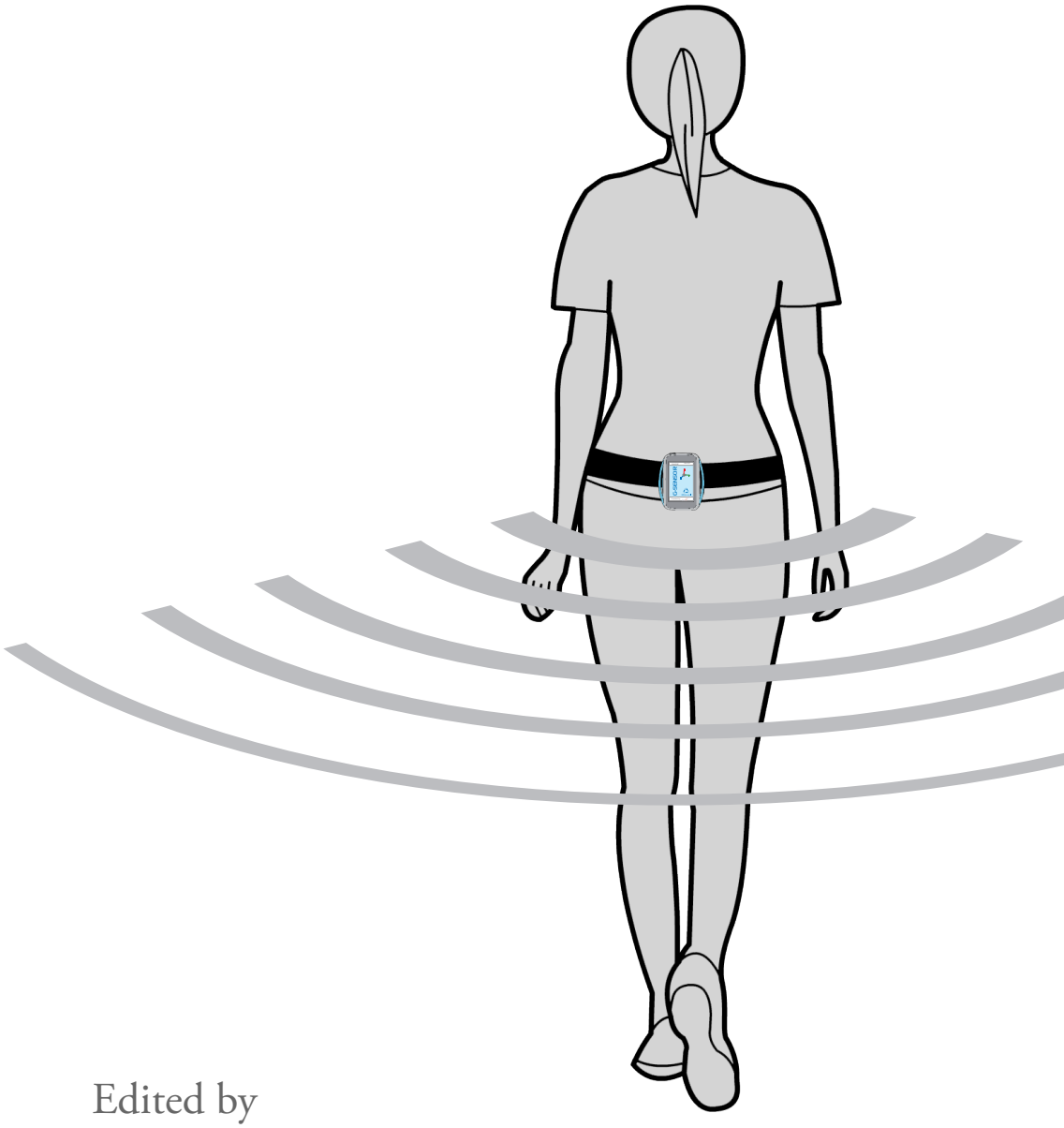
BTS G-WALK



Edited by
Dr Luciano Bissolotti °
Specialist in Physical Medicine and Rehabilitation
Specialist in Sports Medicine
and
PaoloGaffurini, PhD *
Functional Rehabilitation and Recovery Service
LARIN *
Rehabilitation Clinic Domus Salutis

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BTS Biomedical

Chapter 1

Introduction

Among the different activities of a rehabilitation service, the use of the gait analysis system BTS G-WALK allows the clinician to execute the following evaluations:

1. Overground Functional Gait analysis of patients affected by movement disorders derived by neurological or orthopaedic diseases. This gait cycle instrumental evaluation can be performed on different kinds of surfaces (smooth or rough floor and even on outdoor grounds).
2. Functional Gait analysis during Treadmill training with or without body weight suspension and at different velocities (from 0.8 to 6.5km/h)
3. Motor performance can be tested during functional global evaluation in sports rehabilitation with injured athletes, with or without a medical history of surgical treatments, during and at the end of the recovery process. Jump and Counter Movement Jump (CMJ) can be tested on athletes coming from different sports even during global performance assessment to evaluate training adaptations and effectiveness.

