – -502)
mean_Sag_Knee_ROM_L_R	65.36 ± 4.73 (61.73 – 69.00)	64.19 ± 2.31 (62.26 – 66.12)
Sag_L_Max_stKneeA	17.54 ± 5.46 (13.34 – 21.73)	19.54 ± 4.55 (15.73 – 23.34)
Sag_R_Max_stKneeA	20.61± 5.17 (16.63 – 24.59)	19.74 ± 5.46 (15.18 – 24.30)
Sag_L_Max_ndKneeA	64.96 ± 4.69 (61.36 – 68.57)	63.74 ± 3.01 (61.22 – 66.25)
Sag_R_Max_ndKneeA	67.51 ± 5.07 (63.61 – 71.40)	65.20 ± 3.16 (62.56 – 67.85)
mean_Sag_t_Max_stKneeA_L_R	15.66 ± 2.01 (14.12 – 17.20)	15.68 ± 1.31 (14.59 – 16.78)
mean_Sag_t_Max_ndKneeA_L_R	73.80 ± .93 (73.09 – 74.51)	74.28 ± .45 (73.90 – 74.65)
mean_Sag_Min_ndKneeA_L_R	4.91 ± 4.87 (1.17 – 8.65)	6.79 ± 3.76 (3.65 – 9.93)
Sag_t_L_Min_ndKneeA	39.41 ± 2.02 (37.85 – 40.96)	38.94 ± 2.43 (36.91 – 40.97)
Sag_t_R_Min_ndKneeA	40.80 ± 1.93 (39.32 – 42.29)	40.87 ± 2.09 (39.13 – 42.61)
mean_Sag_KneeA_CI_L_R	.95 ± 2.11 (-.66 – 2.57)	.20 ± 4.34 (-3.42 – 3.83)
Sag_L_TT_ROM	25.68 ± 4.00 (22.60 – 28.76)	29.33 ± 4.70 (25.40 – 33.26)
Sag_R_TT_ROM	28.74 ± 6.68 (23.60 – 33.87)	30.58 ± 3.82 (27.39 – 33.78)
mean_Sag_TT_MaxDf_STph_L_R	12.27 ± 2.42 (10.41 – 14.14)	12.09 ± 3.48 (9.18 – 15.00)
mean_Sag_TT_MaxDf_SWph_L_R	4.45 ± 2.06 (2.86 – 6.04)	5.98 ± 2.85 (3.59 – 8.36)
mean_FPA_MedV_STph_L_R	-6.39 ± 2.10 (-8.00 – -4.78)	-6.24 ± 2.21 (-8.08 – -4.40)

Table 22. – Descriptive statistics of the Gait Parameters variables of the Age Group 9.

	9 Years Old Group n= 10
	Mean ± SD (95% CI)
Spatial and Temporal Parameters	
cadence	125.50 ± 4.11 (122.56 – 128.44)
speed	1.18 ± .13 (1.09 – 1.27)
mean_L_step_L_R	.564 ± .050 (.528 – .600)
Mean_Cycle_time_L_R	.96 ± .2 (.95 - .97)
mean_dT_unipodal_L_R	39.82 ± .85 (39.21 – 40.42)
Displace_CoM	3.49 ± .56 (3.09 – 3.89)
Normalized to Anthropometrics	
Rt_ASIS_Calc	2.35 ± .27 (2.16 – 2.55)

MEAN_STEPFACTOR_L_R	.905 ± .073 (.853 – .958)
GAIT EVENTS	
MEAN_T_LR_L_R	6.43 ± .72 (5.91 – 6.94)
MEAN_T_MID_ST_L_R	10.26 ± .73 (9.73 – 10.78)
MEAN_T_TST_L_R	38.65 ± .42 (38.49 – 38.81)
MEAN_T_PSW_L_R	50.02 ± .08 (49.97 – 50.07)
T_L_INIT_SW	59.93 ± 1.02 (59.20 – 60.65)
T_R_INIT_SW	60.44 ± .68 (59.96 – 60.93)
MEAN_T_MID_SW_L_R	80.31 ±1.50 (79.24 – 81.38)
MEAN_T_TSW_L_R	88.68 ± .38 (88.54 – 88.82)
KEY KINEMATIC EVENTS	
MEAN_SAG_PELVIS_ROM_L_R	4.54 ± .71 (4.03 – 5.04)
MEAN_PELVIS_SAG_MEDV_L_R	11.88 ± 3.15 (9.62 – 14.13)
MEAN_PELVIS_TRANS_MEDV_L_R	.016 ± .565 (-.388 – .420)
MEAN_SAG_HIP_ROM_L_R	45.26 ± 4.82 (41.81 – 48.71)
MEAN_SAG_MAX_HIPA_L_R	37.92 ± 3.81 (35.19 – 40.64)
MEAN_SAG_T_MAX_HIPA_L_R	89.18 ± 1.37 (88.20 – 90.15)
MEAN_SAG_MIN_HIPA_L_R	-5.27 ± 7.23 (-10.44 – -.10)
MEAN_SAG_T_MIN_HIPA_L_R	53.47 ± .68 (52.99 – 53.95)
MEAN_TRANS_MIDV_HIP_STPH_L_R	.38 ± 5.67 (-3.68 – 4.43)
MEAN_FRONT_MAX_HIP_SWPH_L_R	-7.03 ± 2.02 (-8.47 – -5.58)
MEAN_SAG_KNEE_ROM_L_R	66.84 ± 4.43 (63.67 – 70.00)
SAG_L_MAX_STKNEEA	18.85 ± 5.80 (14.70 – 23.01)
SAG_R_MAX_STKNEEA	21.27 ± 5.28 (17.49 – 25.05)
SAG_L_MAX_NDKNEEA	66.80 ± 3.76 (64.11 – 69.49)
SAG_R_MAX_NDKNEEA	65.95 ± 2.96 (64.84 – 69.07)
MEAN_SAG_T_MAX_STKNEEA_L_R	17.36 ± 6.91 (12.41 – 22.30)
MEAN_SAG_T_MAX_NDKNEEA_L_R	74.23 ± .93 (73.57 – 74.90)
MEAN_SAG_MIN_NDKNEEA_L_R	4.80 ± 2.50 (3.01 – 6.59)
SAG_T_L_MIN_NDKNEEA	38.38 ± 3.08 (36.18 – 40.58)
SAG_T_R_MIN_NDKNEEA	39.74 ± 2.93 (37.65 – 41.84)
MEAN_SAG_KNEEA_CI_L_R	.06 ± 3.78 (-2.64 – 2.76)
SAG_L_TT_ROM	28.22 ± 4.48 (25.02 – 31.43)
SAG_R_TT_ROM	29.65 ± 2.99 (27.51 – 31.79)
MEAN_SAG_TT_MAXDF_STPH_L_R	13.00 ± 3.01 (10.84 – 15.15)
MEAN_SAG_TT_MAXDF_SWPH_L_R	5.68 ± 2.23 (4.08 – 7.28)
MEAN_FPA_MEDV_STPH_L_R	-5.24 ± 4.23 (-8.26 – -2.21)

The spatial and temporal parameters variables revealed little changes on walking speed between Age Groups, with values of 1.16m/s, 1.15m/s and 1.18m/s for the 7, 8 and 9 years old groups, respectively. The number of steps per minute revealed to decrease as age increased (132.47, 129.39, and 125.50 steps/min for the 7, 8, and 9 years old groups, respectively), with a statistically significant difference between the 7 and 9years old Groups (p_value=.005). Step length increased along with age, .527, .535 and .564 m, for the 7, 8 and 9 years old groups, respectively. The time required to complete 1 GC also showed a little increase, with increasing age Group, namely between the 8 and 9 years old Groups, with the 7 years old Group taking .91s to complete a full cycle, the 8 years old Group taking .92s, and the 9 years old Group taking .96s. No considerable differences were detected on the percentages of unipodal support (39.17, 39.33 and 39.82 %, for the 7, 8 and 9 years old Groups, respectively). The vertical displacement of the CoM revealed little differences among Age Groups, the most evident being between the 8 and 9 years old Groups (3.39cm, 3.33cm and 3.49cm for the 7, 8 and 9 years old group, respectively). The values registered for the Rt_ASIS_Calc showed an oscillating pattern for the Age Groups, with a smaller value of 2.04 presented by the 8 years old Group. The recorded values for the 7 and 9 years old Groups were 2.24 and 2.35, respectively. The higher value for the 9 years old Group reveals a narrower base of support, reflecting an higher level of maturity[76]. The same oscillating pattern was observed for the StepFactor, with the 7 years old group showing a mean value of .863, the 8 years old Group recording a mean value of .849, and the 9 years old Group a value of .905. Again, the 9 years old Group showing a higher value, this time of normalized step length, revealing an actual increase in this variable despite of musculoskeletal growth.

Concerning the gait periods and phases occurred for each Age Group, very small differences were found. The timing of the specific kinematic events that dictate the end and/or the beginning of each phase was calculated and it is presented on Figures 73, 74 and 75. No statistically significant or even appreciable differences were found.

Stance Phase					**Swing Phase**			
Initial Contact	Loading Response	Mid Stance	Terminal Stance	Pre-Swing	Initial Swing	Mid Swing	Terminal Swing	
0	6.50	10.47	38.08	49.97	60.45(L)/ 60.54 (R)	80.47	87.07	100%

Figure 73. – Percentage of the gait cycle events for the 7 years old Group of the present study (n=9).

Stance Phase					**Swing Phase**			
Initial Contact	Loading Response	Mid Stance	Terminal Stance	Pre-Swing	Initial Swing	Mid Swing	Terminal Swing	
0	6.42	10.71	38.62	50.04	60.60(L)/ 61.14(R)	81.62	88.66	100%

Figure 74. – Percentage of the gait cycle events for the 8 years old Group of the present study (n=8).

Stance Phase					Swing Phase			
Initial Contact	Loading Response	Mid Stance	Terminal Stance	Pre-Swing	Initial Swing	Mid Swing	Terminal Swing	
0	6.43	10.26	38.65	50.02	59.93(L)/ 60.44(R)	80.31	88.68	100%

Figure 75. – Percentage of the gait cycle events for the 9 years old Group of the present study (n=10).

The key kinematic events were compared between age groups. The value for the mean range of pelvic tilt showed very similar values for all groups (4.40º, 4.11º and 4.54º, for the 7, 8 and 9 years old groups, respectively). The value for the mean pelvic tilt was higher for the older groups, revealing a tendency to increase with the children's age. The registered values were of 8.91º for the 7, 10.13º for the 8 and 11.88º for the 9 years old Groups. The value of mean pelvic rotation showed little differences among the groups, with -.093º for the 7, -.011º for the 8 and .016º for the 9 years old Groups. The mean value for the range of hip flexion was 40.05º, 41.05º and 45.26º for the 7, 8 and 9 years old group, respectively, with the ROM showing a tendency to augment with age. The mean value of maximum hip flexion was 34.91º, 34.31º and 37.92º for the 7, 8 and 9 years old group, respectively, with little differences between the 7 and 8 years old Groups, and with a higher value for the 9 years old Group. The time of occurrence of this hip flexion peak was quite similar among all of the Age Groups, with 88.26%, 89.67% and 89.18% for the 7, 8 and 9 years old Group, respectively. The mean value of minimum hip flexion showed a tendency to increase along with age, i.e., the value hip extension seems to decrease along with age. The registered values were of -9.97º, -6.75º and -5.27º for the 7, 8 and 9 years old Groups, respectively. The mean value for the percentage of GC of the occurrence of this minimum hip flexion revealed no appreciable differences among groups, with registered values of 53.05%, 53.29% and 53.47% for the 7, 8 and 9 years old group, respectively. The value of mean hip rotation during ST was similar for the 7 and 9 years old Groups, while the 8 years old Group showed a smaller value. The registered values were -.069º, -3.04º and .38º for the 7, 8 and 9 years old Groups, respectively. The mean value of peak abduction in swing was similar between the 7 and 8 years old Groups, with the 9 years old Group showing a smaller value. The registered values were -6.25º, -6.38 and -7.03 for the 7, 8 and 9 years old Groups, respectively. The mean value for the range of knee flexion was similar between all the groups, with the older group showing a little higher ROM. The registered values were 65.36º, 64.19º and 66.84º for the 7, 8 and 9 years old group, respectively. The mean value for the first knee flexion peak revealed to be quite fluctuating, showing no tendencies age wise, as previously noticed. The values were 17.54º, 19.54º and 18.85º for the left side of the 7, 8 and 9 years old Groups, respectively, and 20.61º, 19.74º and 21.27º for the right side of the 7, 8 and 9 years old group, respectively. The mean value for the second knee flexion peak was 64.96º, 63.74º and 66.80º for the left side of the 7, 8 and 9 years old Groups, respectively, and 67.51º, 65.20º and 65.95º for the right side of the 7, 8 and 9 years old Groups, respectively. Again, a measure showing irregularities that reflect no tendencies age related. Regarding the timing for the first peak, it was a little higher (latter) for the older group, with values of 15.66%, 15.68% and 17.36% for the 7, 8 and 9 years old Groups, respectively. The second peak was quite similar among all the age groups, with values of 73.80%, 74.28% and 74.23% for the 7, 8 and 9 years old Groups, respectively. The mean value of knee minimum flexion following loading response was 4.91º, 6.79º and 4.80º for the 7, 8 and 9 years old Groups, respectively, with a higher value registered for the 8 years old Group. The time of occurrence of this minimum flexion was quite similar among all of the age groups, with values of 39.41%, 38.94% and 38.38% for the left side of the 7, 8 and 9 years old group, respectively, and 40.80%, 40.87% and 39.74% for the right side of the 7, 8 and 9 years old group, respectively. The mean value of knee flexion at initial contact showed no considerable differences among the age groups, with values of .95º, .20º, .06º and for the 7, 8 and 9 years old Groups, respectively. Regarding the tibiotarsal ROM, it was a little higher for the 8 year old Group that reached 29.33º for the left and 30.58º for the right sides, while the 7 and 9 years old Groups registered 25.68º and 28.22º for the left, and 28.74º and 28.22º for the right sides, respectively. The maximum dorsiflexion during ST was very similar among groups, with values of 12.27º, 12.09º and 13.00º for the 7, 8 and 9 years old group, respectively. The maximum dorsiflexion during SW registered slightly smaller values for the youngest group that showed a mean value of 4.45º, while the 8 and 9 years old Groups reached mean values of 5.98º and 5.68º, respectively. The mean value of Foot Progression Angle was similar among groups, with the older group revealing a slightly smaller physiological angle of out-toeing. The registered mean values were -6.39º, -6.24º and -5.24º for the 7, 8 and 9 years old group, respectively.

REPEATABILITY AND RELIABILITY ANALYSIS

From the 27 children tested on the LBFM, 11 returned 1 week later (5 to 7 days time window), for retesting purposes. All of the Gait Parameters Variables were calculated once more with the new collected data, and again, the data was evaluated for symmetry among sides, now creating the “MEAN_variable_L_R#2” variables, with the arithmetic mean of left and right, for those with no significant differences found at the significance level of 5%. Only one of the variables of day 2 with significant differences is common with those same variables of day 1, the timing of initial swing (p_value=.028). The other variables with significant differences were dT_unipodal (p_value=.009), t_LR (p_value=.045), t_Mid_St (p_value=.022), t_L_PSw (p_value=.025), Sag_t_TT_MaxDf_STph (p_value=.013), which means that all of these were compared for each side, always.

The Interclass Correlation Coefficient (Table 24) showed high values (ICC shown values between [-1; -.7] or [.7; 1]) for the variables, speed .851, L_step .965, dT_R_unipodal .789, Displace_CoM .780, StepFactor .942, t_L_LR .805, t_L_Mid_St .703, t_L_Init_Sw .803, Sag_Hip_ndmax_ROM .930, Sag_t_Min_HipA .803, Trans_MedV_Hip_STph .804, Front_Max_Hip_SWph .765, Sag_Knee_stminROM .754, Sag_Min_ndKneeA .767, Sag_t_Min_ndLKneeA .769 and FPA_MedV_STph .833. The ICC reflects how much a high SEM, and/or low variability between individuals is compromising their discrimination. The variables with low ICC may reflect the low variability among the healthy subjects[46], as well as result of a small number of participants (n=11).

The variables that showed higher values of absolute difference of means (see Table 23) were the Minimum Hip Angle (2.01º), the First (2.05º and 2.15º for the left and right sides respectively) and Second (2.35º and 1.84º for the left and right sides respectively) Maximum Knee Angles, and the Maximum Dorsiflexion Angles for the ST (2.00º) and SW (2.03º). The remaining variables showed differences of 1% or 1º, or lower, with variables as Step Length and Cycle Time showing differences of .01 (meters and seconds, respectively). Some variables showed high values of SD on both sessions, maybe reflecting a higher range of individual variability, while others showed considerable changes on the SD value between sessions probably revealing the presence of variability of some source (instrument or assessor related). An example of this is the variable Cadence, with high values of SD, 6.14 and 4.77 steps/min on the 1st and 2nd collection days, respectively. Other example, this time of a fluctuating SD value is the variable Hip ROM, with 9.24º and 3.92º on the 1st and 2nd collection days, respectively. Some variables showed consistent low SD values, indicating low individual variability, and maybe little influence of other sources of variability. An example of this is the variable Step Length, with consistently low SD values, with .05 and .57 for the 1st and 2nd collection days, respectively.

Regarding SEM (see Table 23), 8 variables revealed values between 2º and 5º (classified as reasonable[45]), while all others were bellow 2º. Higher measurement error was found on the variables Cadence (3.64 steps/min), Mean Value of Pelvic Tilt (2.48º), Maximum Hip Angle (2.56º), Minimum Hip angle (4.94º), First Maximum Knee Angle for the left side (2.45º), Knee Angle at Initial Contact (2.40º), and TT ROM, for the left (2.79º) and the right (2.76º) sides. All other SEM registered values were very low, with variables as Step Length showing SEM of .01 m.

Table 23. – Reproducibility (Agreement and Reliability) analysis of the Gait Parameters variables.

	DAY 1	DAY 2 (RETEST)	DIFFERENCE OF THE MEANS (SD)	SEM	ICC
SPATIAL AND TEMPORAL PARAMETERS					
CADENCE	128.98 ± 6.14	130.89 ± 4.77	1.91(5.14)	3.64	.482
SPEED	1.17 ± .12	1.21 ± .13	.04 (.07)	.05	.851**
L_STEP*	.543 ± .05	.554 ± .057	.01 (.01)	.01	.965**
CYCLE_TIME	.934 ± .04	.92 ± .034	-.01 (.04)	.03	.468
DT_LUNIPODAL	39.41 ± .63	38.93 ± .526	-.52 (.72)	.51	.015
DT_RUNIPODAL	39.50 ± 1.53	40.05 ± 1.17	.60 (.77)	.55	.789**
DISPLACE_COM	3.41 ± .51	3.52 ± .006	.11 (.004)	.003	.780**
NORMALIZED TO ANTHROPOMETRICS					
RT_ASIS_CALC	2.223 ± .31	2.172 ± .37	-.095 (.29)	.20	.677
STEPFACTOR*	.875 ± .067	.874 ± .070	-.001 (.02)	.02	.942**
GAIT EVENTS					
T_L_LR	6.51 ± 1.17	6.53 ± 1.55	.12 (.93)	.66	.805**
T_R_LR	6.39± .69	7.36 ± 1.31	.79 (1.05)	.75	.389
T_L_MID_ST	10.49 ± .64	10.33 ± .76	-.19 (.51)	.36	.703**
T_R_MID_ST	10.44 ± .66	10.57 ± .67	.21 (.54)	.38	.684
T_L_TST	38.34 ± 1.08	38.04 ± 1.35	-.30 (1.36)	.96	.293
T_R_TST	38.41 ± 1.03	39.11 ± 1.05	.70 (1.31)	.92	.250
T_L_PSW	49.85 ± .47	49.44 ± .67	-.42 (.47)	.33	.527
T_R_PSW	50.18 ± .59	50.56 ± .74	.31 (.63)	.45	.477
T_L_INIT_SW	60.30 ± .83	60.13 ± 1.26	-.07 (.72)	.51	.803**
T_R_INIT_SW	60.68 ± .68	60.97 ± .57	.10 (.62)	.44	.441
T_MID_SW*	80.75 ± 1.50	81.20 ± .95	.43 (.88)	.62	.690
T_TSW*	88.05 ± 2.39	88.55 ± 1.10	-.22 (1.24)	.88	.221
KEY KINEMATIC EVENTS					
SAG_PELVIS_ROM*	4.37 ± .60	4.62 ± .64	.25 (.76)	.54	.267
PELVIS_SAG_MEDV*	10.37 ± 3.28	9.12 ± 2.46	-1.25 (3.51)	2.48	.284
PELVIS_TRANS_MEDV*	-.028 ± 0.45	-.002 ± .396	.026 (.76)	.54	.284
SAG_HIP_NDMAX_ROM*	42.28 ± 9.24	44.05 ± 3.92	1.77 (1.68)	1.19	.930**
SAG_NDMAX_HIPA*	35.85 ± 4.39	35.65 ± 4.10	-.20 (3.62)	2.56	.617
SAG_T_NDMAX_HIPA*	89.02 ±1.61	89.27 ± 1.65	.25 (1.04)	.74	.785**
SAG_MIN_HIPA*	-7.28 ± 5.90	-9.29 ± 4.01	-2.01 (6.99)	4.94	.251
SAG_T_MIN_HIPA*	53.28 ±0.85	52.96 ± .736	-.32 (.52)	.37	.803**
TRANS_MIDV_HIP_STPH*	-.78 ± 5.86	-.36 ± 4.73	.42 (2.45)	1.73	.804**
FRONT_MAX_HIP_SWPH*	-6.58 ± 1.72	-6.10 ± 2.27	.48 (1.32)	.93	.765**
SAG_KNEE_STMINROM*	65.56 ± 4.04	64.38 ± 3.76	-1.18 (2.58)	1.82	.754**
SAG_L_MAX_STKNEEA	18.62 ± 5.21	16.57 ± 3.37	-2.05 (3.47)	2.45	.531
SAG_R_MAX_STKNEEA	20.60 ± 5.13	18.45 ± 4.28	-2.15 (2.79)	1.97	.665
SAG_L_MAX_NDKNEEA	65.28 ± 3.97	62.93 ± 3.15	-2.35 (2.56)	1.81	.478
SAG_R_MAX_NDKNEEA	66.62 ± 3.81	64.78 ± 1.87	-1.84 (2.68)	1.90	.180
SAG_T_MAX_STKNEEA*	16.29 ± 4.35	14.80 ± 1.36	-1.49 (1.98)	1.40	.318
SAG_T_MAX_NDKNEEA*	74.10 ± .82	74.25 ± .938	.15 (1.09)	.77	.304
SAG_MIN_NDKNEEA*	5.43 ± 3.75	3.73 ± 3.15	-1.7 (1.49)	1.05	.767**
SAG_T_L_MIN_NDKNEEA	38.89 ± 2.51	39.11 ± 3.06	.22 (1.69)	1.19	.769**
SAG_T_R_MIN_NDKNEEA	40.43 ± 2.36	40.45 ± 2.86	.02 (2.22)	1.57	.678
SAG_KNEEA_CI*	.40 ± 3.40	-.42 ± 2.73	-.82 (3.4)	2.40	.497
SAG_L_TT_ROM	27.70 ± 4.49	28.85 ± 3.64	1.15 (3.94)	2.79	.490
SAG_R_TT_ROM	29.62 ± 4.62	29.34 ± 2.79	-.28 (3.90)	2.76	.205
SAG_TT_MAXDF_STPH*	12.49 ± 2.89	10.49 ± 2.05	-2.00 (2.12)	1.50	.671
SAG_TT_MAXDF_SWPH*	5.36 ± 2.38	3.33 ± 1.28	-2.03 (2.26)	1.60	.250
FPA_MEDV_STPH*	-5.92 ± 3.02	-5.95 ± 2.29	-.03 (1.85)	1.31	.833**

*The variable is represented by the mean value of left and right sides;
**The variables show a strong correlation (ICC between [-1; -.7] or [.7; 1]);
SEM – Standard Error of Measurement

Clinical Measurements and Gait Parameters: Correlation Analysis

To perceive the eventual existence of correlations among the two sets of variables (the Clinical Measurements Variables, and the Gait Parameters Variables), the Pearson Correlation Coefficient was calculated by crossing all variables (see Appendix VIII). The correlations considered strong are the ones which the coefficient fell on the window [-1; -.7] or [.7; 1]. No strong correlations were found between any of the variables. The literature refers that efforts have been made to understand how the clinical angular static data can be related to the dynamic collected in the laboratory. If such relation was found, one could infer about dynamic angles, by measuring them in a static clinical way. Unfortunately, once again, this analysis reveals, as previously studies has[49], that poor correlation exists between these two sources of data. “Indeed, if such strong relationships did exist, then there would be little need to perform the gait analysis” [4 (p. 137)].

Much more could have been done with the vast information collected from the sample. Unfortunately the available time revealed to be insufficient to allow a deeper analysis of all of the data. Therefore a choice had to be made, and the kinematic data prevailed, specifically the Gait Parameters variables. Nevertheless, all of the data was treated, analyzed and presented in accordance to the analysis made.

CONCLUSION

The analysis of Joint Angular Displacement, Moments, and Powers revealed a good overlapping of the left and right side curves, with wave patterns in accordance to the literature. All of the components of the GRF revealed timings and intensity patterns in agreement with previously published work. The EMG data analysis revealed good symmetry among left and right sides, with timings of activation in accordance to the literature.

The variables of Clinical Measurements, as expected, fell within published physiological ranges. As the children were selected according to their health status, that was an assumption at start. Some features were found when children were compared according to gender, Height and Mass showed no differences, as did Tibial Torsion. The Female Gender revealed a tendency to geno valgo, longer inferior limbs, higher Femoral Anteversion, and statistically significant higher Hip Internal Rotation. The Male Gender showed a predominance of geno varu. All findings are in accordance to the previously mentioned published literature. Regarding comparisons between age groups, the majority of differences were found between the Age Groups 7 and 8, with little differences found between the groups 8 and 9. Height, Mass, and measures of inferior limb length showed higher values when comparing the 7 and 8 years old groups, with no considerable differences when comparing the 8 and 9 years old groups. The distribution of geno varus/valgus fell within previously mentioned regular physiological ranges, although it doesn't give that impression, as varus is dominant in the older groups, and valgus in the younger groups. One must keep in mind that, this not being a prospective study, the children in the older and younger groups are not the same, so the results do not reflect an evolution with age, just a possible healthy distribution of inferior limbs frontal alignment. Hip rotations showed little differences, while the Femoral Anteversion showed lower values when comparing the 8 with the 7 years old Groups. The 9 years old Group showed little differences when compared to the 8 years old Group. Tibial Torsion showed little changes in all Age Groups.

All of the Spatial and Temporal parameters collected are in accordance to the published work. Some of the gait events showed a little delayed, such as LR (2% to 6.45%), TST (31% to 38.37%) and MSW (75% to 80.75%). The processed kinematic key events comparable to those usually presented on the literature are in accordance to published work. From the kinematic events calculated besides the usually reported ones, the Timing of Maximum Hip Flexion showed a good consistency among subjects, with little SD value, and therefore, a good variable to take in account when assessing normal Hip wave behavior. However, the variables Knee 1st Flexion Maximum and its' respective time of occurrence showed high values of SD (approximately 5º and 4% respectively), revealing a poor variable to detect abnormalities, although this first flexion wave it's indicative of healthy development, as stated before. Regarding the comparisons among Gender Groups, the Spatial and Temporal parameters reflected the findings in the Anthropometrics, a female group with longer limbs that walked slightly faster, with a slightly longer non-normalized step, and completed the Cycle also a little faster. The measure of step length normalized to musculoskeletal data, StepFactor, showed no differences between Gender Groups, which supports the possibility of influence of the musculoskeletal growth. The mean CoM vertical displacement is the only variable that revealed statistically significant differences between gender groups, with the female group showing a higher mean value of 3.62 cm, while the male group showed 3.21 cm, probably related to the influence of inferior limbs length. The Rt_ASIS_Calc was inferior for the Female group, indicating a larger base of support, reflection of the geno valgus. No appreciable differences were found on the gait periods and phases. Regarding the key kinematic events some differences were found between Gender Groups. The value for the mean pelvic tilt revealed statistically significant differences among Gender Groups, with the Female Group registering a higher value, as expected in accordance to the literature[43]. The mean value for Hip ROM was higher for the Female Group that reached the 45.21º, while the Male Group only registered 39.56º. The mean value of Maximum Hip Flexion was statistically significant different between groups, with the Female Group registering a higher value of 37.64º, while the Male Group registered 34.18º. The value of mean Hip Rotation during ST was quite different among the Gender Groups, with 1.32º (SD=5.34) for the Female Group and -2.73º (SD=5.82) for the Male Group. It is important to highlight the fact that this is a measure with high error associated[45], in fact, it is noticeable the low consistency given the elevated SD values. The mean value of knee ROM showed statistically significant differences between groups, with a higher mean value for the Male Group that registered 67.44º, while the Female group reached the 63.54º. Probably the small differences occurring in an inverted way for the measures of hip and knee flexions are reflecting the compensatory relation between these two articulated joints. Generally, the females showed a slightly superior First Maximum Knee Flexion value, with little differences among Gender Groups in the Second Maximum Knee Flexion value. The mean value of knee flexion at initial contact revealed statistically significant differences between groups, with the males showing an inferior mean value (-1.01º for the Male Group and 1.92º for the Female Group) that reaches the inferior boundary of the published normal range of variability (0º to 10º, namely when velocity changes are present)[56]. The Maximum Dorsiflexion during ST registered a little higher mean value for the females, while during SW revealed no appreciable differences among Gender Groups.

Regarding the comparisons of Spatial and Temporal parameters among Age Groups, the number of steps per minute revealed to decrease as age increased (132.47, 129.39, and 125.50 steps/min for the 7, 8, and 9 years old groups, respectively), with a statistically significant difference between the 7 and 9years old Groups. The the Rt_ASIS_Calc was higher for the 9 years old Group revealing a narrower base of support. The StepFactor showed a higher value for the 9 years old Group, revealing an actual increase in this variable despite of musculoskeletal growth. No appreciable differences among Age Groups were found regarding gait periods and phases. Considering the key kinematic events, the variables mean Pelvic Tilt, Hip ROM, and value of Maximum Hip Flexion were higher for the 9 years old Group. The mean value of Minimum Hip Flexion showed a tendency to increase along with age, i.e., the maximum value of hip extension seems to decrease along with age. The value of mean hip rotation during ST was smaller for the 8 years old Group. The mean value for the first knee flexion peak revealed, again, to be quite fluctuating, showing no tendencies age wise, except for its' time of occurrence that appeared to be a little higher (latter) for the older group.

The reproducibility analysis showed a considerable number of variables with little ICC values, maybe as a reflection of a low variability between healthy subjects that challenges the discrimination between individuals, and/ or, the small sample size. Eight variables presented SEM values between 2º and 5º, while all others were bellow 2º. Higher SEM values were found on the variables Cadence (3.64 steps/min), Mean Value of Pelvic Tilt (2.48º), Maximum Hip Angle (2.56º), Minimum Hip angle (4.94º), First Maximum Knee Angle for the left side (2.45º), Knee Angle at Initial Contact (2.40º), and TT ROM, for the left (2.79º) and the right (2.76º) sides.

The higher values of absolute difference of means between days were found on the variables Minimum Hip Angle (2.01º), the First (2.05º and 2.15º for the left and right sides respectively) and Second (2.35º and 1.84º for the left and right sides respectively) Maximum Knee Angles, and the Maximum Dorsiflexion Angles for the ST (2.00º) and SW (2.03º). The remaining variables showed differences of 1% or 1º, or lower, with variables as Step Length and Cycle Time showing differences of .01 (meters and seconds, respectively).

No correlations were found between the two sets of variables (the Clinical Measurements Variables, and the Gait Parameters Variables), which reinforces previously published data that showed that the dynamic angle behavior cannot be inferred through the collection of static clinical data.

In this study we gathered vast published information concerning gait reference data and developed a protocol that intends to be a knowledge support for the continuous development of a reference database. Although the ages included in the present work are only between 7 and 9, we expect to continue this work, and hopefully, include all of the gait variability present on healthy individuals, of any age. In the future, we hope to contribute with new data analysis, namely to determine the Minimal Important Change (MIC), which indicates the minimum difference implying clinical significance, instead of statistical significance. It implies the definition of what is “minimally important” on the clinical context, and the ideal methods for calculating it are still being developed[5]. Also, the study of clinically relevant “kinetic events” could be considered.

The small sample size for the retest in the present study may limit the conclusions about the associated error for this collection procedure, therefore, a continuous and updated error analysis would be advised for an addiction of individuals, as for any protocol changes.

BIBLIOGRAPHY

1- Ancel, P., et al. (2006). Cerebral Palsy among very preterm children in relation to gestational age and neonatal ultrasound abnormalities: the EPIPAGE cohort study. *Pediatrics*, 117, 828-835.

2- Assi, A., Ghanem, I., Lavaste, F. & Skalli, W.(2009). Gait analysis in children and uncertainty assessment for Davis protocol and Gillette Gait Index. *Gait & Posture*, 30, 22-26.

3- Bacon-Shone VC. et al. (2000). Gait of Normal Hong Kong Chinese Children: The Bootstrap Approach. *Hong Kong Physiotherapy Journal*, 18(1), 21-25.

4- Baker R. (2013). *Measuring Walking*. Mac Keith Press.

5- Bleyenheuft C, Detrembleur C. (2012). Kinematic covariation in pediatric, adult and elderly subjects: is gait control influenced by age? *Clinical Biomechanics*, 27(6), 568-72.

6- Bonthuis, M. et al. (2012). Use of National and International Growth Charts for Studying Height in European Children: Development of Up-To-Date European Height--or-Age Charts. *PLOS One*, 7 (8), 11.

7- Bovi G, Rabuffetti M, Mazzoleni P, Ferrarin M. (2011). A multiple-task gait analysis approach: kinematic, kinetic and EMG reference data for healthy young and adult subjects. *Gait & Posture,* 33(1), 6-13.

8- Broughton, N.S. (1997). *A textbook of Paediatric Orthopaedics*. UK: WB Saunders Company.

9- Cans, C. (2000). Surveillance of cerebral palsy in Europe: a collaboration of cerebral palsy surveys and registers. Developmental Medicine & Child Neurology, 42, 816-824.

10- Chester, V.L, Tingley, M. & Biden, E.N. (2006). A comparison of kinetic gait parameters for 3-13 year olds. *Clinical Biomechanics*, 21(7), 726-32.

11- Chester V.L., Tingley M, Biden E.N. (2007). Review: Comparison of two normative paediatric gait databases. *Dynamic Medicine*, 6:8.

12- Criswell, E. (2011). *Cram's introduction to surface electromyography* (2nd ed.). Jones and Bartlett Publishers.

13- Cupp T, Oeffinger D, Tylkowski C, Augsburger S. (1999). Age-related kinetic changes in normal pediatrics. *Journal of Pediatric Orthopaedics*, 19(4), 475-8.

14- DeLuca, P.A., Davis III, R.B., Õunpuu, S., Rose, S. & Sirkin, R. (1997). Alterations in surgical decision making in patients with cerebral palsy based on three-dimensional gait analysis. *Journal of Pediatric Orthopaedics*, 17, 608-614.

15- Dimeglio A. (2001). Growth in pediatric orthopaedics. *Journal of Pediatric Orthopaedics*, 21, 549-555.

16- Diop M, Rahmani A, Belli A, Gautheron V, Geyssant A, Cottalorda J. (2005). Influence of speed variation and age on ground reaction forces and stride parameters of children's normal gait. *International Journal of Sports Medicine*, 26(8), 682-7.

17- Eng JJ, Winter DA. (1995). Kinetic Analysis of the Lower Limbs During Walking: What Can Be Gained From Three-Dimensional Model? *Journal of Biomechanics*, 28(6), 753-8.

18- Fabry, G. (1997). Normal and abnormal torsional development of the lower extremities*. Acta Ortopédica Bélgica*, 63 (4), 229-232.

19- Froehle, A.W., Nahhas, R.W., Sherwood, R.J. & Duren, D.L. (2013). Age-related changes in spatiotemporal characteristics of gait accompany ongoing lower limb linear growth in late childhood and early adolescence. *Gait & Posture*, 38(1), 14-19.

20- Fuller G. (2008). *Neurological Examination Made Easy* (4th ed.). Edinburgh: Churchill Livingstone Elsevier.

21- Gage JR. (2004). *The Treatment of Gait Problems in Cerebral Palsy*. Mac Keith Press.

22- Ganley KJ, Powers CM. (2005). Gait kinematics and kinetics of 7-year-old children: a comparison to adults using age-specific anthropometric data. *Gait & Posture*, 21(2), 141-5.

23- Gorton III, G.E., Hebert, D.A. & Gannotti, M.E. (2009). Assessment of the kinematic variability among 12 motion analysis laboratories. *Gait & Posture*, 29, 398-402.

24- Graça, A.M. (2014). Determining the neurological outcome of prematuriry – a state of the art review. *Acta Pediátrica Portuguesa*, 45, 211-225.

25- Granata KP, Padua DA, Abel MF. (2005). Repeatability of surface EMG during gait in children. *Gait & Posture*, 22(4), 346-50.

26- Gronley, J.K. & Perry, J. (1984). Gait analysis techniques: Rancho Los Amigos Hospital Gait Laboratory. *Physical Therapy*, 64, 1831-1838.

27- Hausdorff JM1, Zemany L, Peng C, Goldberger AL. (1999). Maturation of gait dynamics: stride-to-stride variability and its temporal organization in children. *Journal of Applied Physiology*, 86(3), 1040-7.

28- Hensinger, R.N. (1986). *Standards in Pediatric Orthopedics. Tables, charts, and graphs illustrating growth*. New York: Raven Press

29- Herring, J.A. (2014). *Tachdjian's Pediatric Orthopaedics* (5^{th} ed.). USA: Elsevier Saunders.

30- Hillman SJ, Stansfield BW, Richardson AM, Robb JE. (2009). Development of temporal and distance parameters of gait in normal children. *Gait & Posture*, 29(1), 81-5.

31- Hintz, S.R., et al. (2011). Early-childhood neurodevelopmental outcomes are not improving for infants born at <25 weeks' gestational age. *Pediatrics*, 127 (1), 62-70.

32- Hof, L. (1996). Scaling gait data to body size. *Gait & Posture*, 4, 222-223.

33- Jacquemier M., GIard Y., Pomero V., Viehweger E., Jouve J. & Bollini G. (2008). Rotational profile of the lower limb in 1319 healthy children. *Gait & Posture,* 28, 187-193.

34- INE (2013). *Estatísticas Demográficas 2013*. INE Portugal

35- Jones S., Khandekar S. & Tolessa E. (2013). Normal variants of the lower limbs in pediatric orthopedics. *International Journal of Clinical Medicine*, 4, 12-17.

36- Kuo, A.D. (2007). The six determinants of gait and the inverted pendulum analogy: a dynamic walking perspective. *Human Movement Science*, 26, 617-656.

37- Leardini A, Benedetti MG, Berti L, Bettinelli D, Nativo R. & Giannini S. (2007). Rear-foot, mid-foot and fore-foot motion during the stance phase of gait. *Gait & Posture*, 25(3), 453-462.

38- Leardini A, Sawacha Z, Paolini G, Ingrosso S, Nativo R, Benedetti MG. (2007). A new anatomically based protocol for gait analysis in children. *Gait & Posture*, 26, 560-571.

39- Lythgo N, Wilson C, Galea M. (2009). Basic gait and symmetry measures for primary school-aged children and young adults whilst walking barefoot and with shoes. *Gait & Posture*, 30(4), 502-6.

40- Lulic, T.J. & Muftic, O. (2002). Trajectory of the human body mass centre during walking at different speed. In *International Design Conference – Design*, Dubrovnik, May 14-17 2002 (797-802).

41- Magee, D.J. (2013). *Orthopedic Physical Assessment* (6th ed.). Canada: Elsevier Saunders.

42- Manal K, McClay I, Stanhope S, Richards J, Galinat B. (2000). Comparison of surface mounted markers and attachment methods in estimating tibial rotations during walking: an in vivo study. *Gait & Posture*, 11(1), 38-45.

43- McDowell, B., Hewitt, V., Nurse, A., Weston, T. & Baker, R. (2000). The variability of goniometric measurements in ambulatory children with spastic cerebral palsy. *Gait & Posture*, 12, 114-121.

44- McGibbon NH. et al. (2009). Immediate and Long-Term Effects of Hippotherapy on Symmetry of Adductor Muscle Activity and Functional Ability in Children With Spastic Cerebral Palsy. *Archives of Physical Medicine and Rehabilitation*, 90, 966-974.

45- McGinley, J.L., Baker, R., Wolfe, R. & Morris, M.E. (2009). The reliability of three-dimensional kinematic gait measurements: a systematic review. *Gait & Posture*, 29, 360-369.

46- McMulkin, M.L., Gulliford, J.J. & Ferguson, R.L. (nd). Correlation of static and dynamic measures of lower extremity range of motion in normal children.

47- Mudge, A.J., et al. (2014). Normative reference values for lower limb joint range, bone torsion, and alignment in children aged 4-16 years. Journal of Pediatric Orthopaedics, 23, 15-25.

48- N 010/2013. Programa Nacional de Saúde Infantil e Juvenil. Lisboa DGS

49- Neves, M.C., Campagnolo, J.L. (2009). Desvios axiais dos membros inferiores. Revista Portuguesa de Clínica Geral, 25, 7.

50- Novacheck TF. (1998). The biomechanics of running. *Gait & Posture*, 7(1): 77-95.

51- Oeffinger D, Brauch B, Cranfill S, Hisle C, Wynn C, Hicks R, Augsburger S. (1999). Comparison of gait with and without shoes in children. *Gait & Posture*, 9(2), 95-100.

52- Ounpuu S., Gage JR., Davis RB. (1991). Three-Dimensional Lower Extremity Joint Kinetics in Normal Pediatric Gait. Journal of Pediatric Orthopaedics, 11, 341-349.

53- Pamela, S. & Hassan, G. (2003). Lower extremity abnormalities in children. *American Family Physician*, 68 (3), 461-468.

54- Panjavi, B. & Mortazavi, S.M.J. (2007). Rotational deformities of the lower limb in children. Iranian Journal of Pediatrics, 17 (4), 393-397.

55- Perry J., Burfield J.M. (1992). *Gait Analysis. Normal and Pathological Function*. SLACK Incorporated.

56- Perry J., Burfield J.M. (2010). *Gait Analysis. Normal and Pathological Function* (2nd ed.). SLACK Incorporated.

57- Petrie A. (2006). Review Article: Statistics in Orthopaedic Papers. *The Journal of Bone&Joint Surgery*, 88B, 1121-36.

58- Pountney T. (2007). *Physiotherapy for Children*. Elsevier Ltd.

59- Richards J. (2008). *Biomechanics in Clinic and Research*. Churchill Livingstone.

60- Robertson, D.G.E. et al. (2004). *Research Methods in Biomechanics* (2nd ed.). Human Kinetics.

61- Robertson, C.M.T., Watt, M. & Yasui, Y.Y. (2007). Changes in the Prevalence of Cerebral Palsy for children born very prematurely within a population-based program over 30 years. *American Medical Association*, 297 (24), 2733-2740.

62- Romei, M., Galli, M., Motta, F., Schwartz, M. & Crivellini, M. (2004). Use of normalcy index for the evaluation of gait pathology. *Gait & Posture*, 19, 85-90.

63- Rose, S.A., Ounpuu, S. & DeLuca, P.A. (1991). Strategies for the assessment of pediatric gait in the clinical setting. *Physical Therapy*, 71, 961-980.

64- Samson W, Desroches G, Cheze L, Dumas R. (2009). 3D joint dynamics analysis of healthy children's gait. *Journal of Biomechanics*, 42, 2447-2453.

65- Sass P., Hassan G. (2003). Lower Extremity Abnormalities in Children. *American Family Physician*, 68(3), 461-468.

66- Schutthe, L., Narayanan, U., Stout, J.L., Selber, P., Gage, J.R. & Schwartz, M.H. (2000). An index for quantifying deviations from normal gait. *Gait & Posture*, 11, 25-31.

67- Schwartz, M., Trost, J.P. & Wervey, R.A. (2004). Measurement and management of errors in quantitative gait data. *Gait & Posture*, 20: 196-203.

68- Schwartz, M.H. & Rozumalski, A. (2008). The gait deviation index: a new comprehensive index of gait pathology. *Gait & Posture*, 28, 351-357.

69- Schwartz, M., Rozumalski, A. & Trost, J.P. (2008). The effect of walking speed on the gait of typically developing children. *Journal of Biomechanics*, 41, 1639-50.

70- Slaton DS. (1985). Gait Cycle Duration in 3-Year-Old Children. *Physical Therapy*, 65(1), 17-21.

71- Staheli, L.T., Engel, G.M. (1972). Tibial Torsion. A Method Of Assessment and a Survey of Normal Children. *Clinical Orthopaedics and Related Research*, 86, 183-186.

72- Staheli L.T., Corbett M., Wyss C. & King H. (1985). Lower-extremity rotational problems in children. *The Journal of Bone and Joint Surgery,* 67A (1), 39-47.

73- Staheli, L.T. (2001). *Practice of pediatric orthopaedics*. USA: Lippincott Williams & Wilkins.

74- Steele, K.M., Seth, A., Hicks, J.L., Schwartz, M.S., Delp, S.L. (2010). Muscle contributions to support and progression during single-limb stance in crouch gait. *Journal of Biomechanics*, 43(11), 2099-105.

75- Stolze, H., Kuhtz-Buschbeck, J.P., Mondwurf, C., Jöhnk, K. & Friege, L. (1998). Retest reliability of spatiotemporal gait parameters in children and adults. *Gait & Posture*, 7, 125-130.

76- Sutherland D., Olshen R.Biden E., Wyatt M. (1988). *The Development Of Mature Walking*. Clinics in Developmental Medicine No. 104/105. Mac Keith Press Oxford Blackwell Scientific Publications Lt Philadelphia, J.B. Lippincott Co.

77- Sutherland D. (1997). Review Paper: The development of mature walking. *Gait & Posture*, 6, 163-170.

78- Vet, H.C., Terwee, C.B., Ostelo, R.W., Beckerman, H., Knol, D.L. & Bouter, L.M. (2006). Minimal changes in health status questionnaires: distinction between minimally detectable change and minimally important change. *Health and Quality of Life Outcomes*, 4,54.

79- Vet H.C.W., Terwee C.B., Knol D.L., Bouter L.M. (2006). When to use agreement versus reliability measures. *Journal of Clinical Epidemiology*, 59, 1033-39.

80- Wegener et al. (2011). Effect of children's shoes on gait: a systematic review and meta-analysis. *Journal of Foot and Ankle Research*, 4:3.

81- WHO (2006). *WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development.* Department of Nutrition for Health and Development.

82- Weir J. P. (2005). Quantifying Test_Retest Reliability Using the Intraclass Correlation Coefficient and the SEM Journal of Strength and Conditioning Research, 19(1), 231–240.

83- Wren T. et al. (2007). Gillette Gait Index as a Gait Analysis Summary Measure. Comparison with Qualitative Visual Assessments of Overall Gait. *Journal of Pediatric Orthopaedics*, 27(7), 765-768.

84- Wren, T., et al. (2009). Effects of Preoperative Gait Analysis on Costs and Amount of Surgery. *Journal of Pediatric Orthopedics*, 29(6), 558-563.

85- Zaheer F, Roy SH, De Luca CJ. (2012). Preferred sensor sites for surface EMG signal decomposition. *Physiological Measurement*, 33(2),195-206.

86- International Association for Dance Medicine & Science, https://www.iadms.org/page/325, accessed on 25/12/2013

87- INE, Portal do Instituto Nacional de Estatística, http://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_main, accessed on 25/12/2013, ine@ine.pt.

88- Patient.co.uk, http://www.patient.co.uk/doctor/Gait-Abnormalities-in-children.htm, accessed on 26/12/2013.

89- SENIEM, Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles, http://www.seniam.org/, accessed on 25/12/2013

90- The Royal Children's Hospital Melbourne, Clinical Practice Guidelines, http://www.rch.org.au/Templates/RchPbTwoCol.aspx?pageid=2761, accessed on 25/12/2013.

91- C-Motion Wiki Documentation, https://www.c-motion.com/v3dwiki/index.php/Visual3D_Overview, accessed on 25/12/2013.

92- Wikipedia, http://en.wikipedia.org/wiki/Calcaneus, accessed on 25/12/2013.

APPENDICES

APPENDIX I – SCIENTIFIC ARTICLE

"Inter and Intra Individual Variability Of The Gait Fundamental Parameters On Healthy Children: Definition of the Clinically Relevant Normative Data"

Vera Bagão, Filipa João[a], Sílvia Cabral[a], António P. Veloso[a]

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APPENDIX II – LETTER TO THE PRIVATE SCHOOL DIRECTION BOARD

Direção da Cooperativa de Ensino "A Torre"

Lisboa, Janeiro 2014

Assunto: Pedido de autorização para a avaliação biomecânica de crianças do 1º ciclo do ensino básico.

Exma. Direção da Cooperativa de Ensino "A Torre"

O meu nome é Vera Cristina Manilhas Lopes Bagão, sou licenciada em Fisioterapia e frequento o Mestrado em Ciências da Fisioterapia, na área de Biomecânica, na Faculdade de Motricidade Humana da Universidade de Lisboa.

Para a concretização da dissertação de mestrado será desenvolvido um estudo com o objetivo de estabelecer a norma dos parâmetros fundamentais da marcha em crianças saudáveis. Esta norma é fundamental para o desenvolvimento de um projeto de cooperação entre esta faculdade e diversos hospitais do país, que visa ajudar crianças com Paralisia Cerebral.

Durante a realização deste projeto ocorrerão visitas por parte dos profissionais às aulas de Educação Física que decorrem na Faculdade de Motricidade Humana, onde serão entregues os Questionários de Saúde e Consentimento Informado a preencher pelos encarregados de educação que aceitem participar no estudo. Será ainda realizado um exame para despiste de comprometimento neuromuscular e ortopédico no colégio a Torre.

As crianças consideradas aptas nesta avaliação, serão então avaliadas no Laboratório de Biomecânica e Morfologia Funcional da Faculdade de Motricidade Humana (FMH), durante os períodos em que decorreriam as aulas de Educação Física aí protocolarmente previstas, não acarretando portanto qualquer transtorno extra aos encarregados de educação ou colégio, e garantindo as condições de segurança e responsabilidade já vigentes nesse protocolo. As recolhas decorrerão com um tempo médio esperado de 1h por recolha de cada criança, sendo que estão previstas duas recolhas por criança, com o intervalo de 1 semana.

Durante as avaliações no Laboratório as crianças deverão usar roupa leve (calção curto/fato de banho) e os testes serão realizados sem calçado. Num espaço aquecido, de acesso restrito e já preparado para este efeito. As crianças serão avaliadas por profissionais treinados. Posteriormente serão colocados marcadores passivos em locais anatómicos específicos que, por retrorreflexão permitirão a análise do movimento da criança, com recurso a câmaras específicas. Em avaliação estarão simples tarefas de marcha. Todos os procedimentos do processo de avaliação se encontram distribuídos por um grupo de profissionais devidamente qualificado para o desempenho de cada função atribuída, não se esperando, portanto, qualquer acréscimo de risco ao já expectável nas aulas de Educação Física.

Assim sendo, venho por este meio solicitar a V. (s) Ex.ª (s) a autorização para o desenvolvimento deste projeto nesta escola.

Para qualquer esclarecimento que entenda necessário pode contactar-me por telemóvel através do 915424838, ou por email através de vbagao.86@gmail.com. Poderá também contactar o laboratório diretamente através do 21 414 9127.

Atenciosamente,

Vera Cristina Marilhas Lopes Bagão.

(Answer from" Cooperativa Torre", by email)

Cooperativa Torre <cooptorre@gmail.com> 23/06

para mim

Bom dia,

A direção da cooperativa "A Torre" autoriza a professora Vera Bagão, no âmbito do mestrado em Ciências da Fisioterapia (área da biomecânica), a efetuar os testes de avaliação biomecânica com os nossos alunos do 2º e 3º anos na Faculdade de Motricidade Humana.

A Direção
Clara Vilhena

No dia 23 de Junho de 2014 às 10:46, Vera bagão <vbagao.86@gmail.com> escreveu:

...