All these tests can be performed quickly and with a high cost/benefit ratio given the quick fitting process of the device on patients and the intuitive management of the software.

Spatial-temporal gait parameters

- Velocity
- Cadence
- Step Length
- Stride Length
- Step Width

- Gait Cycle duration
- Stance phase duration
- Swing phase duration
- Double and single support duration

BTS G-WALK allows to evaluate spatial-temporal parameters, pelvic kinematic and a direct comparison with normative limits.
Gait kinematic assessments using BTS G-WALK can be applied in several pathological conditions, such as:

ORTHOPEDIC FIELD:

- Gait disorders due to vertebral deformities like scoliosis, iper-kyphosis and lordosis both congenital and acquired, with or without neurogenic claudication due to spinal stenosis.
- Lower limbs impairment due to trauma (fractures, sprains, ligament injuries) and surgery (joint replacement, anterior cruciate ligament reconstruction, etc.), or congenital and structural biomechanical alterations (patello-femoral misalignment, lower limbs asymmetries, pelvis torsional vices).

NEUROLOGICAL FIELD

- Gait training in congenital or acquired brain injury such as **Traumatic Brain Injury (TBI)** or **in stroke patients** with and residual walking ability, including the assessment of pharmacological treatments such as botulin toxin or different functional surgery procedures for containment and correction of biomechanical incorrect behaviours.
- Outcome of **Spinal Cord Inury** resulting from incomplete para- or quadriplegia in order to define the basic elements of the gait cycle and changes on follow up.
- Neurodegenerative diseases such as **Parkinson's disease,** Normal Pressure Hydrocephalus (NPH) and **Multiple Sclerosis** in order to define the efficacy of pharmalogical and rehabilitation treatments

- Orthotic and prosthesis evaluation with or without aids (cane, crutches, walker can be performed during prescription process.
- Balance and movement disorder strictly connected to the vestibular system (such as Menière's disease) or cerebellar diseases (ataxia of the gait and the movement of the limbs).

Besides that, BTS G-WALK can also be used in the SPORTS FIELD in order to make functional assessments useful in monitoring sport performances both on the field both in laboratory. In addition to the evaluation of gait cycle asymmetries, there are protocols for jumping, with counter movement (CMJ) and without (SJ), to quantify explosive force of athletes in different sports. From these protocols are evaluated parameters about time of flight, jump height, power generated.

The use of BTS G-WALK in clinical procedures: Application fields and clinical cases

The use of instrumental evaluation for gait parameters through BTS G-WALK is particularly advantageous because of the headiness, the completeness of data obtainable, the speed of test execution even in conditions of multitasking both for the patient and the system. The ability to detect data in a multi-parametric way also produces a cost benefit ratio significantly advantageous in the field of clinical rehabilitative pathways characterized by a growing disparity between available resources and emerging demands.

The clinical cases reported below are a testimony to the sensitivity of the system to detect even thin changes in the patient motor performances.

Case 1:

HZ, male patient affected by expressive aphasia and right hemiparesis resulting from haemorrhagic stroke in the territory of the basal ganglia of the left in the sub-acute phase (> 30 days) and during neuro-motor rehabilitation applied to improve safety and gait symmetry:

- initial clinical evaluation: scale Trunk Control Test 75/100, Motricity index: lower limb 81/100, upper limb 0/100

Aim of the assessment: functional evaluation before and after rehabilitation treatment.