> Bom dia
>
> como combinado, envio em anexo o pedido de autorização aos alunos à participação num estudo na FMH, que diz respeito às crianças que frequentam estas instalações às segundas e quartas entre as 9h e as 10h, e terças entre as 14h e as 15h.
>
> Muito agradecida pela atenção
>
> Despeço-me com os meus melhores cumprimentos,
>
> Vera Bagão

APPENDIX III – FREE AND INFORMED CONSENT

"STUDY OF THE INTER AND INTRA INDIVIDUAL VARIABILITY OF THE GAIT ANALYSIS FUNDAMENTAL PARAMETERS ON HEALTHY CHILDREN:
DEFINITION OF THE CLINICALLY RELEVANT NORMATIVE DATA"

Responsável pelo projeto

Vera Cristina Manilhas Lopes Bagão

Orientação

Professor António Prieto Veloso

Faculdade de Motricidade Humana – Universidade de Lisboa

Laboratório de Biomecânica e Morfologia Funcional

Este documento, designado **Consentimento Informado, Livre e Esclarecido**, contém informação importante em relação ao estudo para o qual foi abordado/a, bem como o que esperar se decidir aceitar que o seu educando participe no mesmo. Leia atentamente toda a informação aqui contida. Deve sentir-se inteiramente livre para colocar qualquer questão, assim como para discutir com terceiros (amigos, familiares) a decisão de participar neste estudo.

O meu nome é Vera Cristina Manilhas Lopes Bagão, sou Licenciada em Fisioterapia e frequento o Mestrado em Ciências da Fisioterapia, na Faculdade de Motricidade Humana (FMH) da Universidade de Lisboa.

Este estudo tem como objetivo a recolha de dados biomecânicos de crianças saudáveis para o estabelecimento da norma dos parâmetros da marcha nesta população.

Para participar neste projeto, o encarregado de educação deverá preencher o Questionário de Saúde que irá receber no colégio, referente ao seu educando, e devolvê-lo, devidamente preenchido. Após retorno dos questionários, ocorrerão visitas por parte dos profissionais durante as aulas de Educação Física na Faculdade de Motricidade Humana, alturas em que será efetuado um despiste de comprometimento neuromuscular e ortopédico. Todas as crianças do Colégio "a Torre", com 7 ,8, 9 e 10 anos, cuja história clínica, e condições atuais musculo-esquelética e neuromuscular, não apresentem alterações à normalidade poderão ser incluídas neste estudo. As crianças consideradas aptas nesta avaliação serão então avaliadas no Laboratório de Biomecânica e Morfologia Funcional da FMH, durante os períodos em que decorreriam as aulas de Educação Física aí protocolarmente previstas, não acarretando portanto qualquer transtorno extra aos encarregados de educação, e garantindo as condições de segurança e responsabilidade já vigentes nesse protocolo. As recolhas decorrerão com um tempo médio esperado de 1h00 por cada criança, sendo que estão previstas duas recolhas por criança, com um intervalo de 1 semana.

Durante as avaliações no Laboratório as crianças deverão colocar roupa leve (calção curto/fato de banho) e deslocar-se-ão descalços, num espaço aquecido, de acesso restrito e já preparado para este efeito. As crianças serão medidas por profissionais treinados. Posteriormente serão colocados marcadores em locais anatómicos específicos que, por retrorreflexão permitirão a análise do movimento da criança, com recurso a câmaras específicas. Em avaliação estarão tarefas de marcha. Todos os procedimentos do processo de avaliação se encontram distribuídos por um grupo de profissionais devidamente qualificado para o desempenho de cada função atribuída.

A participação no estudo é voluntária e pode recusar-se a participar. Caso decida que o seu educando pode participar neste estudo, é importante ter conhecimento que pode desistir a qualquer momento, sem qualquer tipo de consequência para si ou para ele.

As crianças que participarem no estudo serão avaliadas no sentido de despistar qualquer compromisso neuromuscular ou ortopédico. Os encarregados de educação de cada criança, se interessados, receberão um relatório individual do Laboratório de Biomecânica e Morfologia Funcional, com os dados obtidos durante as avaliações.

Não é esperado qualquer acréscimo de risco durante a realização das tarefas em avaliação no laboratório, para além dos já expectáveis associados à aula de Educação Física.

Os dados recolhidos pelas câmaras do laboratório garantem o anonimato das crianças, visto não efetuarem recolha de imagens, apenas dos percursos dos marcadores retrorrefletores. Além disso, todos os dados de identificação das crianças serão codificados e armazenados apenas no servidor da FMH. Os dados recolhidos passarão a fazer parte da base de dados da faculdade, podendo apenas ser divulgados com propósito científico, sempre com garantia de anonimato.

Para qualquer questão relacionada com a sua participação neste estudo, por favor contactar: Vera Bagão, através do telemóvel 915424838, ou do email vbagao.86@gmail.com. Poderá também contactar o laboratório diretamente através do 21 414 9127.

Assinatura do Consentimento Informado, Livre e Esclarecido

Li (ou alguém leu para mim) o presente documento e estou consciente do que esperar quanto à participação do meu educando no estudo "ESTUDO DA VARIABILIDADE INTER E INTRA INDIVIDUAL DOS PARÂMETROS FUNDAMENTAIS PARA ANÁLISE DA MARCHA EM CRIANÇAS SAUDÁVEIS: DEFINIÇÃO DE NORMA COM RELEVÂNCIA CLÍNICA". Tive a oportunidade de colocar todas as questões e as respostas esclareceram todas as minhas dúvidas. Assim, aceito voluntariamente que o meu educando participe neste estudo. Foi-me dada uma cópia deste documento.

______________________________	______________________________
Nome do Encarregado de Educação	**Assinatura do Encarregado de Educação**

______________________________	______________________________
Grau de Parentesco com o participante	**Data**

Investigador

Os aspetos mais importantes deste estudo foram explicados ao participante ou ao seu representante, antes de solicitar a sua assinatura. Uma cópia deste documento ser-lhe-á fornecida.

______________________________	______________________________
Nome da pessoa que obtém o consentimento	**Assinatura da pessoa que obtém o consentimento**

____

Data

HEALTH FORM

"STUDY OF THE INTER AND INTRA INDIVIDUAL VARIABILITY OF THE GAIT ANALYSIS FUNDAMENTAL PARAMETERS ON HEALTHY CHILDREN: DEFINITION OF THE CLINICALLY RELEVANT NORMATIVE DATA"

Fill the following form, concerning your child, as accurately as possible.
Thanks for your cooperation.

Name (child):____

Adress:____

Date of Birth (child): ____(**Date**)/________(**Month**)/________(**Year**)

Contact :
Telephone: ________________ Email: __________________________________

Legal Guardian:
Kinship **/** Name

____

____

(Mark with a circle your intended answer)

Birth: At term/ Premature

Gender: F/ M

Birth weight: _________

Delivery: Dystocic/ Eutocic (normal)

Difficult breathing at Birth: yes/ No

Laterality:
- Rather use which hand to:
  - Eat? Right/ Left
  - Write? Right/ Left
  - Throw objects? Right/ Left
- Rather kick (a ball) with which foot? Right/ Left

Is there any family history of:
- Congenital dislocation of the hip? Yes/ No
- Club foot? Yes/ No
- Torsional deformities (inferior limbs)? Yes/ No
- Genu Varu ("bow legs")? Yes/ No
- Genu Valgus ("knock knees")? Yes/ No

Any orthopedic history that led to hospitalization? Yes/ No
If so, please describe: ____.

Development

How old was he/she when began to:

Sit? ____________ (months)

Crawl? ____________ (months)

Stand up? ___________(months)

Walk alone? ___________(months)

Run? ____________(months)

Climb stairs? __________(months)

Took off the diapers? _________(months)

Present Health Status

Currently, does he/she present any illness (including a common cold)? Yes/ No

If so, describe: ____

Does he/she develop recurrent respiratory infections? Yes/ No

How often: ____

Have you ever noted any trouble breathing during the night? Yes/No

How often: ____

Often develops cramps during exercise? Yes/ No

How often: ____

Have you ever noted any abnormal reaction when in contact with cold water (rigidity)? Yes/ No

If so, describe: ____

Takes any medication on regular basis? Yes/ No

If so, describe: ____

Presents any vision impairment? Yes/ No

If so, describe: ____

Presents any hearing impairment? Yes/ No

If so, describe: ____

Thank you for your cooperation!!!

This Health Questionnaire was adapted from: Sutherland D., Olshen R.Biden E., Wyatt M. The Development Of Mature Walking. Clinics in Developmental Medicine No. 104/105. Mac Keith Press Oxford Blackwell Scientific Publications Lt Philadelphia, J.B. Lippincott Co.; 1988.

Appendix V – Orthopedic and Neurological Screening Protocol

Orthopedic and Neurological Screening Protocol

Should be applied on a warm and friendly environment.
This protocol was developed to be applied on children with no detected Neurologic or Orthopedic impairments.

DATE: __/__/_____ Child Code: CR__________

Function	Assessment Details	Observation
Assess the children as he/she arrives. Overall Aspect (asymmetries, atrophies, fasciculation); Posture (joints' positions); Gait (claudication)		
History		
Symptomatology	Present complaints (pain) Family history	
Mental State and Higher Functions		
Orientation	Day, Month, Year; Name; Adress; Date of birth.	
Atention	Test it by asking the child to repeat a serie of numbers – same and reverse order	
Memory	Imediate – repeat a simple adress; Short-term – same adress 5 min later	
Calculation	Simple arithmetics; Multiplication tables	
Abstract Thought	Tradicional sayings ("quem tudo quer…")	
Spacial Perception	Draw a watch with the pointers indicating the requested hour	
Craneal Nerves		
II – Ocular Position	simetry, alignment (squint).Eyelids	
III - Ocular Moviments	Oral comand (right, left, up,down, follow my finguer – converge)	
V, VII - Face	Neutral position; "wrinckle your forehead"; "show me your teeth" (obs. temporalis) Resist jaw opening (simetry)	
VIII - Audition	Hears good? Float tone of voice	
IX, X, XII - Tongue	"open your mouth" (obs. tongue) and say "ahh"' (obs palate); "show me your tongue" "clench your teeth"(obs simetry, size, colour)	
XI - Cervical Moviments	Neutral position; (obs. and palp.); lateral, anterior and posterior tilt, (ECM); "subir e descer ombros" (Trap.). Resist motion.	
Motor System		
Tone and Laxity	Passive Movement of muscular synergic muscles	
	Knee Instability Stress anterior and posterior; Stress varus/ valgus	
Muscular Strength (muscular groups) Allow movement in the available amplitude. Before testing, observe and palpate the muscular contracting Compare sides.	Shoulder abduction/adduction	
	Shoulder flexion/extension	
	Elbow flexion/extension	
	Fingers flexion/extension	
	1st finger flexion/extension	
	Hip flexion/extension	
	Hip flexion/extension	
	Knee flexion/extension	
	Tibiotarsic plantar/dorsi flexion	
	Fingers flexion/extension	
	1st finger flexion/extension	
	Seat, from lying position	
	Cervical flexion/ extension	

Reflexes	Bicipital	
	Tricipital	
	Patellar	
	Aquilian	
	Plantar (Babinsky)	
Sensation (proprioception)	Fingers	
	Toes	
Coordenation	Finger-nose	
	heel-shin (Supine)	

Anatomy	Recording Information	Observations
Standing Height	Orthostatic Position	cm
Weight	Orthostatic Position	Kg
Observation and Palpation of the Spine	N-normal; E-scoliosis; C-cifosis; H-hyperlordosis; O-other	
Inferior Limbs alignment (measure Genu Varus/Valgus)	dist. intercondylar; dist. intermalleolar	IC cm IM cm
MI length Navel –Tibial Malleolus ASIS – Tibial Malleolus Trochanter – Lateral Malleolus	Supine He, Ke	L R cm cm cm cm cm cm
Joint Assessment (Arthrogryposis)	N- normal	
Leg perimeter (fat accumulation)	N- normal	
Feet	C-cavus; P-planus; N-normal	
Feet – dorsal bunion	Y/N	
Motor Tasks		
Gait (posture, step length, turn ability; simetry, base width, Trendelenburg sign…)		
Balance beam like Gait	N- normal	
Tip Toes Gait	N- normal	
Heel Gait	N- normal	
Lift from floor (Gower's Sign)	N- normal	
Stair climbing; run; jump	N- normal	
Throw and catch an object	N- normal	
Unipodal standing and jumping	N- normal	
Romberg's Test (Orthostatic standing; feet together. Allow the subject to adapt. Assure the subject you'll be near to prevent him or her from falling. (don't proceed if there's lack of balance). Ask to close both eyes)	N- negative P- positive	

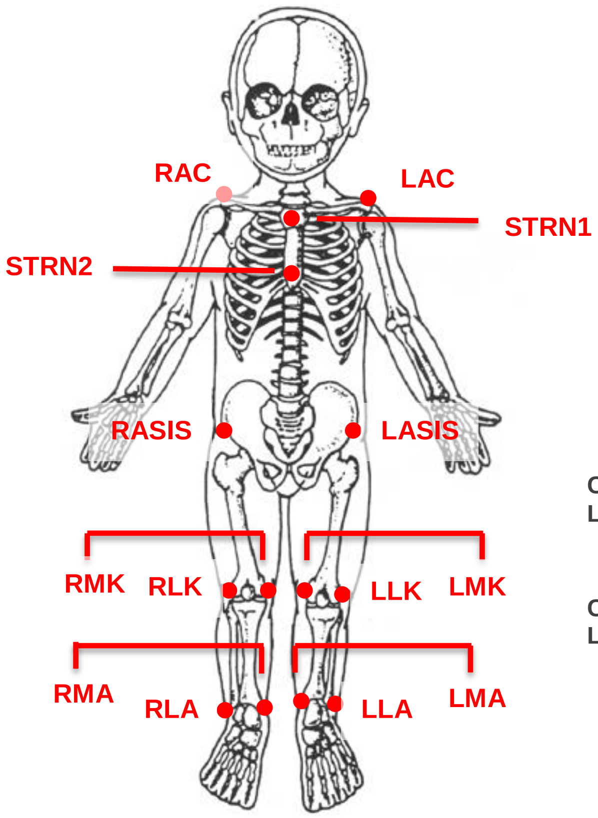
Joint/ Structure	Muscle/ Functio Assessed	Assessment Position	Recording Information	R	L
HIP	Flexum	Supine Contralateral Hf. H examinada com Ke. Controlar lordose lombar.	yes (< tight - table) no		
HIP	Abduction Adductors (except *Gracilis*)	Supine Hf, Kf	< vertical - tight		
HIP	Abdução Adductors (including *Gracilis*)	Decubito dorsal He, Kf	< axe ASIS - tight		
HIP	Abduction Adductores, *Gracilis*, medial IT	Supine He, Ke	< axe ASIS - tight		
HIP	Adduction	Supine He, Ke	< axe ASIS - tight		
Knee	Extension (A) Recurvatum Normal Flexum	Supine He, Ke	Recurvatum (+) Normal (0) Flexum (-)		
Knee	Patella Position	Kf 30 ° Distance between tibial plateau (joint line) and inferior border of the patella	cm		
Knee	Flexion	Supine Hf at 90°	< tight-leg		
Knee	Bilateral Popliteal Angle	Supine Contralateral Hf	< vertical-leg		
Knee	Unilateral Popliteal Angle	Supine Contralateral He	< vertical-leg		
Knee	Active Extension (B)	Assist Hf	< tight-leg		
Knee	'Extension Lag '		A - B		
Tibiotarsic	Plantarflexion *Soleus + Gastrocnemius*	Supine He, Ke	< leg - foot		
Tibiotarsic	Dorsiflexion *Soleus*	Supine Hf, Kf	< leg - foot		
Foot	'Hallux valgus'		< MT1 - PH1		
Hip	Extension *Psoas*	Supine He, Ke	< tight - table		
Hip	Extension *Rectus Femoris*	Prone He, Kf	< tight - table		
Hip	Internal Rotation	Prone He, Kf	< vertical - leg		
Hip	External Rotation	Prone He, Kf	< vertical - leg		
Hip	Anteversão Femoral	Prone He, Kf Palpate great trochanter	< vertical - leg		
Foot	Tibial Torsion	Prone He, Kf	< tight-foot		
Foot	Rearfoot Valgus/ Varus	Prone He, Ke Align valgus/varus rearfoot	If aligns – Normal < leg - rearfoot		
Foot	Forefoot Adduction/ Abduction	Decubito ventral He, Kf Align valgus/varus rearfoot	<axe rearfoot - axeM2		
Foot	Forefoot Supination (varus)/Pronation (valgus)	Prone He, Kf Align valgus/varus rearfoot	< horizontal - axe MTPH Prox		

Note: < - angle; He/f – Hip extended/ flexed; Ke/f – knee extended/ flexed

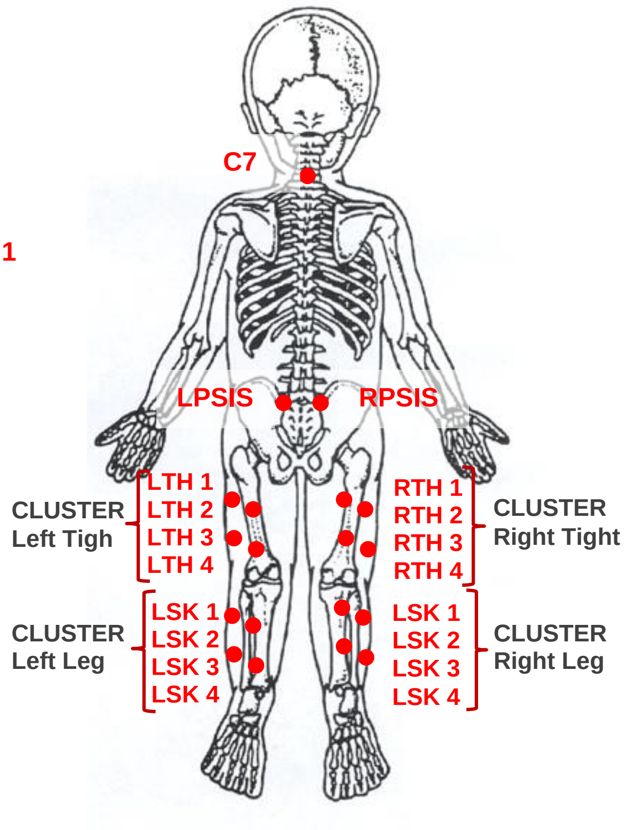
APPENDIX VI – PROTOCOL FOR MARKER PLACEMENT GUIDANCE

RIGHT	LEFT	PROCEDURE
RAC	LAC	Follow the scapula's spine towards the shoulder joint, until you find the acromial angle. Follow the clavicle until you find the acromio-clavicular joint line (small depression). The marker should be placed on the midpoint of this line, which is obliquely oriented (shoulder top).
C7		C7 is the most prominent vertebra in the cervical region (when you see two prominences, C7 is the one that does not disappear with head flexion).
STRN1 - 2		Placed on top of the sternum, one on the manubrium (midpoint), and the other on the midline of sternum's body (for tracking only)
RASIS	LASIS	Palpate along iliac crest in the anterior direction until you find the anterior superior iliac spine (flat surface after the end of the crest).
RPSIS	LPSIS	Palpate along iliac crest in the posterior direction until you find the posterior superior iliac spine (prominence at the posterior end of the crest).
RTH 1-4	LTH 1-4	Thigh cluster placed according with wobbling mass, visibility and sensors.
RLK	LLK	Placed on the lateral epicondyle of the knee - find the mid distance of the ROM, as the epicondyle will change position during the motion.
RMK	LMK	Placed on the medial epicondyle of the knee - find the mid distance of the ROM, as the epicondyle will change position during the motion.
RSK 1-4	LSK 1-4	Shank cluster placed according with wobbling mass, visibility and sensors.
RLA	LLA	Placed on the lateral malleolus along an imaginary line that passes through the transmalleolar axis.
RMA	LMA	Placed on the medial malleolus along an imaginary line that passes through the transmalleolar axis.
RHEE	LHEE	Place the HEE marker on the vertical posterior midline of the calcaneus, as far down the calcaneus as possible, considering heel strike during motion. It should have the same height from the plantar surface of the foot as the P5M marker
RPCA	LPCA	Place the PCA marker on the same midline, above the HEE marker. (It will be used to define the calcaneus).
RLCA RSTL	LLCA LSTL	Place the LCA and STL markers on the lateral and medial aspects of the calcaneus respectively, equidistantly from the HEE marker (for tracking only).
RTOE	LTOE	Place marker on the metatarsal area, between the 2nd and 3rd
R1MP R5MP	L1MP L5MP	Place the P5M and P1M markers on the base of the 5th and 1st metatarsals, respectivelly. Assure they are placed at the same height from the plantar surface of the foot as the markers on the metatarsal heads. Place markers immediately after the tarsometatarsal joints.
R1MD R5MD	L1MD L5MD	Colocado sobre as cabeças dos 1º e 5º metatarsos, imediatamente antes das articulações metatarsofalângicas. Place the D5M and D1M markers on the head of the 5th and 1st metatarsals, respectively. Place markers immediately after the metatarsophalangeal joints, ensuring they are at the same distance from the plantar surface of the foot.
RHLX	LHLX	Place the HLX marker on the hallux on the proximal end of 1st distal phalange at the same height as the D1M marker (adapted from the original)

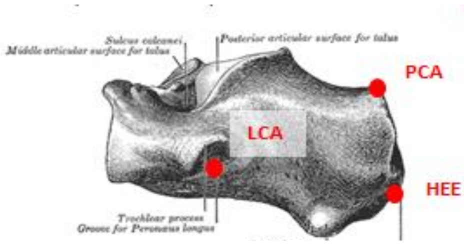
ANATOMICAL CHART FOR MARKER PLACEMENT GUIDANCE



Anterior view of the anatomical chart
Source: The Royal Children's Hospital Melbourne[92]

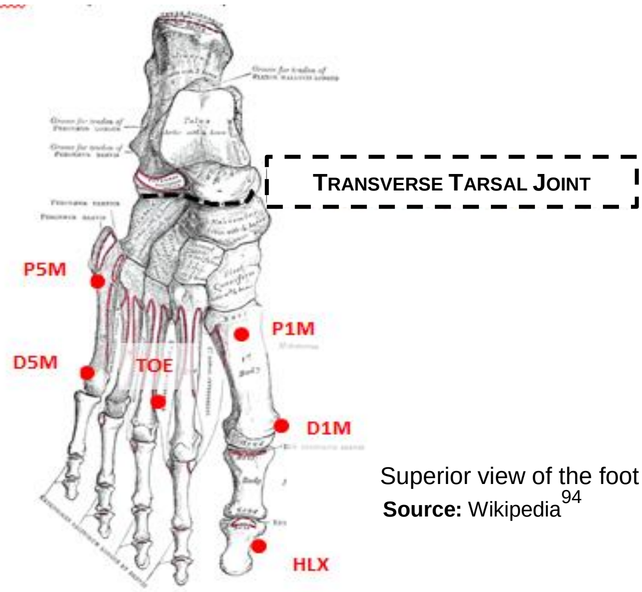


Posterior view of the anatomical chart
Source: The Royal Children's Hospital Melbourne[92]



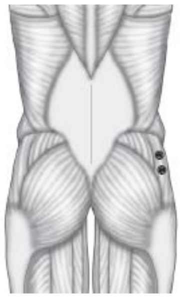
Lateral view of the calcaneus bone
Source: Wikipedia[94]

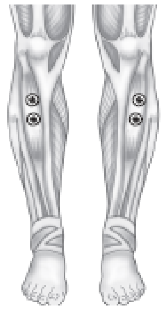
Medial view of the calcaneus bone
Source: Wikipedia[94]



Superior view of the foot
Source: Wikipedia[94]

APPENDIX VII – ELECTROMIOGRAPHY PROTOCOL

GLUTEUS MEDIUS **Electrodes placement:** palpate the iliac crest. Place it parallel to the muscle fibers over the proximal third of the distance between the iliac crest and the greater trochanter. Vertical orientation of muscular fibers. **Behavioral Test:** While the patient is side lying or standing sideways while supporting himself or herself against a wall, have the patient abduct the leg; have the patient walk.	 **Source:** Cram's introduction to surface electromyography[14]
ADDUCTOR LONGUS **Electrodes placement:** place it on the medial aspect of the thigh in an oblique direction, 4 cm from the pubis. Palpate the area while the patient conducts an isometric adduction. **Behavioral Test:** Pressing the knees together to adduct the legs.	 **Source:** Cram's introduction to surface electromyography[14]
RECTUS FEMORIS **Electrodes placement:** place it on the center of the anterior surface of the thigh, approximately half the distance between the knee and the iliac spine. **Behavioral Test:** While seated, ask the subject to extend the knee; ask him or her to squat slightly.	 **Source:** Cram's introduction to surface electromyography[14]
SEMITENDINOSUS **Electrodes placement:** place it parallel to the muscle fibers on the lateral aspect of the thigh, two thirds of the distance between the trochanter and the back of the knee. Palpate for the muscle while manually muscle testing with the knee at 90 degrees and the thigh in a slight lateral rotation. **Behavioral Test:** In a prone position, ask the subject to flex the knee against resistance.	 **Source:** Cram's introduction to surface electromyography[14]

TIBIALIS ANTERIOR **Electrodes placement:** place it at approximately one-quarter to one-third the distance between the knee and the ankle. Palpate the area while the subject dorsiflexes the foot. Place the electrode over the largest muscle mass. **Behavioral Test:** Dorsiflex the foot; stand on tip toes.	 **Source:** Cram's introduction to surface electromyography[14]
GASTROCNEMIUS **Electrodes placement:** place it distal from the knee and 2 cm medial or lateral to midline. **Behavioral Test:** While standing, lean forward. In an open kinetic chain, plantar flex the foot (point the toe); stand on tip toes.	 **Source:** Cram's introduction to surface electromyography[14]

SENSOR ASSIGNMENT PER MUSCLE AND ANALOGIC CHANNEL

MUSCLE	SENSOR	CHANNEL ON ANALOG BOARD QTM	CHANNEL ON ANALOG BOARD EMG
LEFT GLUTEUS MEDIUS (LGLTMED)	1	23	0
LEFT RECTUS FEMURIS (LRF)	2	24	1
LEFT ADDUCTOR LONGUS (LADDLONG)	3	25	2
LEFT SEMITENDINOSO (LST)	4	26	3
LEFT TIBIALIS ANTERIOR (LTA)	5	27	4
LEFT LATERAL GASTROCNEMIUS (LGM)	6	28	5
RIGHT GLUTEUS MEDIUS (RGLTMED)	7	29	6
RIGHT RECTUS FEMURIS (RRF)	8	30	7
RIGHT ADDUCTOR LONGUS (RADDLONG)	9 (13)	31	8
RIGHT SEMITENDINOSO (RST)	10	32	9
RIGHT TIBIALIS ANTERIOR (RTA)	11	33	10
RIGHT LATERAL GASTROCNEMIUS (RGM)	12	34	11