- Once set an assisted / supervised path for 10m, he has been tested with G Walk obtaining the following data:

Misure Rilevate:			Val.Normalità(Uomini)	Val.Normalità(Donne)	
Velocità:	53.0	mt/min	77.4 (±9.48)	71.4 (±10.2)	mt/min
Cadenza Passi:	45.9	strides/min	52.8 (±3.8)	55.8 (±4.4)	strides/min
Lunghezza del Passo	1.16	m	1.46 (±0.130)	1.28 (±0.154)	m
Lunghezza (Emi)Passo SX:	0.63	m (54.9%)	50%	50%	%
Lunghezza (Emi)Passo DX:	0.52	m (45.1%)	50%	50%	%
% Lungh.Passo/Altezza	68.0	%	84.7 (±6.1)	80.7 (±9.1)	%
Durata Ciclo del Passo	1.31	sec	1.14 (±0.08)	1.08 (±0.08)	sec
Durata (Emi)Passo SX:	0.52	sec (39.6%)	---	---	sec
Durata (Emi)Passo DX:	0.78	sec (59.9%)	---	---	sec
Durata del Rotolamento [% del ciclo del passo]	63.1	%	60.31 (±1.7)	60.31 (±1.7)	%
Durata del Rotolamento SX [% del ciclo del passo]	55.5	%	---	---	%
Durata del Rotolamento DX [% del ciclo del passo]	70.8	%	---	---	%
Durata dello Swing [% del ciclo del passo]	35.8	%	39.6 (±1.9)	39.6 (±1.9)	%
Durata dello Swing SX [% del ciclo del passo]	43.7	%	---	---	%
Durata dello Swing DX [% del ciclo del passo]	27.9	%	---	---	%
Durata del Doppio Appoggio [% del ciclo del passo]	13.6	%	9.4 (±2.3)	9.6 (±4.6)	%
Durata del Singolo Appoggio [% del ciclo del passo]	35.8	%	41 (±2)	41 (±2)	%

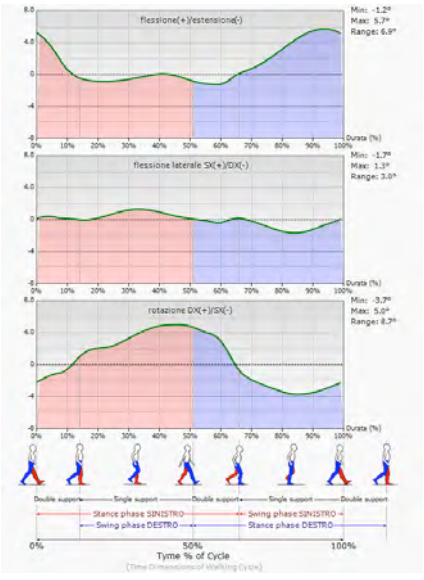
Fig.1a

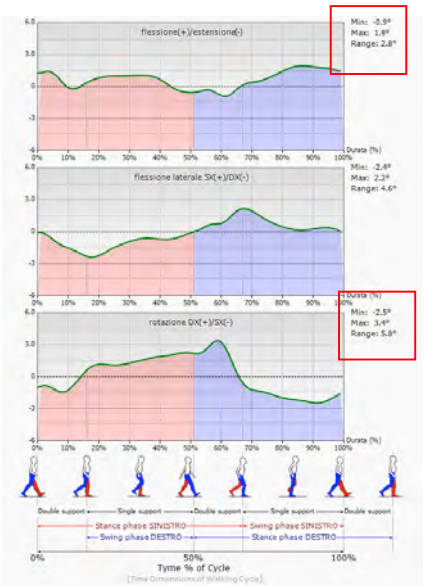
- At the final clinical evaluation: "scale Trunk Control Test" 100/100, Motricity index: lower limb 100/100, upper limb 0/100. Autonomous in the execution of postural passages, walks independently without the use of aids and without any hesitation. RANKIN 3/5; Rivermead 15/15; Tinetti: 27/28 ".

When the rehabilitation program final goal has been achieved, we performed another gait analysis on the patient using BTS G-WALK, obtaining these data:

Misure Rilevate:				Val.Normalità(Uomini)	Val.Normalità(Donne)	
Velocità:	71.7	mt/min		77.4 (±9.48)	71.4 (±10.2)	mt/min
Cadenza Passi:	52.4	strides/min		52.8 (±3.8)	55.8 (±4.4)	strides/min
Lunghezza del Passo	1.38	m		1.46 (±0.130)	1.28 (±0.154)	m
Lunghezza (Emi)Passo SX:	0.64	m	(46.4%)	50%	50%	%
Lunghezza (Emi)Passo DX:	0.74	m	(53.6%)	50%	50%	%
% Lungh.Passo/Altezza	82.2	%		84.7 (±6.1)	80.7 (±9.1)	%
Durata Ciclo del Passo	1.15	sec		1.14 (±0.08)	1.08 (±0.08)	sec
Durata (Emi)Passo SX:	0.59	sec	(51.8%)	---	---	sec
Durata (Emi)Passo DX:	0.56	sec	(48.9%)	---	---	sec
Durata del Rotolamento [% del ciclo del passo]	64.4	%		60.31 (±1.7)	60.31 (±1.7)	%
Durata del Rotolamento SX [% del ciclo del passo]	65.6	%		---	---	%
Durata del Rotolamento DX [% del ciclo del passo]	63.1	%		---	---	%
Durata dello Swing [% del ciclo del passo]	33.8	%		39.6 (±1.9)	39.6 (±1.9)	%
Durata dello Swing SX [% del ciclo del passo]	32.5	%		---	---	%
Durata dello Swing DX [% del ciclo del passo]	35.0	%		---	---	%
Durata del Doppio Appoggio [% del ciclo del passo]	15.2	%		9.4 (±2.3)	9.6 (±4.6)	%
Durata del Singolo Appoggio [% del ciclo del passo]	33.8	%		41 (±2)	41 (±2)	%