APPENDIX VIII – RESULTS

FREQUENCY TABLE – CLINICAL MEASUREMENTS VARIABLES

Child Code	Gender (M/F)	M (kg)	H (m)	D. BIRTH	Age Group	DIST IC (m)	DIST IM (m)	K CLASS.	UMB-MM (m)	ASIS-MM (m)	TROC-LM (m)	K EXT (º)	IR (º)	ER (º)	ROT ROM (º)	F ANT (º)	TI. TORS. (º)	COLLECTION DATE	RETEST DATE
CR001	F	22,15	1,28	05-05-2006	7	.010	.000	varum	.745	.690	.645	0	50.00	20.00	70.00	20.00	8.00	25-03-2014	-
CR003	F	22,35	1,33	25-05-2006	7	.000	.005	valgum	.775	.700	.650	0	50.00	18.00	68.00	14.00	10.00	22-04-2014	-
CR004	F	35,4	1,38	01-05-2006	7	.000	.025	valgum	.780	.710	.665	0	40.00	10.00	50.00	10.00	6.00	29-04-2014	-
CR005	M	24,65	1,21	01-06-2006	7	.000	.005	valgum	.660	.605	.550	+4	40.00	24.00	64.00	26.00	6.00	06-05-2014	-
CR006	F	21,75	1,22	05-06-2006	7	.000	.005	valgum	.685	.655	.610	0	50.00	14.00	64.00	28.00	4.00	13-05-2014	-
CR007	M	25,1	1,24	08-06-2006	7	.000	.000	N	.715	.695	.580	0	60.00	22.00	82.00	20.00	4.00	20-05-2014	-
CR008	M	24,15	1,22	08-09-2006	7	.000	.000	N	.660	.605	.565	0	50.00	18.00	68.00	30.00	2.00	03-06-2014	-
CR009	F	31,8	1,32	15-07-2005	8	.000	.020	valgum	.735	.675	.610	+4	50.00	12.00	62.00	22.00	6.00	11-06-2014	-
CR010	M	35,75	1,37	09-02-2005	9	.000	.020	valgum	.755	.670	.600	0	52.00	30.00	82.00	14.00	2.00	16-06-2014	23-06-2014
CR011	F	22,7	1,23	18-09-2006	7	.000	.015	valgum	.660	.645	.600	0	42.00	26.00	68.00	18.00	2.00	17-06-2014	-
CR012	M	27,8	1,32	30-05-2005	9	.000	.000	N	.715	.695	.625	0	36.00	20.00	56.00	14.00	6.00	18-06-2014	25-06-2014
CR013	F	26,25	1,31	18-04-2005	9	.010	.000	varum	.720	.660	.595	0	52.00	16.00	68.00	20.00	10.00	23-06-2014	-
CR014	M	37,9	1,36	10-08-2005	8	.000	.030	valgum	.765	.720	.635	0	40.00	12.00	52.00	10.00	6.00	25-06-2014	-
CR015	M	31,5	1,38	05-05-2005	9	.005	.000	varum	.750	.710	.630	0	30.00	20.00	50.00	10.00	6.00	02-07-2014	09-07-2014
CR016	F	33,85	1,43	03-12-2004	9	.000	.000	N	.800	.755	.685	0	38.00	18.00	56.00	24.00	6.00	02-07-2014	09-07-2014
CR017	M	25,8	1,31	22-04-2005	9	.020	.000	varum	.710	.665	.615	0	40.00	22.00	62.00	10.00	6.00	07-07-2014	14-07-2014
CR018	F	28,6	1,31	24-08-2005	8	.000	.010	valgum	.745	.710	.650	0	50.00	20.00	70.00	20.00	4.00	07-07-2014	14-07-2014
CR019	M	28,1	1,34	14-11-2006	7	.010	.000	varum	.760	.690	.645	0	40.00	30.00	70.00	18.00	17.00	08-07-2014	15-07-2014
CR020	M	26,3	1,29	27-10-2005	8	.010	.000	varum	.690	.660	.605	0	40.00	20.00	60.00	10.00	2.00	09-07-2014	16-07-2014
CR021	M	28,25	1,32	08-09-2005	8	.010	.000	varum	.725	.680	.615	0	46.00	20.00	66.00	16.00	6.00	09-07-2014	16-07-2014
CR022	F	25,8	1,3	26-11-2004	9	.000	.015	valgum	.730	.680	.625	0	50.00	22.00	72.00	22.00	2.00	14-07-2014	-
CR023	M	23,3	1,3	11-02-2005	9	.020	.000	varum	.710	.690	.625	0	50.00	10.00	60.00	20.00	4.00	14-07-2014	21-07-2014
CR024	M	26,85	1,31	22-01-2006	8	.010	.000	varum	.720	.680	.620	0	40.00	20.00	60.00	26.00	10.00	15-07-2014	-
CR025	M	36,75	1,43	25-12-2005	8	.000	.010	valgum	.790	.725	.665	0	44.00	18.00	62.00	16.00	6.00	16-07-2014	23-07-2014
CR026	F	28,3	1,32	19-12-2005	8	.000	.010	valgum	.735	.700	.635	0	50.00	20.00	70.00	15.00	5.00	21-07-2014	-
CR027	F	26,8	1,32	20-06-2005	9	.000	.000	N	.745	.685	.630	0	60.00	12.00	72.00	15.00	5.00	21-07-2014	-
CR028	F	25,35	1,3	18-04-2005	9	.005	.000	varum	.725	.685	.605	0	54.00	18.00	72.00	12.00	8.00	23-07-2014	-

FREQUENCY TABLE –GAIT PARAMETERS VARIABLES (DAY 1/#1)

Child Code	Cadence #1	Speed #1	*L_Step #1	Cycle_Time	Inter_ASIS #1	Stride_Width #1	Rt_ASIS_ Calc#1	*StepFactor #1	*dT_Unipodal #1	*t_LR #1	*t_Mid_St #1	*t_Term_St #1
CR001	126.4	.973	.471	.950	.1498	.0873	1.716	.729	36.248	6.044	10.200	36.766
CR003	142.04	1.310	.560	.853	.1853	.0783	2.367	.861	40.420	5.625	9.647	39.419
CR004	144.70	1.458	.602	.827	.1934	.1119	1.728	.905	39.354	5.466	10.593	37.124
CR005	127.85	1.013	.475	.940	.1782	.0657	2.712	.864	38.701	6.954	11.445	38.312
CR006	128.77	1.072	.501	.935	.1759	.0688	2.557	.820	38.959	7.456	11.141	38.384
CR007	126.07	1.062	.509	.954	.1946	.0858	2.268	.877	39.144	6.839	10.610	37.963
CR008	134.10	1.165	.521	.896	.1876	.0753	2.491	.921	40.333	6.009	9.727	37.585
CR009	132.87	1.131	.510	.905	.2213	.1020	2.170	.836	38.314	7.512	11.362	39.186
CR010	125.02	1.195	.571	.960	.2141	.1050	2.039	.952	37.880	7.301	11.732	40.299
CR011	124.92	1.171	.567	.964	.1647	.0818	2.013	.944	39.926	6.585	10.276	37.546
CR012	127.70	1.175	.553	.944	.1960	.0682	2.874	.884	39.312	7.217	10.860	39.499
CR013	120.65	1.211	.603	.998	.1798	.0762	2.360	1.013	40.682	5.942	9.744	38.139
CR014	130.75	1.223	.565	.920	.2145	.0915	2.344	.889	38.635	7.652	11.229	37.533
CR015	117.46	1.088	.555	1.023	.1776	.0831	2.137	.881	40.063	6.986	10.152	37.972
CR016	130.93	1.482	.677	.917	.2014	.0812	2.480	.988	40.322	5.877	9.764	38.042
CR017	126.88	1.178	.558	.948	.1838	.0726	2.532	.907	40.325	5.908	9.701	38.418
CR018	126.38	1.123	.535	.952	.1960	.0870	2.253	.823	39.528	7.055	10.567	37.632
CR019	137.35	1.258	.544	.871	.1942	.0840	2.312	.843	39.421	7.496	10.638	39.639
CR020	138.02	1.049	.452	.870	.1736	.1003	1.731	.747	39.857	5.183	10.342	38.448
CR021	128.25	1.185	.554	.933	.1792	.0802	2.234	.901	40.155	7.363	10.456	38.657
CR022	125.87	1.048	.499	.954	.1830	.0925	1.978	.798	39.012	5.870	11.156	37.974
CR023	123.79	1.093	.533	.971	.1830	.0708	2.585	.852	40.317	5.273	9.690	37.672
CR024	121.98	1.027	.508	.986	.1940	.1086	1.786	.819	39.418	5.653	10.534	38.098
CR025	127.36	1.265	.595	.943	.1892	.1072	1.765	.894	38.982	5.732	10.935	39.764
CR026	129.54	1.200	.561	.927	.1823	.0890	2.048	.883	39.713	5.197	10.260	39.167
CR027	126.42	1.076	.512	.950	.1821	.0789	2.308	.813	39.928	6.874	10.125	38.130
CR028	130.31	1.275	.585	.922	.1802	.0811	2.222	.968	40.323	7.012	9.667	38.705

*The variable is represented by the mean value of left and right sides;

(continues)

FREQUENCY TABLE – GAIT PARAMETERS VARIABLES (DAY 1/#1) (CONTINUATION)

Child Code	*t_PSw #1	t_L_init_SW #1	t_R_init_SW #1	*t_Mid_Sw #1	T_TSW#1	Displace_CoM #1	*Sag_Pelvis_ROM #1	*Pelvis_Sag_MidV #1
CR001	50.280	60.095	61.309	78.569	76.720	.029	4.405	11.673
CR003	49.855	59.866	59.689	79.762	89.451	.035	3.431	8.306
CR004	49.930	60.159	60.136	82.417	87.677	.044	3.995	13.061
CR005	50.004	62.128	61.419	78.089	88.302	.031	4.390	4.776
CR006	49.926	60.757	60.618	80.626	88.383	.036	4.572	12.672
CR007	49.675	60.513	60.394	81.906	88.149	.027	4.224	8.945
CR008	49.954	59.899	59.556	80.792	87.804	.032	5.470	6.006
CR009	50.013	60.987	61.986	81.837	89.519	.033	3.366	11.148
CR010	49.939	62.107	61.686	82.631	90.101	.035	5.172	8.811
CR011	49.954	60.485	60.357	80.358	87.345	.041	4.405	10.089
CR012	49.963	60.235	61.196	78.869	89.473	.038	5.667	12.864
CR013	50.220	58.697	60.900	81.356	88.332	.039	4.264	14.180
CR014	50.032	61.303	61.313	80.904	87.431	.026	4.311	3.458
CR015	50.023	60.201	59.735	78.944	87.895	.036	4.020	16.246
CR016	50.033	58.964	60.701	81.135	88.264	.047	4.903	9.523
CR017	50.007	59.409	60.259	79.389	88.671	.028	4.403	12.189
CR018	50.032	60.252	60.775	80.576	87.784	.036	4.168	12.620
CR019	50.117	60.104	61.347	81.705	89.775	.030	4.723	4.677
CR020	50.034	59.718	61.235	82.934	88.293	.030	3.963	10.478
CR021	50.451	60.732	61.509	80.254	88.926	.030	4.630	8.980
CR022	50.004	60.759	59.547	81.792	87.503	.033	4.805	13.820
CR023	50.006	59.140	60.432	81.279	87.685	.033	4.547	5.709
CR024	49.856	60.269	61.041	84.196	88.427	.035	4.289	12.155
CR025	50.006	61.351	60.694	80.738	89.653	.038	3.544	12.715
CR026	50.011	60.201	60.560	81.530	89.221	.038	4.627	9.513
CR027	50.006	60.323	60.063	79.466	88.244	.028	3.040	14.369
CR028	50.010	59.417	59.923	78.226	88.391	.032	4.539	11.041

*The variable is represented by the mean value of left and right sides;

(continues)

FREQUENCY TABLE – GAIT PARAMETERS VARIABLES (DAY 1/#1) (CONTINUATION)

Child Code	*Pelvis_Trans_MidV #1	*Sag_Hip_ndmax_ROM #1	*Sag_ndmax_HipA #1
CR001	-.320	43.984	36.254
CR003	.405	43.143	32.540
CR004	-.383	43.040	35.274
CR005	-.553	.952	26.764
CR006	-.074	45.603	37.631
CR007	-.155	43.105	39.028
CR008	.258	43.795	36.037
CR009	-.252	40.087	39.589
CR010	1.376	44.244	33.942
CR011	-.118	50.686	38.094
CR012	-.402	45.462	40.656
CR013	-.253	49.438	41.252
CR014	.448	40.885	24.508
CR015	-.232	41.521	40.183
CR016	-.130	54.712	38.845
CR017	-.719	46.741	40.326
CR018	-.424	42.168	40.394
CR019	.107	46.127	32.591
CR020	.037	35.819	32.230
CR021	.777	45.734	35.981
CR022	.350	42.545	38.725
CR023	-.103	41.407	28.851
CR024	-.648	35.970	30.885
CR025	-.210	42.037	36.524
CR026	.185	45.727	34.331
CR027	.135	38.043	37.384
CR028	.139	48.496	39.012

*The variable is represented by the mean value of left and right sides;

(continues)

FREQUENCY TABLE – GAIT PARAMETERS VARIABLES (DAY 1/#1) (CONTINUATION)

Child Code	*Sag_t_ndmax_HipA #1	*Sag_Min_HipA #1	*Sag_t_Min_HipA #1	*Trans_MidV_Hip_STph #1	*Sag_Knee_stmin_ROM #1
CR001	86.514	-7.865	53.497	2.537	62.798
CR003	88.474	-10.668	52.518	2.987	63.111
CR004	91.131	-7.890	51.801	5.804	57.974
CR005	87.695	-17.361	53.287	1.988	67.160
CR006	88.584	-7.947	52.992	4.915	60.695
CR007	87.920	-4.153	54.282	-6.050	69.978
CR008	86.262	-7.787	52.430	-2.569	71.988
CR009	90.424	-.418	53.662	-6.313	63.293
CR010	88.856	10.211	54.201	-10.358	75.126
CR011	88.066	-12.715	54.067	-8.279	70.050
CR012	89.250	-4.804	53.244	-.221	71.509
CR013	91.776	-8.251	53.404	5.037	66.534
CR014	90.719	-16.366	53.744	-19.265	67.159
CR015	88.493	-1.318	53.701	-2.238	64.284
CR016	91.151	-15.826	52.465	-3.546	60.501
CR017	89.698	-6.344	53.325	.989	69.013
CR018	91.596	-1.671	53.357	-.944	60.947
CR019	89.671	-13.349	52.582	-1.950	64.530
CR020	86.691	-3.656	50.988	-1.491	63.733
CR021	89.042	-9.544	54.272	.123	66.129
CR022	88.833	-3.660	54.820	1.252	62.196
CR023	87.559	-12.465	53.676	2.627	63.701
CR024	88.596	-5.215	54.549	-.162	62.799
CR025	88.228	-5.607	52.808	.310	67.053
CR026	92.085	-11.517	52.952	3.431	62.406
CR027	87.782	-.751	52.941	-1.160	67.006
CR028	88.366	-9.537	52.926	11.377	68.520

*The variable is represented by the mean value of left and right sides;

(continues)

FREQUENCY TABLE – GAIT PARAMETERS VARIABLES (DAY 1/#1) (CONTINUATION)

Child Code	Sag_Max_stLKneeA #1	Sag_Max_stRKneeA #1	Sag_Max_ndLKneeA #1	Sag_Max_ndRKneeA #1	*Sag_t_Max_stKneeA #1
CR001	12.972	13.452	61.134	66.088	15.961
CR003	14.041	19.209	62.817	63.368	18.094
CR004	24.042	22.181	60.750	60.629	14.212
CR005	8.007	12.813	62.342	64.603	14.321
CR006	15.545	19.334	60.254	65.049	13.395
CR007	21.343	26.854	70.293	75.035	14.669
CR008	24.338	24.430	72.547	75.498	19.654
CR009	27.216	27.945	68.527	71.025	14.978
CR010	16.025	23.488	69.685	67.709	15.565
CR011	20.270	27.111	69.823	69.423	15.469
CR012	12.773	19.077	70.629	68.264	15.575
CR013	29.060	28.581	70.026	70.633	13.488
CR014	12.810	9.342	61.644	61.977	16.808
CR015	17.183	18.781	63.727	65.071	20.668
CR016	27.792	31.185	67.310	67.875	12.999
CR017	17.374	19.036	71.217	70.004	14.980
CR018	23.144	21.415	66.241	67.969	16.174
CR019	17.263	20.103	64.715	67.858	15.155
CR020	16.383	14.978	60.919	61.619	17.109
CR021	16.046	20.594	65.466	66.291	17.107
CR022	20.316	20.558	63.156	62.091	12.652
CR023	17.714	20.944	63.759	63.788	19.261
CR024	20.171	21.108	59.554	63.856	13.616
CR025	18.839	20.871	62.990	65.139	14.538
CR026	21.699	21.673	64.544	63.747	15.137
CR027	10.775	13.072	60.424	64.260	35.459
CR028	19.524	17.992	68.030	69.835	12.923

*The variable is represented by the mean value of left and right sides;

(continues)

FREQUENCY TABLE – GAIT PARAMETERS VARIABLES (DAY 1/#1) (CONTINUATION)

Child Code	*Sag_t_Max_ndKneeA #1	*Sag_Min_ndKneeA #1	Sag_t_Min_ndLKneeA #1	Sag_t_Min_ndRKneeA #1	Sag_LTT_ROM #1	Sag_RTT_ROM #1	*Sag_TT_MaxDf_STph #1
CR001	74.074	1.706	38.165	42.217	20.644	18.421	12.876
CR003	72.488	4.493	41.048	41.897	25.860	29.461	10.048
CR004	72.504	4.925	37.732	38.381	23.243	21.288	10.723
CR005	73.741	-2.565	38.220	39.335	28.483	26.134	10.805
CR006	74.678	1.393	37.923	40.405	27.776	33.630	11.987
CR007	74.605	12.762	42.413	42.027	27.527	35.881	13.305
CR008	73.450	11.485	36.849	37.718	31.503	38.244	13.862
CR009	74.812	12.420	40.831	41.840	22.797	24.967	15.413
CR010	75.893	6.598	37.501	36.437	23.618	25.777	8.125
CR011	73.515	6.713	41.610	42.082	27.137	24.566	17.350
CR012	74.391	2.899	34.987	39.288	29.893	27.854	14.165
CR013	73.796	5.664	42.868	41.152	39.260	35.503	13.827
CR014	74.091	.859	41.616	42.440	27.160	30.419	9.104
CR015	73.275	7.250	39.959	38.507	27.616	27.949	19.022
CR016	73.441	-.337	40.521	42.190	27.791	31.719	11.596
CR017	75.166	5.455	38.926	42.225	28.768	26.410	14.129
CR018	73.667	10.096	39.639	36.398	34.220	36.411	15.450
CR019	75.126	3.316	40.693	43.182	18.956	30.994	9.500
CR020	73.747	6.819	36.421	40.762	22.819	26.452	6.162
CR021	74.670	5.419	34.902	43.173	28.979	33.703	15.662
CR022	75.231	6.251	41.518	43.543	22.877	28.611	13.157
CR023	73.215	7.706	35.542	37.894	26.149	29.252	9.186
CR024	74.604	9.672	37.267	41.517	33.675	33.413	10.233
CR025	74.011	4.034	40.262	41.089	31.450	29.726	11.360
CR026	74.610	4.991	40.596	39.751	33.508	29.578	13.323
CR027	73.616	2.678	33.162	34.416	27.380	31.266	14.264
CR028	74.297	3.821	38.841	41.761	28.859	32.203	12.503

*The variable is represented by the mean value of left and right sides;

(continues)

FREQUENCY TABLE – GAIT PARAMETERS VARIABLES (DAY 1/#1) (CONTINUATION)

Child Code	*Sag_TT_MaxDf_SWph #1	*Front_Max_Hip_SWph #1	*Sag_KneeA_CI #1	*FPA_MidV_STph #1
CR001	3.577	-7.698	.942	-3.573
CR003	1.613	-3.812	.018	-7.017
CR004	5.855	-4.853	2.993	-10.258
CR005	5.659	-6.299	-3.542	-6.025
CR006	2.213	-6.440	1.620	-4.902
CR007	3.629	-5.571	2.924	-6.637
CR008	6.337	-6.377	1.827	-8.446
CR009	10.665	-4.122	6.647	-4.192
CR010	4.443	-8.071	-5.962	-10.807
CR011	7.828	-9.077	-.698	-6.547
CR012	4.540	-6.739	-1.802	-1.820
CR013	6.938	-8.907	3.574	-8.697
CR014	7.022	-6.665	-5.337	-7.035
CR015	8.570	-8.154	.133	2.011
CR016	7.265	-8.424	7.113	-8.147
CR017	8.303	-8.576	1.909	-3.205
CR018	6.351	-6.797	6.219	-5.236
CR019	3.353	-6.146	2.505	-4.103
CR020	.711	-5.464	-2.425	-9.186
CR021	7.113	-8.043	.185	-3.987
CR022	6.477	-6.799	.121	-4.679
CR023	2.740	-2.660	.342	-10.384
CR024	6.678	-9.161	-1.582	-9.736
CR025	4.049	-5.506	-3.277	-4.833
CR026	5.238	-5.310	1.194	-5.716
CR027	2.027	-4.358	-4.737	-1.447
CR028	5.494	-7.579	-.074	-5.201

*The variable is represented by the mean value of left and right sides;

<u>FREQUENCY TABLE – GAIT PARAMETERS VARIABLES (DAY 2/#2)</u>

Child Code	Cadence #2	Speed #2	*L_Step #2	Cycle_Time #2	Inter_ASIS #2	Stride_Width #2	Rt_ASIS_ Calc#2	*StepFactor #2	dt_L_Unipodal #2	dt_R_Unipodal #2	t_L_LR #2	t_R_LR #2
CR010	121.62	1.128	.558	.990	.2281	.1145	1.992	.930	39.082	38.309	6.155	5.624
CR012	129.17	1.175	.547	.930	.1860	.0715	2.601	.875	38.045	39.283	8.084	8.288
CR015	127.58	1.219	.579	.939	.1904	.0759	2.509	.918	38.676	39.163	8.670	9.053
CR016	132.11	1.448	.663	.909	.2065	.0737	2.802	.967	38.790	40.562	6.860	6.090
CR017	127.06	1.167	.552	.947	.1778	.0950	1.872	.897	39.557	41.547	5.208	8.192
CR018	133.62	1.137	.514	.898	.1845	.0873	2.113	.790	38.684	40.268	7.693	8.809
CR019	139.73	1.321	.561	.859	.1859	.0889	2.091	.870	39.678	40.640	7.498	7.325
CR020	130.95	.942	.433	.917	.1705	.1052	1.621	.715	38.271	40.106	4.343	7.037
CR021	136.02	1.243	.549	.885	.1778	.0908	1.958	.892	38.763	39.586	7.486	8.528
CR023	130.82	1.164	.533	.918	.1904	.0763	2.495	.852	39.201	42.220	4.002	5.350
CR025	131.16	1.328	.607	.918	.2087	.1134	1.840	.914	39.498	38.821	5.791	6.637

Child Code	t_L_Mid_St #2	t_R_Mid_St #2	*t_Term_St #2	t_L_PSw #2	t_R_PSw #2	t_L_init_SW #2
CR010	11.453	11.395	39.479	50.632	49.249	62.263
CR012	10.959	11.550	40.378	49.345	50.732	61.078
CR015	10.889	11.061	40.191	49.734	50.096	61.243
CR016	9.659	10.149	38.380	48.999	51.026	59.282
CR017	9.323	9.686	36.929	48.879	51.146	58.468
CR018	10.391	10.765	38.040	48.983	51.033	59.742
CR019	9.932	9.842	38.203	49.510	50.481	59.253
CR020	10.658	10.712	38.941	49.287	50.730	60.386
CR021	10.878	10.612	37.686	49.888	50.138	60.387
CR023	8.998	9.610	37.583	48.327	51.886	58.213
CR025	10.457	10.872	38.509	50.310	49.693	61.134

*The variable is represented by the mean value of left and right sides;

(continues)

FREQUENCY TABLE – GAIT PARAMETERS VARIABLES (DAY 2/#2) (CONTINUATION)

Child Code	T_R_init_SW #2	*t_Mid_Sw #2	t_TSW #2	Displace_CoM #2	*Sag_Pelvis_ROM #2	*Pelvis_Sag_MidV #2	*Pelvis_Trans_MidV #2
CR010	61.508	81.488	89.498	.037	3.658	7.589	-.301
CR012	61.806	79.773	90.554	.040	5.651	7.905	-.029
CR015	60.934	81.094	90.183	.037	4.725	8.534	-.592
CR016	60.609	81.301	88.289	.042	4.496	10.628	-.063
CR017	60.458	79.832	86.927	.028	5.108	6.901	-.222
CR018	61.515	80.250	87.857	.032	4.038	12.554	-.145
CR019	60.417	82.549	88.150	.034	4.783	6.671	.754
CR020	61.719	82.375	88.731	.025	3.529	7.941	.215
CR021	60.999	80.989	87.834	.035	4.970	12.962	-.358
CR023	60.499	82.073	87.870	.034	4.934	6.562	.202
CR025	60.244	81.464	88.209	.043	4.945	12.084	.518

Child Code	*Sag_Hip_ndmax_ROM #2	*Sag_ndmax_HipA #2	*Sag_t_ ndmax_HipA #2	*Sag_Min_HipA #2	*Sag_t_Min_HipA #2
CR010	43.954	34.031	88.970	-9.856	53.818
CR012	45.886	34.311	89.260	-11.327	53.527
CR015	43.310	43.310	89.271	-10.047	53.826
CR016	52.081	37.290	91.056	-14.823	52.701
CR017	46.934	33.340	87.765	-13.385	53.143
CR018	40.372	37.813	92.813	-2.550	53.258
CR019	45.070	32.709	88.453	-12.468	51.782
CR020	36.521	29.825	86.464	-6.724	51.738
CR021	43.549	39.724	89.986	-3.734	53.216
CR023	41.935	30.894	89.140	-11.330	53.257
CR025	44.898	38.932	88.848	-5.928	52.337

*The variable is represented by the mean value of left and right sides;

(continues)

FREQUENCY TABLE – GAIT PARAMETERS VARIABLES (DAY 2/#2) (CONTINUATION)

Child Code	*Trans_MidV_Hip_STph #2	*Sag_Knee_stmin_ROM #2	*Sag_Max_stKneeA #2	*Sag_Max_ndKneeA #2	*Sag_t_Max_stKneeA #2	*Sag_t_Max_ndKneeA #2
CR010	-13.157	69.670	20.374	68.147	13.079	75.104
CR012	3.556	69.054	13.487	65.172	15.555	76.091
CR015	-1.295	68.008	14.533	62.842	16.736	75.087
CR016	.146	59.793	22.029	61.503	12.963	74.142
CR017	3.076	65.878	13.360	64.811	14.558	74.395
CR018	4.336	58.424	18.133	62.506	16.062	73.282
CR019	-2.229	64.766	18.159	64.920	14.298	74.376
CR020	.551	64.257	12.380	60.918	15.869	74.282
CR021	-.785	65.257	18.639	64.753	16.126	72.944
CR023	1.857	60.307	19.325	62.956	13.090	73.209
CR025	.008	62.819	22.200	63.881	14.503	73.790

Child Code	*Sag_KneeA_CI #2	*Sag_Min_ndKneeA #2	*Sag_t_Min_ndLKneeA #2	Sag_TT_ROM #2	*Sag_TT_MaxDf_STph #2	*Sag_TT_MaxDf_SWph #2
CR010	-.974	6.679	35.754	27.039	8.948	5.489
CR012	-5.164	.585	38.632	33.136	11.612	2.223
CR015	4.270	4.121	43.712	34.148	14.218	2.489
CR016	.507	-3.032	41.811	31.933	8.212	4.854
CR017	-3.369	2.679	41.629	28.697	11.491	3.714
CR018	-.698	6.250	40.894	28.620	11.456	4.184
CR019	2.427	1.380	40.972	26.822	8.794	3.204
CR020	.767	5.021	38.185	24.374	8.375	1.239
CR021	-.974	5.996	38.393	28.499	13.052	3.911
CR023	-5.164	7.638	36.389	27.394	8.682	3.410
CR025	1.469	3.715	41.200	29.420	10.515	1.944

*The variable is represented by the mean value of left and right sides;

(continues)

FREQUENCY TABLE – GAIT PARAMETERS VARIABLES (DAY 2/#2) (CONTINUATION)

Child Code	*Front_Max_Hip_SWph #2	*FPA_MidV_STph #2
CR010	-7.552	-10.009
CR012	-5.799	-3.469
CR015	-7.776	-1.766
CR016	-6.628	-7.332
CR017	-9.466	-5.819
CR018	-2.975	-4.774
CR019	-7.08	-5.765
CR020	-4.689	-7.196
CR021	-8.299	-5.200
CR023	-2.154	-8.599
CR025	-4.708	-5.460

*The variable is represented by the mean value of left and right sides;

Clinical Measurements and Gait Parameters: Correlation Analysis (Pearson)

		mass	height	IC_DIST	IM_DIST	UMB_MT	ASIS_MT	TROC_MP	K_EXT	I_ROT	E_ROT
mass	Pearson Correlation	1	.803**	-.300	.548**	.666**	.555**	.441*	.020	-.329	-.114
	Sig. (2-tailed)		.000	.128	.003	.000	.003	.021	.921	.094	.572
	N	27	27	27	27	27	27	27	27	27	27
height	Pearson Correlation	.803**	1	-.032	.211	.897**	.804**	.775**	-.241	-.334	-.129
	Sig. (2-tailed)	.000		.875	.290	.000	.000	.000	.225	.088	.521
	N	27	27	27	27	27	27	27	27	27	27
IC_DIST	Pearson Correlation	-.300	-.032	1	-.470*	-.163	-.075	-.025	-.199	-.189	.011
	Sig. (2-tailed)	.128	.875		.013	.417	.710	.902	.319	.346	.956
	N	27	27	27	27	27	27	27	27	27	27
IM_DIST	Pearson Correlation	.548**	.211	-.470*	1	.232	.111	.109	.414*	.003	-.229
	Sig. (2-tailed)	.003	.290	.013		.245	.581	.589	.032	.988	.250
	N	27	27	27	27	27	27	27	27	27	27
UMB_MT	Pearson Correlation	.666**	.897**	-.163	.232	1	.876**	.845**	-.248	-.080	-.169
	Sig. (2-tailed)	.000	.000	.417	.245		.000	.000	.213	.690	.400
	N	27	27	27	27	27	27	27	27	27	27
ASIS_MT	Pearson Correlation	.555**	.804**	-.075	.111	.876**	1	.873**	-.380	-.151	-.241
	Sig. (2-tailed)	.003	.000	.710	.581	.000		.000	.050	.452	.226
	N	27	27	27	27	27	27	27	27	27	27
TROC_MP	Pearson Correlation	.441*	.775**	-.025	.109	.845**	.873**	1	-.397*	-.244	-.243
	Sig. (2-tailed)	.021	.000	.902	.589	.000	.000		.041	.221	.222
	N	27	27	27	27	27	27	27	27	27	27

		mass	height	IC_DIST	IM_DIST	UMB_MT	ASIS_MT	TROC_MP	K_EXT	I_ROT	E_ROT
K_EXT	Pearson Correlation	.020	-.241	-.199	.414*	-.248	-.380	-.397*	1	-.043	-.054
	Sig. (2-tailed)	.921	.225	.319	.032	.213	.050	.041		.832	.791
	N	27	27	27	27	27	27	27	27	27	27
I_ROT	Pearson Correlation	-.329	-.334	-.189	.003	-.080	-.151	-.244	-.043	1	-.162
	Sig. (2-tailed)	.094	.088	.346	.988	.690	.452	.221	.832		.420
	N	27	27	27	27	27	27	27	27	27	27
E_ROT	Pearson Correlation	-.114	-.129	.011	-.229	-.169	-.241	-.243	-.054	-.162	1
	Sig. (2-tailed)	.572	.521	.956	.250	.400	.226	.222	.791	.420	
	N	27	27	27	27	27	27	27	27	27	27
ROM_ROT	Pearson Correlation	-.362	-.377	-.160	-.143	-.178	-.286	-.369	-.072	.781**	.490**
	Sig. (2-tailed)	.063	.053	.427	.478	.375	.148	.058	.723	.000	.010
	N	27	27	27	27	27	27	27	27	27	27
FEM_ANT	Pearson Correlation	-.388*	-.487**	-.176	-.133	-.392*	-.410*	-.322	.307	.238	.023
	Sig. (2-tailed)	.045	.010	.381	.508	.043	.034	.101	.120	.231	.911
	N	27	27	27	27	27	27	27	27	27	27
TI_TORS	Pearson Correlation	-.005	.252	.294	-.219	.371	.227	.292	.010	-.183	.116
	Sig. (2-tailed)	.982	.205	.137	.273	.056	.255	.139	.961	.362	.564
	N	27	27	27	27	27	27	27	27	27	27
cadence#1	Pearson Correlation	.099	.094	-.219	.255	.219	.055	.243	.065	-.044	-.165
	Sig. (2-tailed)	.623	.640	.272	.200	.272	.784	.221	.747	.827	.411
	N	27	27	27	27	27	27	27	27	27	27
speed#1	Pearson Correlation	.511**	.622**	-.206	.195	.586**	.488**	.536**	-.222	-.206	-.142
	Sig. (2-tailed)	.006	.001	.303	.330	.001	.010	.004	.265	.303	.478
	N	27	27	27	27	27	27	27	27	27	27
mean_L_step_L_R	Pearson Correlation	.524**	.665**	-.119	.085	.560**	.542**	.494**	-.307	-.201	-.083
	Sig. (2-tailed)	.005	.000	.556	.675	.002	.003	.009	.120	.314	.682
	N	27	27	27	27	27	27	27	27	27	27

		mass	height	IC_DIST	IM_DIST	UMB_MT	ASIS_MT	TROC_MP	K_EXT	I_ROT	E_ROT
mean_StepFactor_L_R	Pearson Correlation	.304	.252	-.113	.026	.091	.048	-.087	-.106	-.057	.067
	Sig. (2-tailed)	.123	.204	.575	.899	.650	.812	.667	.597	.777	.738
	N	27	27	27	27	27	27	27	27	27	27
mean_Cycle_time_L_R	Pearson Correlation	-.110	-.087	.219	-.259	-.211	-.048	-.234	-.075	.023	.151
	Sig. (2-tailed)	.585	.668	.272	.193	.291	.813	.241	.709	.910	.454
	N	27	27	27	27	27	27	27	27	27	27
mean_dT_unipodal_L_R	Pearson Correlation	-.161	.047	.208	-.398*	-.121	-.011	-.024	-.285	-.084	-.154
	Sig. (2-tailed)	.422	.815	.298	.040	.546	.958	.907	.150	.675	.443
	N	27	27	27	27	27	27	27	27	27	27
Displace_CoM#1	Pearson Correlation	.255	.380	-.291	.116	.264	.302	.421*	-.117	-.305	-.081
	Sig. (2-tailed)	.199	.051	.141	.566	.183	.126	.029	.563	.122	.688
	N	27	27	27	27	27	27	27	27	27	27
Rt_ASIS_Calc#1	Pearson Correlation	-.251	-.268	.086	-.257	-.291	-.214	-.293	.202	-.013	-.069
	Sig. (2-tailed)	.206	.177	.671	.195	.141	.284	.138	.313	.947	.732
	N	27	27	27	27	27	27	27	27	27	27
mean_t_LR_L_R	Pearson Correlation	.167	-.108	-.267	.239	-.052	-.075	-.228	.277	.027	.185
	Sig. (2-tailed)	.406	.593	.178	.231	.796	.710	.252	.161	.894	.356
	N	27	27	27	27	27	27	27	27	27	27
mean_t_Mid_St_L_R	Pearson Correlation	.409*	.002	-.440*	.599**	.010	-.091	-.155	.441*	-.073	.208
	Sig. (2-tailed)	.034	.993	.022	.001	.960	.652	.441	.021	.717	.297
	N	27	27	27	27	27	27	27	27	27	27
mean_t_TST_L_R	Pearson Correlation	.244	.311	-.093	.065	.216	.057	.015	.127	.012	.385*
	Sig. (2-tailed)	.220	.114	.645	.746	.279	.777	.939	.529	.953	.048
	N	27	27	27	27	27	27	27	27	27	27
mean_t_PSw_L_R	Pearson Correlation	.031	.148	.373	-.130	.082	.004	.142	-.008	-.117	.005
	Sig. (2-tailed)	.879	.462	.056	.519	.683	.983	.481	.967	.560	.979
	N	27	27	27	27	27	27	27	27	27	27

		mass	height	IC_DIST	IM_DIST	UMB_MT	ASIS_MT	TROC_MP	K_EXT	I_ROT	E_ROT
t_L_Init_Sw#1	Pearson Correlation	.335	-.065	-.511**	.509**	-.047	-.198	-.250	.436*	-.009	.277
	Sig. (2-tailed)	.088	.746	.006	.007	.817	.323	.209	.023	.965	.162
	N	27	27	27	27	27	27	27	27	27	27
t_R_Init_Sw#1	Pearson Correlation	.295	.080	.121	.284	.031	-.024	-.072	.432*	-.147	.181
	Sig. (2-tailed)	.135	.691	.547	.152	.880	.907	.722	.024	.465	.367
	N	27	27	27	27	27	27	27	27	27	27
mean_t_Mid_Sw_L_R	Pearson Correlation	.291	.179	-.011	.295	.133	.108	.096	-.151	.046	.000
	Sig. (2-tailed)	.140	.371	.956	.136	.508	.592	.634	.452	.821	1.000
	N	27	27	27	27	27	27	27	27	27	27
mean_t_TSW_L_R	Pearson Correlation	.298	.213	-.171	.131	.025	-.007	-.108	.103	-.088	.075
	Sig. (2-tailed)	.131	.285	.395	.516	.900	.971	.593	.608	.661	.710
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_Pelvis_ROM_L_R	Pearson Correlation	-.089	-.187	.113	-.232	-.298	-.212	-.231	-.236	-.195	.406*
	Sig. (2-tailed)	.657	.350	.573	.244	.132	.288	.246	.236	.329	.035
	N	27	27	27	27	27	27	27	27	27	27
mean_PELVIS_Sag_MedV_L_R	Pearson Correlation	.010	.207	-.024	-.090	.156	.211	.249	-.212	.004	-.164
	Sig. (2-tailed)	.962	.301	.906	.657	.438	.291	.210	.289	.984	.413
	N	27	27	27	27	27	27	27	27	27	27
mean_PELVIS_Trans_MedV_L_R	Pearson Correlation	.216	.154	-.260	.195	.174	.006	-.056	-.241	.327	.212
	Sig. (2-tailed)	.279	.443	.190	.330	.385	.977	.780	.227	.096	.289
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_Hip_ndmax_ROM_L_R	Pearson Correlation	.095	.339	.101	-.037	.345	.458*	.459*	-.678**	.123	-.058
	Sig. (2-tailed)	.638	.084	.617	.855	.078	.016	.016	.000	.540	.774
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_ndMax_HipA_L_R	Pearson Correlation	-.103	.053	-.068	-.148	.039	.119	.093	-.175	.167	.052
	Sig. (2-tailed)	.609	.794	.737	.461	.848	.555	.645	.381	.406	.795
	N	27	27	27	27	27	27	27	27	27	27

		mass	height	IC_DIST	IM_DIST	UMB_MT	ASIS_MT	TROC_MP	K_EXT	I_ROT	E_ROT
mean_Sag_t_ndMax_HipA_L_R	Pearson Correlation	.487**	.462*	-.149	.393*	.461*	.469*	.422*	.008	-.124	-.148
	Sig. (2-tailed)	.010	.015	.458	.043	.015	.014	.028	.970	.537	.462
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_Min_HipA_L_R	Pearson Correlation	.197	.148	-.102	.163	.101	-.008	-.078	-.079	.274	.144
	Sig. (2-tailed)	.325	.461	.612	.418	.617	.967	.698	.696	.167	.475
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_t_Min_HipA_L_R	Pearson Correlation	-.057	-.148	.040	.141	-.120	-.042	-.238	.067	.177	.232
	Sig. (2-tailed)	.779	.461	.845	.482	.553	.835	.232	.740	.377	.243
	N	27	27	27	27	27	27	27	27	27	27
mean_Trans_MedV_Hip_STph_L_R	Pearson Correlation	-.464*	-.140	.264	-.470*	-.084	-.102	.054	-.068	.158	-.167
	Sig. (2-tailed)	.015	.485	.182	.013	.678	.614	.788	.737	.430	.406
	N	27	27	27	27	27	27	27	27	27	27
mean_Front_Max_Hip_SWph_L_R	Pearson Correlation	-.034	-.004	-.126	.218	.130	.097	.121	.229	.330	-.490**
	Sig. (2-tailed)	.868	.985	.531	.274	.517	.632	.547	.251	.093	.009
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_Knee_stminROM_L_R	Pearson Correlation	-.007	-.212	.002	-.103	-.355	-.409*	-.581**	-.024	.149	.431*
	Sig. (2-tailed)	.972	.288	.992	.611	.069	.034	.001	.905	.459	.025
	N	27	27	27	27	27	27	27	27	27	27
Sag_Max_stLKneeA#1	Pearson Correlation	.188	.191	-.087	.200	.145	.171	.141	-.056	.109	-.166
	Sig. (2-tailed)	.347	.340	.664	.318	.469	.393	.483	.783	.588	.407
	N	27	27	27	27	27	27	27	27	27	27
Sag_Max_ndLKneeA#1	Pearson Correlation	-.045	-.137	.036	-.037	-.251	-.222	-.366	.011	.130	.319
	Sig. (2-tailed)	.825	.495	.860	.856	.206	.265	.060	.955	.517	.105
	N	27	27	27	27	27	27	27	27	27	27
Sag_Max_stRKneeA#1	Pearson Correlation	.062	.103	-.124	.084	.044	.075	.019	-.012	.126	.098
	Sig. (2-tailed)	.758	.609	.538	.678	.828	.710	.924	.952	.531	.628
	N	27	27	27	27	27	27	27	27	27	27

		mass	height	IC_DIST	IM_DIST	UMB_MT	ASIS_MT	TROC_MP	K_EXT	I_ROT	E_ROT
Sag_Max_ndRKneeA#1	Pearson Correlation	-.210	-.327	-.010	-.170	-.318	-.300	-.453*	.090	.309	.256
	Sig. (2-tailed)	.293	.096	.961	.398	.106	.128	.018	.654	.116	.197
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_t_Max_stKneeA_L_R	Pearson Correlation	-.073	.012	-.027	-.178	.021	-.027	.014	-.109	.256	-.282
	Sig. (2-tailed)	.719	.954	.893	.374	.916	.895	.944	.588	.198	.154
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_t_Max_ndKneeA_L_R	Pearson Correlation	.083	-.066	.123	.110	-.094	-.134	-.238	.062	.159	.501**
	Sig. (2-tailed)	.682	.744	.542	.584	.642	.506	.231	.758	.427	.008
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_Min_ndKneeA_L_R	Pearson Correlation	-.077	-.165	.058	.142	-.188	-.123	-.246	-.038	.288	-.004
	Sig. (2-tailed)	.704	.410	.773	.480	.347	.542	.216	.849	.145	.985
	N	27	27	27	27	27	27	27	27	27	27
Sag_t_Min_ndLKneeA#1	Pearson Correlation	.134	.095	-.276	.318	.210	.206	.085	.073	-.008	.199
	Sig. (2-tailed)	.506	.636	.164	.105	.294	.302	.675	.717	.967	.319
	N	27	27	27	27	27	27	27	27	27	27
Sag_t_Min_ndRKneeA#1	Pearson Correlation	-.102	-.005	.187	.028	.056	.117	.084	.019	-.199	.204
	Sig. (2-tailed)	.614	.978	.350	.892	.782	.560	.677	.924	.320	.307
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_KneeA_CI_L_R	Pearson Correlation	-.118	.005	.041	.009	.115	.196	.229	.098	.056	-.159
	Sig. (2-tailed)	.558	.981	.840	.965	.567	.327	.250	.628	.781	.427
	N	27	27	27	27	27	27	27	27	27	27

		mass	height	IC_DIST	IM_DIST	UMB_MT	ASIS_MT	TROC_MP	K_EXT	I_ROT	E_ROT
Sag_LTT_ROM#1	Pearson Correlation	-.036	-.059	-.017	-.263	-.174	-.068	-.167	-.132	.082	-.150
	Sig. (2-tailed)	.860	.769	.933	.185	.384	.738	.406	.510	.683	.455
	N	27	27	27	27	27	27	27	27	27	27
Sag_RTT_ROM#1	Pearson Correlation	-.119	-.150	-.093	-.363	-.129	-.044	-.200	-.254	.314	-.055
	Sig. (2-tailed)	.553	.456	.645	.063	.522	.826	.317	.201	.111	.785
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_STph_L_R	Pearson Correlation	-.152	-.137	-.127	-.036	-.167	-.039	-.082	.062	-.002	-.002
	Sig. (2-tailed)	.451	.496	.529	.859	.404	.846	.686	.759	.994	.991
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_SWph_L_R	Pearson Correlation	.326	.141	-.049	.409*	-.012	-.004	-.071	.339	-.321	.001
	Sig. (2-tailed)	.097	.482	.808	.034	.954	.985	.723	.083	.102	.997
	N	27	27	27	27	27	27	27	27	27	27
mean_FPA_MedV_STph_L_R	Pearson Correlation	-.078	.042	-.019	-.169	.057	.131	.109	.077	-.162	.079
	Sig. (2-tailed)	.700	.835	.927	.400	.779	.515	.590	.702	.420	.697
	N	27	27	27	27	27	27	27	27	27	27

		ROM_ROT	FEM_ANT	TI_TORS	cadence#1	Speed#1	mean_L_step_L_R	mean_StepFactor_L_R	mean_Cycle_time_L_R	mean_dT_unipodal_L_R	Displace_CoM#1
mass	Pearson Correlation	-.362	-.388*	-.005	.099	.511**	.524**	.304	-.110	-.161	.255
	Sig. (2-tailed)	.063	.045	.982	.623	.006	.005	.123	.585	.422	.199
	N	27	27	27	27	27	27	27	27	27	27
height	Pearson Correlation	-.377	-.487**	.252	.094	.622**	.665**	.252	-.087	.047	.380
	Sig. (2-tailed)	.053	.010	.205	.640	.001	.000	.204	.668	.815	.051
	N	27	27	27	27	27	27	27	27	27	27
IC_DIST	Pearson Correlation	-.160	-.176	.294	-.219	-.206	-.119	-.113	.219	.208	-.291
	Sig. (2-tailed)	.427	.381	.137	.272	.303	.556	.575	.272	.298	.141
	N	27	27	27	27	27	27	27	27	27	27
IM_DIST	Pearson Correlation	-.143	-.133	-.219	.255	.195	.085	.026	-.259	-.398*	.116
	Sig. (2-tailed)	.478	.508	.273	.200	.330	.675	.899	.193	.040	.566
	N	27	27	27	27	27	27	27	27	27	27
UMB_MT	Pearson Correlation	-.178	-.392*	.371	.219	.586**	.560**	.091	-.211	-.121	.264
	Sig. (2-tailed)	.375	.043	.056	.272	.001	.002	.650	.291	.546	.183
	N	27	27	27	27	27	27	27	27	27	27
ASIS_MT	Pearson Correlation	-.286	-.410*	.227	.055	.488**	.542**	.048	-.048	-.011	.302
	Sig. (2-tailed)	.148	.034	.255	.784	.010	.003	.812	.813	.958	.126
	N	27	27	27	27	27	27	27	27	27	27
TROC_MP	Pearson Correlation	-.369	-.322	.292	.243	.536**	.494**	-.087	-.234	-.024	.421*
	Sig. (2-tailed)	.058	.101	.139	.221	.004	.009	.667	.241	.907	.029
	N	27	27	27	27	27	27	27	27	27	27
K_EXT	Pearson Correlation	-.072	.307	.010	.065	-.222	-.307	-.106	-.075	-.285	-.117
	Sig. (2-tailed)	.723	.120	.961	.747	.265	.120	.597	.709	.150	.563
	N	27	27	27	27	27	27	27	27	27	27
I_ROT	Pearson Correlation	.781**	.238	-.183	-.044	-.206	-.201	-.057	.023	-.084	-.305
	Sig. (2-tailed)	.000	.231	.362	.827	.303	.314	.777	.910	.675	.122
	N	27	27	27	27	27	27	27	27	27	27

		ROM_ ROT	FEM_ ANT	TI_ TORS	cadenc e#1	Speed #1	mean_L_ste p_L_R	mean_Step Factor_L_ R	mean_Cy cle_time_ L_R	mean_dT_ unipodal_L _R	Displace_C oM#1
E_ROT	Pearson Correlation	.490**	.023	.116	-.165	-.142	-.083	.067	.151	-.154	-.081
	Sig. (2-tailed)	.010	.911	.564	.411	.478	.682	.738	.454	.443	.688
	N	27	27	27	27	27	27	27	27	27	27
ROM_ROT	Pearson Correlation	1	.225	-.088	-.143	-.272	-.230	-.008	.115	-.172	-.320
	Sig. (2-tailed)		.259	.663	.476	.170	.248	.969	.567	.391	.103
	N	27	27	27	27	27	27	27	27	27	27
FEM_ANT	Pearson Correlation	.225	1	-.054	-.178	-.295	-.254	-.087	.160	-.117	.103
	Sig. (2-tailed)	.259		.789	.375	.136	.201	.666	.425	.560	.609
	N	27	27	27	27	27	27	27	27	27	27
TI_TORS	Pearson Correlation	-.088	-.054	1	.178	.244	.185	.032	-.164	.045	-.055
	Sig. (2-tailed)	.663	.789		.375	.220	.356	.876	.415	.823	.786
	N	27	27	27	27	27	27	27	27	27	27
cadence#1	Pearson Correlation	-.143	-.178	.178	1	.517**	.051	-.109	-.996**	.050	.064
	Sig. (2-tailed)	.476	.375	.375		.006	.801	.589	.000	.806	.753
	N	27	27	27	27	27	27	27	27	27	27
speed#1	Pearson Correlation	-.272	-.295	.244	.517**	1	.879**	.652**	-.509**	.369	.589**
	Sig. (2-tailed)	.170	.136	.220	.006		.000	.000	.007	.058	.001
	N	27	27	27	27	27	27	27	27	27	27
mean_L_step_L_ R	Pearson Correlation	-.230	-.254	.185	.051	.879**	1	.823**	-.042	.408*	.649**
	Sig. (2-tailed)	.248	.201	.356	.801	.000		.000	.835	.035	.000
	N	27	27	27	27	27	27	27	27	27	27
mean_StepFactor _L_R	Pearson Correlation	-.008	-.087	.032	-.109	.652**	.823**	1	.113	.476*	.462*
	Sig. (2-tailed)	.969	.666	.876	.589	.000	.000		.574	.012	.015
	N	27	27	27	27	27	27	27	27	27	27
mean_Cycle_time _L_R	Pearson Correlation	.115	.160	-.164	-.996**	-.509**	-.042	.113	1	-.025	-.036
	Sig. (2-tailed)	.567	.425	.415	.000	.007	.835	.574		.903	.860
	N	27	27	27	27	27	27	27	27	27	27

		ROM_ ROT	FEM_ ANT	TI_ TORS	cadence#1	Speed #1	mean_L_step_L_R	mean_Step Factor_L_R	mean_Cycle_time_L_R	mean_dT_unipodal_L_R	Displace_CoM#1
mean_dT_unipodal_L_R	Pearson Correlation	-.172	-.117	.045	.050	.369	.408*	.476*	-.025	1	.234
	Sig. (2-tailed)	.391	.560	.823	.806	.058	.035	.012	.903		.239
	N	27	27	27	27	27	27	27	27	27	27
Displace_CoM#1	Pearson Correlation	-.320	.103	-.055	.064	.589**	.649**	.462*	-.036	.234	1
	Sig. (2-tailed)	.103	.609	.786	.753	.001	.000	.015	.860	.239	
	N	27	27	27	27	27	27	27	27	27	27
Rt_ASIS_Calc#1	Pearson Correlation	-.056	.239	.050	-.099	.038	.101	.299	.097	.338	-.092
	Sig. (2-tailed)	.783	.230	.803	.622	.851	.618	.130	.631	.085	.647
	N	27	27	27	27	27	27	27	27	27	27
mean_t_LR_L_R	Pearson Correlation	.141	.022	.111	-.163	-.122	-.066	.076	.138	-.271	-.309
	Sig. (2-tailed)	.483	.914	.580	.416	.545	.743	.705	.491	.171	.117
	N	27	27	27	27	27	27	27	27	27	27
mean_t_Mid_St_L_R	Pearson Correlation	.067	.107	-.183	-.032	-.240	-.286	-.234	.008	-.656**	-.106
	Sig. (2-tailed)	.739	.594	.360	.875	.229	.148	.240	.970	.000	.597
	N	27	27	27	27	27	27	27	27	27	27
mean_t_TST_L_R	Pearson Correlation	.254	-.186	.231	.119	.202	.169	.181	-.126	.028	.032
	Sig. (2-tailed)	.201	.354	.247	.555	.312	.400	.367	.532	.889	.875
	N	27	27	27	27	27	27	27	27	27	27
mean_t_PSw_L_R	Pearson Correlation	-.100	-.089	.235	-.117	-.007	.060	-.012	.086	-.066	-.097
	Sig. (2-tailed)	.618	.657	.239	.560	.970	.768	.952	.668	.744	.631
	N	27	27	27	27	27	27	27	27	27	27
t_L_Init_Sw#1	Pearson Correlation	.168	.064	-.247	-.053	-.272	-.303	-.188	.030	-.604**	-.224
	Sig. (2-tailed)	.404	.751	.215	.791	.171	.125	.348	.880	.001	.262
	N	27	27	27	27	27	27	27	27	27	27

		ROM_ ROT	FEM_ ANT	TI_ TORS	cadence#1	Speed #1	mean_L_step_L_R	mean_StepFactor_L_R	mean_Cycle_time_L_R	mean_dT_unipodal_L_R	Displace_CoM#1
t_R_Init_Sw#1	Pearson Correlation	-.015	.049	.196	-.032	-.143	-.151	-.131	-.001	-.515**	-.140
	Sig. (2-tailed)	.940	.809	.328	.873	.477	.453	.515	.995	.006	.487
	N	27	27	27	27	27	27	27	27	27	27
mean_t_Mid_Sw_L_R	Pearson Correlation	.040	.136	-.062	.159	.083	-.002	-.073	-.158	-.002	.174
	Sig. (2-tailed)	.842	.498	.757	.429	.681	.992	.719	.431	.993	.387
	N	27	27	27	27	27	27	27	27	27	27
mean_t_TSW_L_R	Pearson Correlation	-.031	-.113	.005	.135	.352	.322	.424*	-.128	.564**	.185
	Sig. (2-tailed)	.879	.575	.979	.502	.072	.102	.027	.525	.002	.355
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_Pelvis_ROM_L_R	Pearson Correlation	.084	.255	-.141	-.130	.055	.126	.295	.104	-.016	.138
	Sig. (2-tailed)	.676	.199	.484	.518	.785	.533	.136	.605	.935	.492
	N	27	27	27	27	27	27	27	27	27	27
mean_PELVIS_Sag_MedV_L_R	Pearson Correlation	-.100	-.170	-.123	-.333	-.096	.065	-.081	.360	.049	.330
	Sig. (2-tailed)	.619	.396	.542	.089	.634	.748	.687	.065	.807	.093
	N	27	27	27	27	27	27	27	27	27	27
mean_PELVIS_Trans_MedV_L_R	Pearson Correlation	.423*	-.175	-.202	.138	.158	.113	.172	-.160	-.055	-.164
	Sig. (2-tailed)	.028	.382	.311	.491	.432	.574	.390	.426	.785	.415
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_Hip_ndmax_ROM_L_R	Pearson Correlation	.072	-.202	.047	.012	.462*	.549**	.342	-.012	.245	.320
	Sig. (2-tailed)	.720	.313	.816	.951	.015	.003	.081	.954	.219	.104
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_ndMax_HipA_L_R	Pearson Correlation	.180	.000	-.120	-.250	.093	.244	.228	.254	.179	.310
	Sig. (2-tailed)	.368	1.000	.552	.209	.643	.219	.254	.200	.371	.116
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_t_ndMax_HipA_L_R	Pearson Correlation	-.203	-.182	.239	.062	.533**	.590**	.401*	-.058	.170	.446*
	Sig. (2-tailed)	.309	.365	.229	.759	.004	.001	.038	.773	.397	.020
	N	27	27	27	27	27	27	27	27	27	27

		ROM_ ROT	FEM_ ANT	TI_ TORS	cadenc e#1	Speed #1	mean_L_ste p_L_R	mean_Step Factor_L_ R	mean_Cy cle_time_ L_R	mean_dT_ unipodal_L _R	Displace_C oM#1
mean_Sag_Min_H ipA_L_R	Pearson Correlation	.333	-.164	-.331	-.240	-.272	-.198	-.167	.246	-.247	-.082
	Sig. (2-tailed)	.090	.413	.092	.228	.169	.321	.406	.216	.215	.686
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_t_Min _HipA_L_R	Pearson Correlation	.303	.224	-.106	-.703**	-.418*	-.102	.049	.694**	-.249	-.201
	Sig. (2-tailed)	.124	.262	.600	.000	.030	.613	.808	.000	.210	.315
	N	27	27	27	27	27	27	27	27	27	27
mean_Trans_Med V_Hip_STph_L_R	Pearson Correlation	.035	.087	.238	.098	.043	-.011	-.042	-.085	.268	.215
	Sig. (2-tailed)	.864	.667	.232	.627	.832	.957	.835	.673	.176	.282
	N	27	27	27	27	27	27	27	27	27	27
mean_Front_Max _Hip_SWph_L_R	Pearson Correlation	-.019	-.060	-.066	.485*	.009	-.253	-.375	-.479*	-.001	-.172
	Sig. (2-tailed)	.927	.765	.743	.010	.964	.202	.054	.011	.995	.390
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_Knee_ stminROM_L_R	Pearson Correlation	.404*	-.106	-.215	-.284	-.132	.009	.399*	.268	.003	-.318
	Sig. (2-tailed)	.037	.598	.281	.151	.513	.965	.039	.177	.987	.105
	N	27	27	27	27	27	27	27	27	27	27
Sag_Max_stLKne eA#1	Pearson Correlation	-.009	.243	-.031	.034	.410*	.458*	.433*	-.029	.310	.527**
	Sig. (2-tailed)	.966	.223	.879	.866	.034	.016	.024	.885	.116	.005
	N	27	27	27	27	27	27	27	27	27	27
Sag_Max_ndLKne eA#1	Pearson Correlation	.317	.058	-.164	-.166	.197	.330	.623**	.156	.260	.089
	Sig. (2-tailed)	.107	.775	.414	.408	.324	.093	.001	.437	.190	.658
	N	27	27	27	27	27	27	27	27	27	27
Sag_Max_stRKne eA#1	Pearson Correlation	.173	.344	-.075	-.073	.382*	.485*	.539**	.079	.296	.599**
	Sig. (2-tailed)	.388	.079	.709	.719	.049	.010	.004	.695	.133	.001
	N	27	27	27	27	27	27	27	27	27	27

		ROM_ ROT	FEM_ ANT	TI_ TORS	cadenc e#1	Speed #1	mean_L_ste p_L_R	mean_Step Factor_L_ R	mean_Cy cle_time_ L_R	mean_dT_ unipodal_L _R	Displace_C oM#1
Sag_Max_ndRKn eeA#1	Pearson Correlation	.435*	.333	-.023	-.197	-.007	.106	.424*	.180	.126	-.093
	Sig. (2-tailed)	.023	.090	.909	.325	.973	.600	.028	.370	.532	.645
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_t_Max _stKneeA_L_R	Pearson Correlation	.048	-.183	-.123	-.073	-.210	-.201	-.234	.076	.170	-.326
	Sig. (2-tailed)	.813	.361	.541	.718	.293	.315	.240	.706	.397	.097
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_t_Max _ndKneeA_L_R	Pearson Correlation	.458*	.080	.016	-.298	-.292	-.192	-.062	.249	-.369	-.356
	Sig. (2-tailed)	.016	.692	.938	.131	.139	.337	.758	.210	.058	.068
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_Min_n dKneeA_L_R	Pearson Correlation	.252	.117	-.252	-.112	-.222	-.195	-.055	.125	.147	-.100
	Sig. (2-tailed)	.204	.563	.204	.578	.266	.329	.787	.534	.465	.621
	N	27	27	27	27	27	27	27	27	27	27
Sag_t_Min_ndLKn eeA#1	Pearson Correlation	.119	.032	.201	-.027	.223	.292	.283	.046	-.025	.182
	Sig. (2-tailed)	.556	.872	.315	.894	.264	.140	.153	.822	.901	.363
	N	27	27	27	27	27	27	27	27	27	27
Sag_t_Min_ndRK neeA#1	Pearson Correlation	-.047	.027	.365	.124	.108	.068	.018	-.133	-.059	-.097
	Sig. (2-tailed)	.817	.896	.061	.539	.591	.737	.928	.508	.769	.629
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_Knee A_CI_L_R	Pearson Correlation	-.051	.324	.169	.153	.279	.240	.122	-.150	.202	.355
	Sig. (2-tailed)	.799	.099	.400	.446	.159	.229	.545	.456	.313	.069
	N	27	27	27	27	27	27	27	27	27	27
Sag_LTT_ROM#1	Pearson Correlation	-.022	.195	-.048	-.437*	.026	.290	.447*	.450*	.465*	.259
	Sig. (2-tailed)	.913	.329	.812	.023	.897	.143	.019	.019	.015	.191
	N	27	27	27	27	27	27	27	27	27	27

		ROM_ ROT	FEM_ ANT	TI_ TORS	cadence#1	Speed #1	mean_L_step_L_R	mean_StepFactor_L_R	mean_Cycle_time_L_R	mean_dT_unipodal_L_R	Displace_CoM#1
Sag_RTT_ROM#1	Pearson Correlation	.242	.384*	.048	-.181	.022	.126	.275	.173	.536**	-.082
	Sig. (2-tailed)	.223	.048	.812	.367	.914	.530	.165	.389	.004	.683
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_STph_L_R	Pearson Correlation	-.003	.064	-.135	-.451*	-.128	.105	.184	.458*	.169	.133
	Sig. (2-tailed)	.988	.750	.503	.018	.525	.604	.358	.016	.398	.508
	N	27	27	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_SWph_L_R	Pearson Correlation	-.283	.068	-.041	-.294	.148	.327	.420*	.290	.068	.212
	Sig. (2-tailed)	.152	.737	.838	.137	.460	.096	.029	.143	.737	.288
	N	27	27	27	27	27	27	27	27	27	27
mean_FPA_MedV_STph_L_R	Pearson Correlation	-.093	-.207	.148	-.290	-.255	-.141	-.227	.287	-.065	-.241
	Sig. (2-tailed)	.643	.300	.460	.142	.199	.484	.256	.146	.746	.227
	N	27	27	27	27	27	27	27	27	27	27

		Rt_ASIS_Calc#1	mean_t_LR_L_R	mean_t_Mid_St_L_R	mean_t_TST_L_R	mean_t_PSw_L_R	t_L_Init_Sw#1	t_R_Init_Sw#1	mean_t_Mid_Sw_L_R	mean_t_TSW_L_R
mass	Pearson Correlation	-.251	.167	.409*	.244	.031	.335	.295	.291	.298
	Sig. (2-tailed)	.206	.406	.034	.220	.879	.088	.135	.140	.131
	N	27	27	27	27	27	27	27	27	27
height	Pearson Correlation	-.268	-.108	.002	.311	.148	-.065	.080	.179	.213
	Sig. (2-tailed)	.177	.593	.993	.114	.462	.746	.691	.371	.285
	N	27	27	27	27	27	27	27	27	27
IC_DIST	Pearson Correlation	.086	-.267	-.440*	-.093	.373	-.511**	.121	-.011	-.171
	Sig. (2-tailed)	.671	.178	.022	.645	.056	.006	.547	.956	.395
	N	27	27	27	27	27	27	27	27	27
IM_DIST	Pearson Correlation	-.257	.239	.599**	.065	-.130	.509**	.284	.295	.131
	Sig. (2-tailed)	.195	.231	.001	.746	.519	.007	.152	.136	.516
	N	27	27	27	27	27	27	27	27	27
UMB_MT	Pearson Correlation	-.291	-.052	.010	.216	.082	-.047	.031	.133	.025
	Sig. (2-tailed)	.141	.796	.960	.279	.683	.817	.880	.508	.900
	N	27	27	27	27	27	27	27	27	27
ASIS_MT	Pearson Correlation	-.214	-.075	-.091	.057	.004	-.198	-.024	.108	-.007
	Sig. (2-tailed)	.284	.710	.652	.777	.983	.323	.907	.592	.971
	N	27	27	27	27	27	27	27	27	27
TROC_MP	Pearson Correlation	-.293	-.228	-.155	.015	.142	-.250	-.072	.096	-.108
	Sig. (2-tailed)	.138	.252	.441	.939	.481	.209	.722	.634	.593
	N	27	27	27	27	27	27	27	27	27

		Rt_ASIS_Calc#1	mean_t_LR_L_R	mean_t_Mid_St_L_R	mean_t_TST_L_R	mean_t_PSw_L_R	t_L_Init_Sw#1	t_R_Init_Sw#1	mean_t_Mid_Sw_L_R	mean_t_TSW_L_R
K_EXT	Pearson Correlation	.202	.277	.441*	.127	-.008	.436*	.432*	-.151	.103
	Sig. (2-tailed)	.313	.161	.021	.529	.967	.023	.024	.452	.608
	N	27	27	27	27	27	27	27	27	27
I_ROT	Pearson Correlation	-.013	.027	-.073	.012	-.117	-.009	-.147	.046	-.088
	Sig. (2-tailed)	.947	.894	.717	.953	.560	.965	.465	.821	.661
	N	27	27	27	27	27	27	27	27	27
E_ROT	Pearson Correlation	-.069	.185	.208	.385*	.005	.277	.181	.000	.075
	Sig. (2-tailed)	.732	.356	.297	.048	.979	.162	.367	1.000	.710
	N	27	27	27	27	27	27	27	27	27
ROM_ROT	Pearson Correlation	-.056	.141	.067	.254	-.100	.168	-.015	.040	-.031
	Sig. (2-tailed)	.783	.483	.739	.201	.618	.404	.940	.842	.879
	N	27	27	27	27	27	27	27	27	27
FEM_ANT	Pearson Correlation	.239	.022	.107	-.186	-.089	.064	.049	.136	-.113
	Sig. (2-tailed)	.230	.914	.594	.354	.657	.751	.809	.498	.575
	N	27	27	27	27	27	27	27	27	27
TI_TORS	Pearson Correlation	.050	.111	-.183	.231	.235	-.247	.196	-.062	.005
	Sig. (2-tailed)	.803	.580	.360	.247	.239	.215	.328	.757	.979
	N	27	27	27	27	27	27	27	27	27
cadence#1	Pearson Correlation	-.099	-.163	-.032	.119	-.117	-.053	-.032	.159	.135
	Sig. (2-tailed)	.622	.416	.875	.555	.560	.791	.873	.429	.502
	N	27	27	27	27	27	27	27	27	27
speed#1	Pearson Correlation	.038	-.122	-.240	.202	-.007	-.272	-.143	.083	.352
	Sig. (2-tailed)	.851	.545	.229	.312	.970	.171	.477	.681	.072
	N	27	27	27	27	27	27	27	27	27
mean_L_step_L_R	Pearson Correlation	.101	-.066	-.286	.169	.060	-.303	-.151	-.002	.322
	Sig. (2-tailed)	.618	.743	.148	.400	.768	.125	.453	.992	.102
	N	27	27	27	27	27	27	27	27	27

		Rt_ASIS_Calc#1	mean_t_LR_L_R	mean_t_Mid_St_L_R	mean_t_TST_L_R	mean_t_PSw_L_R	t_L_Init_Sw#1	t_R_Init_Sw#1	mean_t_Mid_Sw_L_R	mean_t_TSW_L_R
mean_StepFactor_L_R	Pearson Correlation	.299	.076	-.234	.181	-.012	-.188	-.131	-.073	.424*
	Sig. (2-tailed)	.130	.705	.240	.367	.952	.348	.515	.719	.027
	N	27	27	27	27	27	27	27	27	27
mean_Cycle_time_L_R	Pearson Correlation	.097	.138	.008	-.126	.086	.030	-.001	-.158	-.128
	Sig. (2-tailed)	.631	.491	.970	.532	.668	.880	.995	.431	.525
	N	27	27	27	27	27	27	27	27	27
mean_dT_unipodal_L_R	Pearson Correlation	.338	-.271	-.656**	.028	-.066	-.604**	-.515**	-.002	.564**
	Sig. (2-tailed)	.085	.171	.000	.889	.744	.001	.006	.993	.002
	N	27	27	27	27	27	27	27	27	27
Displace_CoM#1	Pearson Correlation	-.092	-.309	-.106	.032	-.097	-.224	-.140	.174	.185
	Sig. (2-tailed)	.647	.117	.597	.875	.631	.262	.487	.387	.355
	N	27	27	27	27	27	27	27	27	27
Rt_ASIS_Calc#1	Pearson Correlation	1	.365	-.105	.128	-.070	-.119	-.029	-.455*	.314
	Sig. (2-tailed)		.061	.604	.525	.728	.554	.884	.017	.111
	N	27	27	27	27	27	27	27	27	27
mean_t_LR_L_R	Pearson Correlation	.365	1	.509**	.215	.116	.486*	.392*	-.298	.148
	Sig. (2-tailed)	.061		.007	.282	.563	.010	.043	.131	.461
	N	27	27	27	27	27	27	27	27	27
mean_t_Mid_St_L_R	Pearson Correlation	-.105	.509**	1	.307	-.121	.882**	.554**	.228	.162
	Sig. (2-tailed)	.604	.007		.119	.548	.000	.003	.253	.420
	N	27	27	27	27	27	27	27	27	27
mean_t_TST_L_R	Pearson Correlation	.128	.215	.307	1	-.078	.300	.304	.081	.644**
	Sig. (2-tailed)	.525	.282	.119		.697	.129	.124	.687	.000
	N	27	27	27	27	27	27	27	27	27
mean_t_PSw_L_R	Pearson Correlation	-.070	.116	-.121	-.078	1	-.130	.366	-.260	-.332
	Sig. (2-tailed)	.728	.563	.548	.697		.517	.060	.190	.091
	N	27	27	27	27	27	27	27	27	27

		Rt_ASIS_Calc#1	mean_t_LR_L_R	mean_t_Mid_St_L_R	mean_t_TST_L_R	mean_t_PSw_L_R	t_L_Init_Sw#1	t_R_Init_Sw#1	mean_t_Mid_Sw_L_R	mean_t_TSW_L_R
t_L_Init_Sw#1	Pearson Correlation	-.119	.486*	.882**	.300	-.130	1	.392*	.013	.124
	Sig. (2-tailed)	.554	.010	.000	.129	.517		.043	.950	.536
	N	27	27	27	27	27	27	27	27	27
t_R_Init_Sw#1	Pearson Correlation	-.029	.392*	.554**	.304	.366	.392*	1	.199	-.025
	Sig. (2-tailed)	.884	.043	.003	.124	.060	.043		.319	.902
	N	27	27	27	27	27	27	27	27	27
mean_t_Mid_Sw_L_R	Pearson Correlation	-.455*	-.298	.228	.081	-.260	.013	.199	1	.287
	Sig. (2-tailed)	.017	.131	.253	.687	.190	.950	.319		.147
	N	27	27	27	27	27	27	27	27	27
mean_t_TSW_L_R	Pearson Correlation	.314	.148	.162	.644**	-.332	.124	-.025	.287	1
	Sig. (2-tailed)	.111	.461	.420	.000	.091	.536	.902	.147	
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Pelvis_ROM_L_R	Pearson Correlation	.360	.102	.054	.047	.080	-.046	.064	-.008	-.010
	Sig. (2-tailed)	.065	.612	.787	.816	.692	.820	.751	.970	.961
	N	27	27	27	27	27	27	27	27	27
mean_PELVIS_Sag_MedV_L_R	Pearson Correlation	-.317	-.134	-.103	-.077	.022	-.208	-.279	-.059	-.091
	Sig. (2-tailed)	.107	.507	.610	.701	.913	.298	.158	.771	.651
	N	27	27	27	27	27	27	27	27	27
mean_PELVIS_Trans_MedV_L_R	Pearson Correlation	-.080	.235	.205	.383*	.156	.312	.059	.167	.208
	Sig. (2-tailed)	.690	.239	.306	.048	.438	.113	.771	.406	.299
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Hip_ndmax_ROM_L_R	Pearson Correlation	-.123	-.069	-.412*	.029	.107	-.529**	-.233	.171	-.016
	Sig. (2-tailed)	.542	.731	.033	.887	.594	.005	.243	.393	.936
	N	27	27	27	27	27	27	27	27	27
mean_Sag_ndMax_HipA_L_R	Pearson Correlation	.015	.086	-.241	.022	.049	-.345	-.275	-.189	.000
	Sig. (2-tailed)	.940	.668	.225	.911	.807	.078	.165	.345	.999
	N	27	27	27	27	27	27	27	27	27

		Rt_ASIS_Calc#1	mean_t_LR_L_R	mean_t_Mid_St_L_R	mean_t_TST_L_R	mean_t_PSw_L_R	t_L_Init_Sw#1	t_R_Init_Sw#1	mean_t_Mid_Sw_L_R	mean_t_TSW_L_R
mean_Sag_t_ndMax_HipA_L_R	Pearson Correlation	.074	.072	.079	.118	.117	-.138	.176	.221	.325
	Sig. (2-tailed)	.715	.722	.695	.557	.562	.494	.380	.267	.098
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Min_HipA_L_R	Pearson Correlation	-.310	.145	.296	.295	-.177	.244	.055	.256	.115
	Sig. (2-tailed)	.116	.470	.134	.135	.376	.219	.785	.198	.569
	N	27	27	27	27	27	27	27	27	27
mean_Sag_t_Min_HipA_L_R	Pearson Correlation	.034	.337	.312	-.052	.017	.339	.109	.029	-.078
	Sig. (2-tailed)	.865	.086	.113	.796	.931	.083	.587	.886	.699
	N	27	27	27	27	27	27	27	27	27
mean_Trans_MedV_Hip_STph_L_R	Pearson Correlation	.002	-.399*	-.428*	-.016	.144	-.443*	-.355	-.264	-.090
	Sig. (2-tailed)	.993	.039	.026	.938	.474	.021	.069	.183	.655
	N	27	27	27	27	27	27	27	27	27
mean_Front_Max_Hip_SWph_L_R	Pearson Correlation	.087	-.178	.041	.125	-.274	.056	-.107	.071	.158
	Sig. (2-tailed)	.667	.373	.840	.536	.167	.781	.594	.725	.431
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Knee_stminROM_L_R	Pearson Correlation	.287	.333	.098	.338	-.128	.269	.082	-.213	.204
	Sig. (2-tailed)	.147	.090	.625	.085	.525	.174	.686	.286	.306
	N	27	27	27	27	27	27	27	27	27
Sag_Max_stLKneeA#1	Pearson Correlation	-.189	-.275	-.261	-.129	-.049	-.452*	-.133	.477*	.163
	Sig. (2-tailed)	.345	.166	.189	.520	.806	.018	.509	.012	.416
	N	27	27	27	27	27	27	27	27	27
Sag_Max_ndLKneeA#1	Pearson Correlation	.393*	.185	-.189	.201	-.071	-.194	-.033	-.116	.245
	Sig. (2-tailed)	.043	.354	.346	.315	.724	.333	.871	.563	.218
	N	27	27	27	27	27	27	27	27	27
Sag_Max_stRKneeA#1	Pearson Correlation	.007	-.144	-.169	.108	-.162	-.298	-.062	.400*	.293
	Sig. (2-tailed)	.974	.474	.400	.593	.420	.131	.758	.039	.139
	N	27	27	27	27	27	27	27	27	27

		Rt_ASIS_Calc#1	mean_t_LR_L_R	mean_t_Mid_St_L_R	mean_t_TST_L_R	mean_t_PSw_L_R	t_L_Init_Sw#1	t_R_Init_Sw#1	mean_t_Mid_Sw_L_R	mean_t_TSW_L_R
Sag_Max_ndRKneeA#1	Pearson Correlation	.337	.291	-.203	.060	-.109	-.175	-.011	-.133	.062
	Sig. (2-tailed)	.086	.141	.310	.767	.589	.382	.957	.510	.760
	N	27	27	27	27	27	27	27	27	27
mean_Sag_t_Max_stKneeA_L_R	Pearson Correlation	.102	.077	-.229	-.104	.034	-.026	-.238	-.229	-.019
	Sig. (2-tailed)	.614	.702	.251	.606	.866	.897	.232	.251	.923
	N	27	27	27	27	27	27	27	27	27
mean_Sag_t_Max_ndKneeA_L_R	Pearson Correlation	-.012	.393*	.500**	.465*	.087	.367	.427*	.214	.151
	Sig. (2-tailed)	.953	.042	.008	.015	.667	.060	.026	.284	.452
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Min_ndKneeA_L_R	Pearson Correlation	-.244	-.101	-.088	-.048	-.302	-.115	-.136	.483*	.165
	Sig. (2-tailed)	.219	.616	.661	.813	.126	.568	.499	.011	.412
	N	27	27	27	27	27	27	27	27	27
Sag_t_Min_ndLKneeA#1	Pearson Correlation	-.134	-.006	.048	-.001	-.184	-.027	-.090	.132	.034
	Sig. (2-tailed)	.504	.977	.812	.995	.359	.895	.655	.510	.868
	N	27	27	27	27	27	27	27	27	27
Sag_t_Min_ndRKneeA#1	Pearson Correlation	-.139	-.016	-.019	.034	.205	-.111	.143	.065	-.120
	Sig. (2-tailed)	.490	.938	.924	.867	.305	.583	.475	.746	.553
	N	27	27	27	27	27	27	27	27	27
mean_Sag_KneeA_CI_L_R	Pearson Correlation	.099	-.093	-.324	-.235	.069	-.520**	-.083	.109	-.062
	Sig. (2-tailed)	.624	.645	.099	.239	.733	.005	.680	.587	.757
	N	27	27	27	27	27	27	27	27	27

		Rt_ASIS_Calc#1	mean_t_LR_L_R	mean_t_Mid_St_L_R	mean_t_TST_L_R	mean_t_PSw_L_R	t_L_Init_Sw#1	t_R_Init_Sw#1	mean_t_Mid_Sw_L_R	mean_t_TSW_L_R
Sag_LTT_ROM#1	Pearson Correlation	.232	-.149	-.274	-.033	-.003	-.225	-.143	-.044	.258
	Sig. (2-tailed)	.244	.457	.166	.868	.989	.259	.476	.828	.193
	N	27	27	27	27	27	27	27	27	27
Sag_RTT_ROM#1	Pearson Correlation	.372	.149	-.224	.056	-.111	-.218	-.224	.146	.424*
	Sig. (2-tailed)	.056	.460	.262	.782	.581	.274	.262	.468	.028
	N	27	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_STph_L_R	Pearson Correlation	.131	.278	-.185	-.223	.181	-.089	-.272	-.435*	-.092
	Sig. (2-tailed)	.516	.161	.356	.263	.366	.661	.170	.023	.648
	N	27	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_SWph_L_R	Pearson Correlation	.025	.220	.073	-.168	.180	.042	.084	-.023	.082
	Sig. (2-tailed)	.903	.270	.717	.402	.369	.834	.678	.910	.683
	N	27	27	27	27	27	27	27	27	27
mean_FPA_MedV_STph_L_R	Pearson Correlation	.182	.435*	.011	.086	.239	.086	-.120	-.640**	-.109
	Sig. (2-tailed)	.364	.023	.958	.669	.230	.670	.550	.000	.589
	N	27	27	27	27	27	27	27	27	27

		mean_Sag_Pelvis_ROM_L_R	mean_PELVIS_Sag_MedV_L_R	mean_PELVIS_Trans_MedV_L_R	mean_Sag_Hip_ndmax_ROM_L_R	mean_Sag_ndMax_HipA_L_R	mean_Sag_t_ndMax_HipA_L_R	mean_Sag_Min_HipA_L_R	mean_Sag_t_Min_HipA_L_R	mean_Trans_MedV_Hip_STph_L_R
mass	Pearson Correlation	-.089	.010	.216	.095	-.103	.487**	.197	-.057	-.464*
	Sig. (2-tailed)	.657	.962	.279	.638	.609	.010	.325	.779	.015
	N	27	27	27	27	27	27	27	27	27
height	Pearson Correlation	-.187	.207	.154	.339	.053	.462*	.148	-.148	-.140
	Sig. (2-tailed)	.350	.301	.443	.084	.794	.015	.461	.461	.485
	N	27	27	27	27	27	27	27	27	27
IC_DIST	Pearson Correlation	.113	-.024	-.260	.101	-.068	-.149	-.102	.040	.264
	Sig. (2-tailed)	.573	.906	.190	.617	.737	.458	.612	.845	.182
	N	27	27	27	27	27	27	27	27	27
IM_DIST	Pearson Correlation	-.232	-.090	.195	-.037	-.148	.393*	.163	.141	-.470*
	Sig. (2-tailed)	.244	.657	.330	.855	.461	.043	.418	.482	.013
	N	27	27	27	27	27	27	27	27	27
UMB_MT	Pearson Correlation	-.298	.156	.174	.345	.039	.461*	.101	-.120	-.084
	Sig. (2-tailed)	.132	.438	.385	.078	.848	.015	.617	.553	.678
	N	27	27	27	27	27	27	27	27	27
ASIS_MT	Pearson Correlation	-.212	.211	.006	.458*	.119	.469*	-.008	-.042	-.102
	Sig. (2-tailed)	.288	.291	.977	.016	.555	.014	.967	.835	.614
	N	27	27	27	27	27	27	27	27	27
TROC_MP	Pearson Correlation	-.231	.249	-.056	.459*	.093	.422*	-.078	-.238	.054
	Sig. (2-tailed)	.246	.210	.780	.016	.645	.028	.698	.232	.788
	N	27	27	27	27	27	27	27	27	27

		mean_Sag_Pelvis_ROM_L_R	mean_PELVIS_Sag_MedV_L_R	mean_PELVIS_Trans_MedV_L_R	mean_Sag_Hip_ndmax_ROM_L_R	mean_Sag_ndMax_HipA_L_R	mean_Sag_t_ndMax_HipA_L_R	mean_Sag_Min_HipA_L_R	mean_Sag_t_Min_HipA_L_R	mean_Trans_MedV_Hip_STph_L_R
K_EXT	Pearson Correlation	-.236	-.212	-.241	-.678**	-.175	.008	-.079	.067	-.068
	Sig. (2-tailed)	.236	.289	.227	.000	.381	.970	.696	.740	.737
	N	27	27	27	27	27	27	27	27	27
I_ROT	Pearson Correlation	-.195	.004	.327	.123	.167	-.124	.274	.177	.158
	Sig. (2-tailed)	.329	.984	.096	.540	.406	.537	.167	.377	.430
	N	27	27	27	27	27	27	27	27	27
E_ROT	Pearson Correlation	.406*	-.164	.212	-.058	.052	-.148	.144	.232	-.167
	Sig. (2-tailed)	.035	.413	.289	.774	.795	.462	.475	.243	.406
	N	27	27	27	27	27	27	27	27	27
ROM_ROT	Pearson Correlation	.084	-.100	.423*	.072	.180	-.203	.333	.303	.035
	Sig. (2-tailed)	.676	.619	.028	.720	.368	.309	.090	.124	.864
	N	27	27	27	27	27	27	27	27	27
FEM_ANT	Pearson Correlation	.255	-.170	-.175	-.202	.000	-.182	-.164	.224	.087
	Sig. (2-tailed)	.199	.396	.382	.313	1.000	.365	.413	.262	.667
	N	27	27	27	27	27	27	27	27	27
TI_TORS	Pearson Correlation	-.141	-.123	-.202	.047	-.120	.239	-.331	-.106	.238
	Sig. (2-tailed)	.484	.542	.311	.816	.552	.229	.092	.600	.232
	N	27	27	27	27	27	27	27	27	27
cadence#1	Pearson Correlation	-.130	-.333	.138	.012	-.250	.062	-.240	-.703**	.098
	Sig. (2-tailed)	.518	.089	.491	.951	.209	.759	.228	.000	.627
	N	27	27	27	27	27	27	27	27	27
speed#1	Pearson Correlation	.055	-.096	.158	.462*	.093	.533**	-.272	-.418*	.043
	Sig. (2-tailed)	.785	.634	.432	.015	.643	.004	.169	.030	.832
	N	27	27	27	27	27	27	27	27	27
mean_L_step_L_R	Pearson Correlation	.126	.065	.113	.549**	.244	.590**	-.198	-.102	-.011
	Sig. (2-tailed)	.533	.748	.574	.003	.219	.001	.321	.613	.957
	N	27	27	27	27	27	27	27	27	27

		mean_Sag_Pelvis_ROM_L_R	mean_PELVIS_Sag_MedV_L_R	mean_PELVIS_Trans_MedV_L_R	mean_Sag_Hip_ndmax_ROM_L_R	mean_Sag_ndMax_HipA_L_R	mean_Sag_t_ndMax_HipA_L_R	mean_Sag_Min_HipA_L_R	mean_Sag_t_Min_HipA_L_R	mean_Trans_MedV_Hip_STph_L_R
mean_StepFactor_L_R	Pearson Correlation	.295	-.081	.172	.342	.228	.401*	-.167	.049	-.042
	Sig. (2-tailed)	.136	.687	.390	.081	.254	.038	.406	.808	.835
	N	27	27	27	27	27	27	27	27	27
mean_Cycle_time_L_R	Pearson Correlation	.104	.360	-.160	-.012	.254	-.058	.246	.694**	-.085
	Sig. (2-tailed)	.605	.065	.426	.954	.200	.773	.216	.000	.673
	N	27	27	27	27	27	27	27	27	27
mean_dT_unipodal_L_R	Pearson Correlation	-.016	.049	-.055	.245	.179	.170	-.247	-.249	.268
	Sig. (2-tailed)	.935	.807	.785	.219	.371	.397	.215	.210	.176
	N	27	27	27	27	27	27	27	27	27
Displace_CoM #1	Pearson Correlation	.138	.330	-.164	.320	.310	.446*	-.082	-.201	.215
	Sig. (2-tailed)	.492	.093	.415	.104	.116	.020	.686	.315	.282
	N	27	27	27	27	27	27	27	27	27
Rt_ASIS_Calc #1	Pearson Correlation	.360	-.317	-.080	-.123	.015	.074	-.310	.034	.002
	Sig. (2-tailed)	.065	.107	.690	.542	.940	.715	.116	.865	.993
	N	27	27	27	27	27	27	27	27	27
mean_t_LR_L_R	Pearson Correlation	.102	-.134	.235	-.069	.086	.072	.145	.337	-.399*
	Sig. (2-tailed)	.612	.507	.239	.731	.668	.722	.470	.086	.039
	N	27	27	27	27	27	27	27	27	27
mean_t_Mid_St_L_R	Pearson Correlation	.054	-.103	.205	-.412*	-.241	.079	.296	.312	-.428*
	Sig. (2-tailed)	.787	.610	.306	.033	.225	.695	.134	.113	.026
	N	27	27	27	27	27	27	27	27	27
mean_t_TST_L_R	Pearson Correlation	.047	-.077	.383*	.029	.022	.118	.295	-.052	-.016
	Sig. (2-tailed)	.816	.701	.048	.887	.911	.557	.135	.796	.938
	N	27	27	27	27	27	27	27	27	27
mean_t_PSw_L_R	Pearson Correlation	.080	.022	.156	.107	.049	.117	-.177	.017	.144
	Sig. (2-tailed)	.692	.913	.438	.594	.807	.562	.376	.931	.474
	N	27	27	27	27	27	27	27	27	27

		mean_Sag_Pelvis_ROM_L_R	mean_PELVIS_Sag_MedV_L_R	mean_PELVIS_Trans_MedV_L_R	mean_Sag_Hip_ndmax_ROM_L_R	mean_Sag_ndMax_HipA_L_R	mean_Sag_t_ndMax_HipA_L_R	mean_Sag_Min_HipA_L_R	mean_Sag_t_Min_HipA_L_R	mean_Trans_MedV_Hip_STph_L_R
t_L_Init_Sw#1	Pearson Correlation	-.046	-.208	.312	-.529**	-.345	-.138	.244	.339	-.443*
	Sig. (2-tailed)	.820	.298	.113	.005	.078	.494	.219	.083	.021
	N	27	27	27	27	27	27	27	27	27
t_R_Init_Sw#1	Pearson Correlation	.064	-.279	.059	-.233	-.275	.176	.055	.109	-.355
	Sig. (2-tailed)	.751	.158	.771	.243	.165	.380	.785	.587	.069
	N	27	27	27	27	27	27	27	27	27
mean_t_Mid_Sw_L_R	Pearson Correlation	-.008	-.059	.167	.171	-.189	.221	.256	.029	-.264
	Sig. (2-tailed)	.970	.771	.406	.393	.345	.267	.198	.886	.183
	N	27	27	27	27	27	27	27	27	27
mean_t_TSW_L_R	Pearson Correlation	-.010	-.091	.208	-.016	.000	.325	.115	-.078	-.090
	Sig. (2-tailed)	.961	.651	.299	.936	.999	.098	.569	.699	.655
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Pelvis_ROM_L_R	Pearson Correlation	1	-.280	.203	.196	.030	-.014	-.111	.161	-.040
	Sig. (2-tailed)		.158	.310	.327	.884	.946	.581	.423	.841
	N	27	27	27	27	27	27	27	27	27
mean_PELVIS_Sag_MedV_L_R	Pearson Correlation	-.280	1	-.321	.272	.737**	.132	.535**	.060	.382*
	Sig. (2-tailed)	.158		.102	.171	.000	.510	.004	.767	.049
	N	27	27	27	27	27	27	27	27	27
mean_PELVIS_Trans_MedV_L_R	Pearson Correlation	.203	-.321	1	.227	-.210	-.075	.240	.128	-.327
	Sig. (2-tailed)	.310	.102		.256	.293	.712	.228	.523	.096
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Hip_ndmax_ROM_L_R	Pearson Correlation	.196	.272	.227	1	.540**	.297	.122	.001	-.019
	Sig. (2-tailed)	.327	.171	.256		.004	.133	.544	.997	.927
	N	27	27	27	27	27	27	27	27	27
mean_Sag_ndMax_HipA_L_R	Pearson Correlation	.030	.737**	-.210	.540**	1	.189	.423*	.073	.281
	Sig. (2-tailed)	.884	.000	.293	.004		.344	.028	.716	.156
	N	27	27	27	27	27	27	27	27	27

		mean_Sag_Pelvis_ROM_L_R	mean_PELVIS_Sag_MedV_L_R	mean_PELVIS_Trans_MedV_L_R	mean_Sag_Hip_ndmax_ROM_L_R	mean_Sag_ndMax_HipA_L_R	mean_Sag_t_ndMax_HipA_L_R	mean_Sag_Min_HipA_L_R	mean_Sag_t_Min_HipA_L_R	mean_Trans_MedV_Hip_STph_L_R
mean_Sag_t_ndMax_HipA_L_R	Pearson Correlation	-.014	.132	-.075	.297	.189	1	-.104	.018	-.043
	Sig. (2-tailed)	.946	.510	.712	.133	.344		.607	.928	.829
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Min_HipA_L_R	Pearson Correlation	-.111	.535**	.240	.122	.423*	-.104	1	.200	-.116
	Sig. (2-tailed)	.581	.004	.228	.544	.028	.607		.318	.566
	N	27	27	27	27	27	27	27	27	27
mean_Sag_t_Min_HipA_L_R	Pearson Correlation	.161	.060	.128	.001	.073	.018	.200	1	-.292
	Sig. (2-tailed)	.423	.767	.523	.997	.716	.928	.318		.140
	N	27	27	27	27	27	27	27	27	27
mean_Trans_MedV_Hip_STph_L_R	Pearson Correlation	-.040	.382*	-.327	-.019	.281	-.043	-.116	-.292	1
	Sig. (2-tailed)	.841	.049	.096	.927	.156	.829	.566	.140	
	N	27	27	27	27	27	27	27	27	27
mean_Front_Max_Hip_SWph_L_R	Pearson Correlation	-.408*	-.244	.061	-.228	-.304	-.120	-.030	-.362	.105
	Sig. (2-tailed)	.035	.219	.762	.253	.123	.549	.882	.063	.604
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Knee_stminROM_L_R	Pearson Correlation	.359	-.233	.333	-.014	.045	-.347	.259	.260	-.366
	Sig. (2-tailed)	.066	.243	.089	.946	.824	.076	.192	.190	.061
	N	27	27	27	27	27	27	27	27	27
Sag_Max_stLKneeA#1	Pearson Correlation	.049	.222	-.142	.507**	.478*	.493**	.068	-.043	.077
	Sig. (2-tailed)	.807	.266	.480	.007	.012	.009	.736	.832	.702
	N	27	27	27	27	27	27	27	27	27
Sag_Max_ndLKneeA#1	Pearson Correlation	.460*	-.070	.074	.372	.514**	.124	.158	.171	-.162
	Sig. (2-tailed)	.016	.728	.714	.056	.006	.537	.432	.393	.420
	N	27	27	27	27	27	27	27	27	27
Sag_Max_stRKneeA#1	Pearson Correlation	.178	.149	-.027	.490**	.523**	.337	.124	.127	.002
	Sig. (2-tailed)	.374	.458	.894	.009	.005	.086	.539	.527	.991
	N	27	27	27	27	27	27	27	27	27

		mean_Sag_Pelvis_ROM_L_R	mean_PELVIS_Sag_MedV_L_R	mean_PELVIS_Trans_MedV_L_R	mean_Sag_Hip_ndmax_ROM_L_R	mean_Sag_ndMax_HipA_L_R	mean_Sag_t_ndMax_HipA_L_R	mean_Sag_Min_HipA_L_R	mean_Sag_t_Min_HipA_L_R	mean_Trans_MedV_Hip_STph_L_R
Sag_Max_ndRKneeA#1	Pearson Correlation	.294	-.075	-.068	.277	.514**	-.075	.137	.170	-.107
	Sig. (2-tailed)	.137	.709	.735	.162	.006	.710	.496	.398	.597
	N	27	27	27	27	27	27	27	27	27
mean_Sag_t_Max_stKneeA_L_R	Pearson Correlation	-.403*	.102	.159	-.098	-.044	-.305	.225	-.121	-.129
	Sig. (2-tailed)	.037	.612	.428	.625	.829	.122	.259	.546	.522
	N	27	27	27	27	27	27	27	27	27
mean_Sag_t_Max_ndKneeA_L_R	Pearson Correlation	.351	-.022	.279	.090	.119	.077	.371	.485*	-.203
	Sig. (2-tailed)	.073	.914	.159	.654	.555	.703	.057	.010	.309
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Min_ndKneeA_L_R	Pearson Correlation	-.080	.146	-.004	.226	.302	-.063	.512**	.250	-.148
	Sig. (2-tailed)	.691	.466	.984	.257	.126	.757	.006	.209	.461
	N	27	27	27	27	27	27	27	27	27
Sag_t_Min_ndLKneeA#1	Pearson Correlation	-.120	-.053	-.077	.206	.141	.422*	-.217	.180	-.205
	Sig. (2-tailed)	.553	.793	.703	.303	.484	.028	.277	.369	.306
	N	27	27	27	27	27	27	27	27	27
Sag_t_Min_ndRKneeA#1	Pearson Correlation	.064	-.160	-.057	.219	-.006	.072	-.439*	.185	-.025
	Sig. (2-tailed)	.752	.424	.777	.273	.975	.722	.022	.356	.903
	N	27	27	27	27	27	27	27	27	27
mean_Sag_KneeA_CI_L_R	Pearson Correlation	.017	.162	-.378	.383*	.524**	.444*	-.130	-.119	.255
	Sig. (2-tailed)	.932	.418	.052	.049	.005	.020	.519	.556	.199
	N	27	27	27	27	27	27	27	27	27

		mean_Sag_Pelvis_ROM_L_R	mean_PELVIS_Sag_MedV_L_R	mean_PELVIS_Trans_MedV_L_R	mean_Sag_Hip_ndmax_ROM_L_R	mean_Sag_ndMax_HipA_L_R	mean_Sag_t_ndMax_HipA_L_R	mean_Sag_Min_HipA_L_R	mean_Sag_t_Min_HipA_L_R	mean_Trans_MedV_Hip_STph_L_R
Sag_LTT_ROM#1	Pearson Correlation	.070	.225	-.252	.039	.217	.331	-.075	.127	.194
	Sig. (2-tailed)	.729	.260	.205	.845	.277	.091	.711	.527	.332
	N	27	27	27	27	27	27	27	27	27
Sag_RTT_ROM#1	Pearson Correlation	.155	-.103	.115	.165	.130	.119	-.056	.094	.021
	Sig. (2-tailed)	.442	.609	.569	.412	.517	.553	.781	.641	.916
	N	27	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_STph_L_R	Pearson Correlation	-.047	.488**	-.247	.227	.688**	.133	.119	.373	.053
	Sig. (2-tailed)	.817	.010	.214	.255	.000	.509	.553	.056	.793
	N	27	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_SWph_L_R	Pearson Correlation	.095	.142	-.205	.099	.299	.444*	-.016	.420*	-.248
	Sig. (2-tailed)	.636	.479	.305	.623	.130	.020	.936	.029	.211
	N	27	27	27	27	27	27	27	27	27
mean_FPA_MedV_STph_L_R	Pearson Correlation	-.168	.410*	-.197	.009	.439*	-.052	.110	.149	.071
	Sig. (2-tailed)	.401	.034	.324	.965	.022	.796	.586	.457	.724
	N	27	27	27	27	27	27	27	27	27

		mean_Front_Max_Hip_SWph_L_R	mean_Sag_Knee_stmin ROM_L_R	Sag_Max_stLKnee A#1	Sag_Max_ndLKneeA#1	Sag_Max_stRKneeA#1	Sag_Max_ndRKneeA#1	mean_Sag_t_Max_stKneeA_L_R	mean_Sag_t_Max_nd KneeA_L_R	mean_Sag_Min_nd KneeA_L_R
mass	Pearson Correlation	-.034	-.007	.188	-.045	.062	-.210	-.073	.083	-.077
	Sig. (2-tailed)	.868	.972	.347	.825	.758	.293	.719	.682	.704
	N	27	27	27	27	27	27	27	27	27
height	Pearson Correlation	-.004	-.212	.191	-.137	.103	-.327	.012	-.066	-.165
	Sig. (2-tailed)	.985	.288	.340	.495	.609	.096	.954	.744	.410
	N	27	27	27	27	27	27	27	27	27
IC_DIST	Pearson Correlation	-.126	.002	-.087	.036	-.124	-.010	-.027	.123	.058
	Sig. (2-tailed)	.531	.992	.664	.860	.538	.961	.893	.542	.773
	N	27	27	27	27	27	27	27	27	27
IM_DIST	Pearson Correlation	.218	-.103	.200	-.037	.084	-.170	-.178	.110	.142
	Sig. (2-tailed)	.274	.611	.318	.856	.678	.398	.374	.584	.480
	N	27	27	27	27	27	27	27	27	27
UMB_MT	Pearson Correlation	.130	-.355	.145	-.251	.044	-.318	.021	-.094	-.188
	Sig. (2-tailed)	.517	.069	.469	.206	.828	.106	.916	.642	.347
	N	27	27	27	27	27	27	27	27	27
ASIS_MT	Pearson Correlation	.097	-.409*	.171	-.222	.075	-.300	-.027	-.134	-.123
	Sig. (2-tailed)	.632	.034	.393	.265	.710	.128	.895	.506	.542
	N	27	27	27	27	27	27	27	27	27
TROC_MP	Pearson Correlation	.121	-.581**	.141	-.366	.019	-.453*	.014	-.238	-.246
	Sig. (2-tailed)	.547	.001	.483	.060	.924	.018	.944	.231	.216
	N	27	27	27	27	27	27	27	27	27

		mean_Front_Max_Hip_SWph_L_R	mean_Sag_Knee_stminROM_L_R	Sag_Max_stLKneeA#1	Sag_Max_ndLKneeA#1	Sag_Max_stRKneeA#1	Sag_Max_ndRKneeA#1	mean_Sag_t_Max_stKneeA_L_R	mean_Sag_t_Max_ndKneeA_L_R	mean_Sag_Min_ndKneeA_L_R
K_EXT	Pearson Correlation	.229	-.024	-.056	.011	-.012	.090	-.109	.062	-.038
	Sig. (2-tailed)	.251	.905	.783	.955	.952	.654	.588	.758	.849
	N	27	27	27	27	27	27	27	27	27
I_ROT	Pearson Correlation	.330	.149	.109	.130	.126	.309	.256	.159	.288
	Sig. (2-tailed)	.093	.459	.588	.517	.531	.116	.198	.427	.145
	N	27	27	27	27	27	27	27	27	27
E_ROT	Pearson Correlation	-.490**	.431*	-.166	.319	.098	.256	-.282	.501**	-.004
	Sig. (2-tailed)	.009	.025	.407	.105	.628	.197	.154	.008	.985
	N	27	27	27	27	27	27	27	27	27
ROM_ROT	Pearson Correlation	-.019	.404*	-.009	.317	.173	.435*	.048	.458*	.252
	Sig. (2-tailed)	.927	.037	.966	.107	.388	.023	.813	.016	.204
	N	27	27	27	27	27	27	27	27	27
FEM_ANT	Pearson Correlation	-.060	-.106	.243	.058	.344	.333	-.183	.080	.117
	Sig. (2-tailed)	.765	.598	.223	.775	.079	.090	.361	.692	.563
	N	27	27	27	27	27	27	27	27	27
TI_TORS	Pearson Correlation	-.066	-.215	-.031	-.164	-.075	-.023	-.123	.016	-.252
	Sig. (2-tailed)	.743	.281	.879	.414	.709	.909	.541	.938	.204
	N	27	27	27	27	27	27	27	27	27
cadence#1	Pearson Correlation	.485*	-.284	.034	-.166	-.073	-.197	-.073	-.298	-.112
	Sig. (2-tailed)	.010	.151	.866	.408	.719	.325	.718	.131	.578
	N	27	27	27	27	27	27	27	27	27
speed#1	Pearson Correlation	.009	-.132	.410*	.197	.382*	-.007	-.210	-.292	-.222
	Sig. (2-tailed)	.964	.513	.034	.324	.049	.973	.293	.139	.266
	N	27	27	27	27	27	27	27	27	27
mean_L_step_L_R	Pearson Correlation	-.253	.009	.458*	.330	.485*	.106	-.201	-.192	-.195
	Sig. (2-tailed)	.202	.965	.016	.093	.010	.600	.315	.337	.329
	N	27	27	27	27	27	27	27	27	27

		mean_Front_Max_Hip_SWph_L_R	mean_Sag_Knee_stminROM_L_R	Sag_Max_stLKneeA#1	Sag_Max_ndLKneeA#1	Sag_Max_stRKneeA#1	Sag_Max_ndRKneeA#1	mean_Sag_t_Max_stKneeA_L_R	mean_Sag_t_Max_ndKneeA_L_R	mean_Sag_Min_ndKneeA_L_R
mean_StepFactor_L_R	Pearson Correlation	-.375	.399*	.433*	.623**	.539**	.424*	-.234	-.062	-.055
	Sig. (2-tailed)	.054	.039	.024	.001	.004	.028	.240	.758	.787
	N	27	27	27	27	27	27	27	27	27
mean_Cycle_time_L_R	Pearson Correlation	-.479*	.268	-.029	.156	.079	.180	.076	.249	.125
	Sig. (2-tailed)	.011	.177	.885	.437	.695	.370	.706	.210	.534
	N	27	27	27	27	27	27	27	27	27
mean_dT_unipodal_L_R	Pearson Correlation	-.001	.003	.310	.260	.296	.126	.170	-.369	.147
	Sig. (2-tailed)	.995	.987	.116	.190	.133	.532	.397	.058	.465
	N	27	27	27	27	27	27	27	27	27
Displace_CoM#1	Pearson Correlation	-.172	-.318	.527**	.089	.599**	-.093	-.326	-.356	-.100
	Sig. (2-tailed)	.390	.105	.005	.658	.001	.645	.097	.068	.621
	N	27	27	27	27	27	27	27	27	27
Rt_ASIS_Calc#1	Pearson Correlation	.087	.287	-.189	.393*	.007	.337	.102	-.012	-.244
	Sig. (2-tailed)	.667	.147	.345	.043	.974	.086	.614	.953	.219
	N	27	27	27	27	27	27	27	27	27
mean_t_LR_L_R	Pearson Correlation	-.178	.333	-.275	.185	-.144	.291	.077	.393*	-.101
	Sig. (2-tailed)	.373	.090	.166	.354	.474	.141	.702	.042	.616
	N	27	27	27	27	27	27	27	27	27
mean_t_Mid_St_L_R	Pearson Correlation	.041	.098	-.261	-.189	-.169	-.203	-.229	.500**	-.088
	Sig. (2-tailed)	.840	.625	.189	.346	.400	.310	.251	.008	.661
	N	27	27	27	27	27	27	27	27	27
mean_t_TST_L_R	Pearson Correlation	.125	.338	-.129	.201	.108	.060	-.104	.465*	-.048
	Sig. (2-tailed)	.536	.085	.520	.315	.593	.767	.606	.015	.813
	N	27	27	27	27	27	27	27	27	27
mean_t_PSw_L_R	Pearson Correlation	-.274	-.128	-.049	-.071	-.162	-.109	.034	.087	-.302
	Sig. (2-tailed)	.167	.525	.806	.724	.420	.589	.866	.667	.126
	N	27	27	27	27	27	27	27	27	27

		mean_Front_Max_Hip_SWph_L_R	mean_Sag_Knee_stminROM_L_R	Sag_Max_stLKneeA#1	Sag_Max_ndLKneeA#1	Sag_Max_stRKneeA#1	Sag_Max_ndRKneeA#1	mean_Sag_t_Max_stKneeA_L_R	mean_Sag_t_Max_ndKneeA_L_R	mean_Sag_Min_ndKneeA_L_R
t_L_Init_Sw#1	Pearson Correlation	.056	.269	-.452*	-.194	-.298	-.175	-.026	.367	-.115
	Sig. (2-tailed)	.781	.174	.018	.333	.131	.382	.897	.060	.568
	N	27	27	27	27	27	27	27	27	27
t_R_Init_Sw#1	Pearson Correlation	-.107	.082	-.133	-.033	-.062	-.011	-.238	.427*	-.136
	Sig. (2-tailed)	.594	.686	.509	.871	.758	.957	.232	.026	.499
	N	27	27	27	27	27	27	27	27	27
mean_t_Mid_Sw_L_R	Pearson Correlation	.071	-.213	.477*	-.116	.400*	-.133	-.229	.214	.483*
	Sig. (2-tailed)	.725	.286	.012	.563	.039	.510	.251	.284	.011
	N	27	27	27	27	27	27	27	27	27
mean_t_TSW_L_R	Pearson Correlation	.158	.204	.163	.245	.293	.062	-.019	.151	.165
	Sig. (2-tailed)	.431	.306	.416	.218	.139	.760	.923	.452	.412
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Pelvis_ROM_L_R	Pearson Correlation	-.408*	.359	.049	.460*	.178	.294	-.403*	.351	-.080
	Sig. (2-tailed)	.035	.066	.807	.016	.374	.137	.037	.073	.691
	N	27	27	27	27	27	27	27	27	27
mean_PELVIS_Sag_MedV_L_R	Pearson Correlation	-.244	-.233	.222	-.070	.149	-.075	.102	-.022	.146
	Sig. (2-tailed)	.219	.243	.266	.728	.458	.709	.612	.914	.466
	N	27	27	27	27	27	27	27	27	27
mean_PELVIS_Trans_MedV_L_R	Pearson Correlation	.061	.333	-.142	.074	-.027	-.068	.159	.279	-.004
	Sig. (2-tailed)	.762	.089	.480	.714	.894	.735	.428	.159	.984
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Hip_ndmax_ROM_L_R	Pearson Correlation	-.228	-.014	.507**	.372	.490**	.277	-.098	.090	.226
	Sig. (2-tailed)	.253	.946	.007	.056	.009	.162	.625	.654	.257
	N	27	27	27	27	27	27	27	27	27
mean_Sag_ndMax_HipA_L_R	Pearson Correlation	-.304	.045	.478*	.514**	.523**	.514**	-.044	.119	.302
	Sig. (2-tailed)	.123	.824	.012	.006	.005	.006	.829	.555	.126
	N	27	27	27	27	27	27	27	27	27

		mean_Front_Max_Hip_SWph_L_R	mean_Sag_Knee_stminROM_L_R	Sag_Max_stLKneeA#1	Sag_Max_ndLKneeA#1	Sag_Max_stRKneeA#1	Sag_Max_ndRKneeA#1	mean_Sag_t_Max_stKneeA_L_R	mean_Sag_t_Max_ndKneeA_L_R	mean_Sag_Min_ndKneeA_L_R
mean_Sag_t_ndMax_HipA_L_R	Pearson Correlation	-.120	-.347	.493**	.124	.337	-.075	-.305	.077	-.063
	Sig. (2-tailed)	.549	.076	.009	.537	.086	.710	.122	.703	.757
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Min_HipA_L_R	Pearson Correlation	-.030	.259	.068	.158	.124	.137	.225	.371	.512**
	Sig. (2-tailed)	.882	.192	.736	.432	.539	.496	.259	.057	.006
	N	27	27	27	27	27	27	27	27	27
mean_Sag_t_Min_HipA_L_R	Pearson Correlation	-.362	.260	-.043	.171	.127	.170	-.121	.485*	.250
	Sig. (2-tailed)	.063	.190	.832	.393	.527	.398	.546	.010	.209
	N	27	27	27	27	27	27	27	27	27
mean_Trans_MedV_Hip_STph_L_R	Pearson Correlation	.105	-.366	.077	-.162	.002	-.107	-.129	-.203	-.148
	Sig. (2-tailed)	.604	.061	.702	.420	.991	.597	.522	.309	.461
	N	27	27	27	27	27	27	27	27	27
mean_Front_Max_Hip_SWph_L_R	Pearson Correlation	1	-.249	-.142	-.298	-.178	-.260	.356	-.319	.105
	Sig. (2-tailed)		.210	.481	.132	.375	.191	.069	.105	.604
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Knee_stminROM_L_R	Pearson Correlation	-.249	1	-.239	.644**	.009	.556**	.140	.346	.128
	Sig. (2-tailed)	.210		.231	.000	.964	.003	.487	.077	.525
	N	27	27	27	27	27	27	27	27	27
Sag_Max_stLKneeA#1	Pearson Correlation	-.142	-.239	1	.428*	.841**	.413*	-.374	-.063	.526**
	Sig. (2-tailed)	.481	.231		.026	.000	.032	.055	.755	.005
	N	27	27	27	27	27	27	27	27	27
Sag_Max_ndLKneeA#1	Pearson Correlation	-.298	.644**	.428*	1	.598**	.858**	-.201	.245	.389*
	Sig. (2-tailed)	.132	.000	.026		.001	.000	.314	.217	.045
	N	27	27	27	27	27	27	27	27	27
Sag_Max_stRKneeA#1	Pearson Correlation	-.178	.009	.841**	.598**	1	.554**	-.359	.037	.486*
	Sig. (2-tailed)	.375	.964	.000	.001		.003	.066	.856	.010
	N	27	27	27	27	27	27	27	27	27

		mean_Front_Max_Hip_SWph_L_R	mean_Sag_Knee_stminROM_L_R	Sag_Max_stLKneeA#1	Sag_Max_ndLKneeA#1	Sag_Max_stRKneeA#1	Sag_Max_ndRKneeA#1	mean_Sag_t_Max_stKneeA_L_R	mean_Sag_t_Max_ndKneeA_L_R	mean_Sag_Min_ndKneeA_L_R
Sag_Max_ndRKneeA#1	Pearson Correlation	-.260	.556**	.413*	.858**	.554**	1	-.112	.230	.455*
	Sig. (2-tailed)	.191	.003	.032	.000	.003		.579	.249	.017
	N	27	27	27	27	27	27	27	27	27
mean_Sag_t_Max_stKneeA_L_R	Pearson Correlation	.356	.140	-.374	-.201	-.359	-.112	1	-.291	.005
	Sig. (2-tailed)	.069	.487	.055	.314	.066	.579		.140	.980
	N	27	27	27	27	27	27	27	27	27
mean_Sag_t_Max_ndKneeA_L_R	Pearson Correlation	-.319	.346	-.063	.245	.037	.230	-.291	1	.099
	Sig. (2-tailed)	.105	.077	.755	.217	.856	.249	.140		.624
	N	27	27	27	27	27	27	27	27	27
mean_Sag_Min_ndKneeA_L_R	Pearson Correlation	.105	.128	.526**	.389*	.486*	.455*	.005	.099	1
	Sig. (2-tailed)	.604	.525	.005	.045	.010	.017	.980	.624	
	N	27	27	27	27	27	27	27	27	27
Sag_t_Min_ndLKneeA#1	Pearson Correlation	-.185	-.119	.455*	.220	.383*	.209	-.528**	.055	.112
	Sig. (2-tailed)	.356	.555	.017	.271	.049	.294	.005	.785	.578
	N	27	27	27	27	27	27	27	27	27
Sag_t_Min_ndRKneeA#1	Pearson Correlation	-.291	-.144	.134	.033	.121	.054	-.608**	.271	-.106
	Sig. (2-tailed)	.141	.473	.504	.869	.547	.791	.001	.172	.600
	N	27	27	27	27	27	27	27	27	27
mean_Sag_KneeA_CI_L_R	Pearson Correlation	-.009	-.488**	.744**	.314	.645**	.410*	-.339	-.127	.328
	Sig. (2-tailed)	.965	.010	.000	.110	.000	.034	.083	.528	.095
	N	27	27	27	27	27	27	27	27	27

		mean_Front_Max_Hip_SWph_L_R	mean_Sag_Knee_stminROM_L_R	Sag_Max_stLKneeA#1	Sag_Max_ndLKneeA#1	Sag_Max_stRKneeA#1	Sag_Max_ndRKneeA#1	mean_Sag_t_Max_stKneeA_L_R	mean_Sag_t_Max_ndKneeA_L_R	mean_Sag_Min_ndKneeA_L_R
Sag_LTT_ROM#1	Pearson Correlation	-.305	.127	.311	.259	.238	.246	-.053	-.127	.128
	Sig. (2-tailed)	.121	.526	.115	.193	.232	.215	.792	.526	.526
	N	27	27	27	27	27	27	27	27	27
Sag_RTT_ROM#1	Pearson Correlation	-.079	.123	.294	.246	.259	.401*	.070	.048	.287
	Sig. (2-tailed)	.696	.540	.137	.216	.192	.038	.728	.813	.146
	N	27	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_STph_L_R	Pearson Correlation	-.311	.075	.230	.383*	.283	.418*	.166	-.050	.258
	Sig. (2-tailed)	.115	.710	.248	.049	.153	.030	.407	.805	.194
	N	27	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_SWph_L_R	Pearson Correlation	-.479*	.037	.482*	.415*	.386*	.311	-.288	.141	.242
	Sig. (2-tailed)	.011	.855	.011	.031	.047	.115	.146	.482	.224
	N	27	27	27	27	27	27	27	27	27
mean_FPA_MedV_STph_L_R	Pearson Correlation	-.090	.025	-.332	-.009	-.300	.066	.325	.132	-.163
	Sig. (2-tailed)	.656	.903	.091	.963	.129	.742	.098	.512	.417
	N	27	27	27	27	27	27	27	27	27

		Sag_t_Min_ndLKneeA#1	Sag_t_Min_ndRKneeA#1	mean_Sag_KneeA_CI_L_R	Sag_LTT_ROM#1	Sag_RTT_ROM#1	mean_Sag_TT_MaxDf_STph_L_R	mean_Sag_TT_MaxDf_SWph_L_R	mean_FPA_MedV_STph_L_R
mass	Pearson Correlation	.134	-.102	-.118	-.036	-.119	-.152	.326	-.078
	Sig. (2-tailed)	.506	.614	.558	.860	.553	.451	.097	.700
	N	27	27	27	27	27	27	27	27
height	Pearson Correlation	.095	-.005	.005	-.059	-.150	-.137	.141	.042
	Sig. (2-tailed)	.636	.978	.981	.769	.456	.496	.482	.835
	N	27	27	27	27	27	27	27	27
IC_DIST	Pearson Correlation	-.276	.187	.041	-.017	-.093	-.127	-.049	-.019
	Sig. (2-tailed)	.164	.350	.840	.933	.645	.529	.808	.927
	N	27	27	27	27	27	27	27	27
IM_DIST	Pearson Correlation	.318	.028	.009	-.263	-.363	-.036	.409*	-.169
	Sig. (2-tailed)	.105	.892	.965	.185	.063	.859	.034	.400
	N	27	27	27	27	27	27	27	27
UMB_MT	Pearson Correlation	.210	.056	.115	-.174	-.129	-.167	-.012	.057
	Sig. (2-tailed)	.294	.782	.567	.384	.522	.404	.954	.779
	N	27	27	27	27	27	27	27	27
ASIS_MT	Pearson Correlation	.206	.117	.196	-.068	-.044	-.039	-.004	.131
	Sig. (2-tailed)	.302	.560	.327	.738	.826	.846	.985	.515
	N	27	27	27	27	27	27	27	27
TROC_MP	Pearson Correlation	.085	.084	.229	-.167	-.200	-.082	-.071	.109
	Sig. (2-tailed)	.675	.677	.250	.406	.317	.686	.723	.590
	N	27	27	27	27	27	27	27	27

		Sag_t_Min_ndLKneeA#1	Sag_t_Min_ndRKneeA#1	mean_Sag_KneeA_CI_L_R	Sag_LTT_ROM#1	Sag_RTT_ROM#1	mean_Sag_TT_MaxDf_STph_L_R	mean_Sag_TT_MaxDf_SWph_L_R	mean_FPA_MedV_STph_L_R
K_EXT	Pearson Correlation	.073	.019	.098	-.132	-.254	.062	.339	.077
	Sig. (2-tailed)	.717	.924	.628	.510	.201	.759	.083	.702
	N	27	27	27	27	27	27	27	27
I_ROT	Pearson Correlation	-.008	-.199	.056	.082	.314	-.002	-.321	-.162
	Sig. (2-tailed)	.967	.320	.781	.683	.111	.994	.102	.420
	N	27	27	27	27	27	27	27	27
E_ROT	Pearson Correlation	.199	.204	-.159	-.150	-.055	-.002	.001	.079
	Sig. (2-tailed)	.319	.307	.427	.455	.785	.991	.997	.697
	N	27	27	27	27	27	27	27	27
ROM_ROT	Pearson Correlation	.119	-.047	-.051	-.022	.242	-.003	-.283	-.093
	Sig. (2-tailed)	.556	.817	.799	.913	.223	.988	.152	.643
	N	27	27	27	27	27	27	27	27
FEM_ANT	Pearson Correlation	.032	.027	.324	.195	.384*	.064	.068	-.207
	Sig. (2-tailed)	.872	.896	.099	.329	.048	.750	.737	.300
	N	27	27	27	27	27	27	27	27
TI_TORS	Pearson Correlation	.201	.365	.169	-.048	.048	-.135	-.041	.148
	Sig. (2-tailed)	.315	.061	.400	.812	.812	.503	.838	.460
	N	27	27	27	27	27	27	27	27
cadence#1	Pearson Correlation	-.027	.124	.153	-.437*	-.181	-.451*	-.294	-.290
	Sig. (2-tailed)	.894	.539	.446	.023	.367	.018	.137	.142
	N	27	27	27	27	27	27	27	27
speed#1	Pearson Correlation	.223	.108	.279	.026	.022	-.128	.148	-.255
	Sig. (2-tailed)	.264	.591	.159	.897	.914	.525	.460	.199
	N	27	27	27	27	27	27	27	27
mean_L_step_L_R	Pearson Correlation	.292	.068	.240	.290	.126	.105	.327	-.141
	Sig. (2-tailed)	.140	.737	.229	.143	.530	.604	.096	.484
	N	27	27	27	27	27	27	27	27

		Sag_t_Min_ndLKneeA#1	Sag_t_Min_ndRKneeA#1	mean_Sag_KneeA_CI_L_R	Sag_LTT_ROM#1	Sag_RTT_ROM#1	mean_Sag_TT_MaxDf_STph_L_R	mean_Sag_TT_MaxDf_SWph_L_R	mean_FPA_MedV_STph_L_R
mean_StepFactor_L_R	Pearson Correlation	.283	.018	.122	.447*	.275	.184	.420*	-.227
	Sig. (2-tailed)	.153	.928	.545	.019	.165	.358	.029	.256
	N	27	27	27	27	27	27	27	27
mean_Cycle_time_L_R	Pearson Correlation	.046	-.133	-.150	.450*	.173	.458*	.290	.287
	Sig. (2-tailed)	.822	.508	.456	.019	.389	.016	.143	.146
	N	27	27	27	27	27	27	27	27
mean_dT_unipodal_L_R	Pearson Correlation	-.025	-.059	.202	.465*	.536**	.169	.068	-.065
	Sig. (2-tailed)	.901	.769	.313	.015	.004	.398	.737	.746
	N	27	27	27	27	27	27	27	27
Displace_CoM#1	Pearson Correlation	.182	-.097	.355	.259	-.082	.133	.212	-.241
	Sig. (2-tailed)	.363	.629	.069	.191	.683	.508	.288	.227
	N	27	27	27	27	27	27	27	27
Rt_ASIS_Calc#1	Pearson Correlation	-.134	-.139	.099	.232	.372	.131	.025	.182
	Sig. (2-tailed)	.504	.490	.624	.244	.056	.516	.903	.364
	N	27	27	27	27	27	27	27	27
mean_t_LR_L_R	Pearson Correlation	-.006	-.016	-.093	-.149	.149	.278	.220	.435*
	Sig. (2-tailed)	.977	.938	.645	.457	.460	.161	.270	.023
	N	27	27	27	27	27	27	27	27
mean_t_Mid_St_L_R	Pearson Correlation	.048	-.019	-.324	-.274	-.224	-.185	.073	.011
	Sig. (2-tailed)	.812	.924	.099	.166	.262	.356	.717	.958
	N	27	27	27	27	27	27	27	27
mean_t_TST_L_R	Pearson Correlation	-.001	.034	-.235	-.033	.056	-.223	-.168	.086
	Sig. (2-tailed)	.995	.867	.239	.868	.782	.263	.402	.669
	N	27	27	27	27	27	27	27	27
mean_t_PSw_L_R	Pearson Correlation	-.184	.205	.069	-.003	-.111	.181	.180	.239
	Sig. (2-tailed)	.359	.305	.733	.989	.581	.366	.369	.230
	N	27	27	27	27	27	27	27	27

		Sag_t_Min_ndLKneeA#1	Sag_t_Min_ndRKneeA#1	mean_Sag_KneeA_CI_L_R	Sag_LTT_ROM#1	Sag_RTT_ROM#1	mean_Sag_TT_MaxDf_STph_L_R	mean_Sag_TT_MaxDf_SWph_L_R	mean_FPA_MedV_STph_L_R
t_L_Init_Sw#1	Pearson Correlation	-.027	-.111	-.520**	-.225	-.218	-.089	.042	.086
	Sig. (2-tailed)	.895	.583	.005	.259	.274	.661	.834	.670
	N	27	27	27	27	27	27	27	27
t_R_Init_Sw#1	Pearson Correlation	-.090	.143	-.083	-.143	-.224	-.272	.084	-.120
	Sig. (2-tailed)	.655	.475	.680	.476	.262	.170	.678	.550
	N	27	27	27	27	27	27	27	27
mean_t_Mid_Sw_L_R	Pearson Correlation	.132	.065	.109	-.044	.146	-.435*	-.023	-.640**
	Sig. (2-tailed)	.510	.746	.587	.828	.468	.023	.910	.000
	N	27	27	27	27	27	27	27	27
mean_t_TSW_L_R	Pearson Correlation	.034	-.120	-.062	.258	.424*	-.092	.082	-.109
	Sig. (2-tailed)	.868	.553	.757	.193	.028	.648	.683	.589
	N	27	27	27	27	27	27	27	27
mean_Sag_Pelvis_ROM_L_R	Pearson Correlation	-.120	.064	.017	.070	.155	-.047	.095	-.168
	Sig. (2-tailed)	.553	.752	.932	.729	.442	.817	.636	.401
	N	27	27	27	27	27	27	27	27
mean_PELVIS_Sag_MedV_L_R	Pearson Correlation	-.053	-.160	.162	.225	-.103	.488**	.142	.410*
	Sig. (2-tailed)	.793	.424	.418	.260	.609	.010	.479	.034
	N	27	27	27	27	27	27	27	27
mean_PELVIS_Trans_MedV_L_R	Pearson Correlation	-.077	-.057	-.378	-.252	.115	-.247	-.205	-.197
	Sig. (2-tailed)	.703	.777	.052	.205	.569	.214	.305	.324
	N	27	27	27	27	27	27	27	27
mean_Sag_Hip_ndmax_ROM_L_R	Pearson Correlation	.206	.219	.383*	.039	.165	.227	.099	.009
	Sig. (2-tailed)	.303	.273	.049	.845	.412	.255	.623	.965
	N	27	27	27	27	27	27	27	27
mean_Sag_ndMax_HipA_L_R	Pearson Correlation	.141	-.006	.524**	.217	.130	.688**	.299	.439*
	Sig. (2-tailed)	.484	.975	.005	.277	.517	.000	.130	.022
	N	27	27	27	27	27	27	27	27

		Sag_t_Min_ndLKneeA#1	Sag_t_Min_ndRKneeA#1	mean_Sag_KneeA_CI_L_R	Sag_LTT_ROM#1	Sag_RTT_ROM#1	mean_Sag_TT_MaxDf_STph_L_R	mean_Sag_TT_MaxDf_SWph_L_R	mean_FPA_MedV_STph_L_R
mean_Sag_t_ndMax_HipA_L_R	Pearson Correlation	.422*	.072	.444*	.331	.119	.133	.444*	-.052
	Sig. (2-tailed)	.028	.722	.020	.091	.553	.509	.020	.796
	N	27	27	27	27	27	27	27	27
mean_Sag_Min_HipA_L_R	Pearson Correlation	-.217	-.439*	-.130	-.075	-.056	.119	-.016	.110
	Sig. (2-tailed)	.277	.022	.519	.711	.781	.553	.936	.586
	N	27	27	27	27	27	27	27	27
mean_Sag_t_Min_HipA_L_R	Pearson Correlation	.180	.185	-.119	.127	.094	.373	.420*	.149
	Sig. (2-tailed)	.369	.356	.556	.527	.641	.056	.029	.457
	N	27	27	27	27	27	27	27	27
mean_Trans_MedV_Hip_STph_L_R	Pearson Correlation	-.205	-.025	.255	.194	.021	.053	-.248	.071
	Sig. (2-tailed)	.306	.903	.199	.332	.916	.793	.211	.724
	N	27	27	27	27	27	27	27	27
mean_Front_Max_Hip_SWph_L_R	Pearson Correlation	-.185	-.291	-.009	-.305	-.079	-.311	-.479*	-.090
	Sig. (2-tailed)	.356	.141	.965	.121	.696	.115	.011	.656
	N	27	27	27	27	27	27	27	27
mean_Sag_Knee_stminROM_L_R	Pearson Correlation	-.119	-.144	-.488**	.127	.123	.075	.037	.025
	Sig. (2-tailed)	.555	.473	.010	.526	.540	.710	.855	.903
	N	27	27	27	27	27	27	27	27
Sag_Max_stLKneeA#1	Pearson Correlation	.455*	.134	.744**	.311	.294	.230	.482*	-.332
	Sig. (2-tailed)	.017	.504	.000	.115	.137	.248	.011	.091
	N	27	27	27	27	27	27	27	27
Sag_Max_ndLKneeA#1	Pearson Correlation	.220	.033	.314	.259	.246	.383*	.415*	-.009
	Sig. (2-tailed)	.271	.869	.110	.193	.216	.049	.031	.963
	N	27	27	27	27	27	27	27	27
Sag_Max_stRKneeA#1	Pearson Correlation	.383*	.121	.645**	.238	.259	.283	.386*	-.300
	Sig. (2-tailed)	.049	.547	.000	.232	.192	.153	.047	.129
	N	27	27	27	27	27	27	27	27

		Sag_t_Min_ndLKneeA#1	Sag_t_Min_ndRKneeA#1	mean_Sag_KneeA_CI_L_R	Sag_LTT_ROM#1	Sag_RTT_ROM#1	mean_Sag_TT_MaxDf_STph_L_R	mean_Sag_TT_MaxDf_SWph_L_R	mean_FPA_MedV_STph_L_R
Sag_Max_ndRKneeA#1	Pearson Correlation	.209	.054	.410*	.246	.401*	.418*	.311	.066
	Sig. (2-tailed)	.294	.791	.034	.215	.038	.030	.115	.742
	N	27	27	27	27	27	27	27	27
mean_Sag_t_Max_stKneeA_L_R	Pearson Correlation	-.528**	-.608**	-.339	-.053	.070	.166	-.288	.325
	Sig. (2-tailed)	.005	.001	.083	.792	.728	.407	.146	.098
	N	27	27	27	27	27	27	27	27
mean_Sag_t_Max_ndKneeA_L_R	Pearson Correlation	.055	.271	-.127	-.127	.048	-.050	.141	.132
	Sig. (2-tailed)	.785	.172	.528	.526	.813	.805	.482	.512
	N	27	27	27	27	27	27	27	27
mean_Sag_Min_ndKneeA_L_R	Pearson Correlation	.112	-.106	.328	.128	.287	.258	.242	-.163
	Sig. (2-tailed)	.578	.600	.095	.526	.146	.194	.224	.417
	N	27	27	27	27	27	27	27	27
Sag_t_Min_ndLKneeA#1	Pearson Correlation	1	.531**	.369	.081	.063	.128	.351	-.047
	Sig. (2-tailed)		.004	.058	.688	.756	.523	.073	.815
	N	27	27	27	27	27	27	27	27
Sag_t_Min_ndRKneeA#1	Pearson Correlation	.531**	1	.218	-.193	-.075	-.038	.222	.038
	Sig. (2-tailed)	.004		.274	.334	.709	.851	.265	.850
	N	27	27	27	27	27	27	27	27
mean_Sag_KneeA_CI_L_R	Pearson Correlation	.369	.218	1	.088	.199	.354	.366	.007
	Sig. (2-tailed)	.058	.274		.661	.321	.070	.060	.974
	N	27	27	27	27	27	27	27	27

		Sag_t_Min_ndLKneeA#1	Sag_t_Min_ndRKneeA#1	mean_Sag_KneeA_CI_L_R	Sag_LTT_ROM#1	Sag_RTT_ROM#1	mean_Sag_TT_MaxDf_STph_L_R	mean_Sag_TT_MaxDf_SWph_L_R	mean_FPA_MedV_STph_L_R
Sag_LTT_ROM#1	Pearson Correlation	.081	-.193	.088	1	.615**	.311	.242	-.067
	Sig. (2-tailed)	.688	.334	.661		.001	.114	.224	.741
	N	27	27	27	27	27	27	27	27
Sag_RTT_ROM#1	Pearson Correlation	.063	-.075	.199	.615**	1	.110	-.023	-.078
	Sig. (2-tailed)	.756	.709	.321	.001		.586	.909	.698
	N	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_STph_L_R	Pearson Correlation	.128	-.038	.354	.311	.110	1	.587**	.659**
	Sig. (2-tailed)	.523	.851	.070	.114	.586		.001	.000
	N	27	27	27	27	27	27	27	27
mean_Sag_TT_MaxDf_SWph_L_R	Pearson Correlation	.351	.222	.366	.242	-.023	.587**	1	.173
	Sig. (2-tailed)	.073	.265	.060	.224	.909	.001		.388
	N	27	27	27	27	27	27	27	27
mean_FPA_MedV_STph_L_R	Pearson Correlation	-.047	.038	.007	-.067	-.078	.659**	.173	1
	Sig. (2-tailed)	.815	.850	.974	.741	.698	.000	.388	
	N	27	27	27	27	27	27	27	27

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).