Even more significant is the comparative evaluation of the biomechanics adjustments of the trunk/hip sector (pelvic oscillation during the gait cycle): this allows underlining gait pattern changes throughout the rehabilitation path. Fig.1c





Conclusions: in the specific case it should be noted, therefore, an improvement of the spontaneous walking speed, a proper symmetry in the step cycle (half of a stride) (Fig1a-b) and a reduction of the proximal trunk compensations processes (Fig.2) both on the sagittal plane (flexion-extension) and on the horizontal one (rotation of the pelvis) as proved by the reduction of the oscillation range.

Case 2:

ZG, male patient affected by left hemiparesis due to an ischemic stroke ACM right.

Aim of the assessment: test as a support to a distal orthoses prescription to help in walking.

Without leg-foot orthoses (NO AFO) the gait analysis has been performed providing these following results (Fig.2a):

Misure Rilevate:			Val.Normalità(Uomini)	Val.Normalità(Donne)	
Velocità:	53.0	mt/min	77.4 (±9.48)	71.4 (±10.2)	mt/min
Cadenza Passi:	45.9	strides/min	52.8 (±3.8)	55.8 (±4.4)	strides/min
Lunghezza del Passo	1.16	m	1.46 (±0.130)	1.28 (±0.154)	m
Lunghezza (Emi)Passo SX:	0.63	m (54.9%)	50%	50%	%
Lunghezza (Emi)Passo DX:	0.52	m (45.1%)	50%	50%	%
% Lungh.Passo/Altezza	68.0	%	84.7 (±6.1)	80.7 (±9.1)	%
Durata Ciclo del Passo	1.31	sec	1.14 (±0.08)	1.08 (±0.08)	sec
Durata (Emi)Passo SX:	0.52	sec (39.6%)	---	---	sec
Durata (Emi)Passo DX:	0.78	sec (59.9%)	---	---	sec
Durata del Rotolamento [% del ciclo del passo]	63.1	%	60.31 (±1.7)	60.31 (±1.7)	%
Durata del Rotolamento SX [% del ciclo del passo]	55.5	%	---	---	%
Durata del Rotolamento DX [% del ciclo del passo]	70.8	%	---	---	%
Durata dello Swing [% del ciclo del passo]	35.8	%	39.6 (±1.9)	39.6 (±1.9)	%
Durata dello Swing SX [% del ciclo del passo]	43.7	%	---	---	%
Durata dello Swing DX [% del ciclo del passo]	27.9	%	---	---	%
Durata del Doppio Appoggio [% del ciclo del passo]	13.6	%	9.4 (±2.3)	9.6 (±4.6)	%
Durata del Singolo Appoggio [% del ciclo del passo]	35.8	%	41 (±2)	41 (±2)	%

With AFO1 (Fig.2b):

Misure Rilevate:			Val.Normalità(Uomini)	Val.Normalità(Donne)	
Velocità:	62.1	mt/min	77.4 (±9.48)	71.4 (±10.2)	mt/min
Cadenza Passi:	51.6	strides/min	52.8 (±3.8)	55.8 (±4.4)	strides/min
Lunghezza del Passo	1.21	m	1.46 (±0.130)	1.28 (±0.154)	m
Lunghezza (Emi)Passo SX:	0.66	m (54.2%)	50%	50%	%
Lunghezza (Emi)Passo DX:	0.56	m (45.8%)	50%	50%	%
% Lungh.Passo/Altezza	71.5	%	84.7 (±6.1)	80.7 (±9.1)	%
Durata Ciclo del Passo	1.16	sec	1.14 (±0.08)	1.08 (±0.08)	sec
Durata (Emi)Passo SX:	0.46	sec (39.4%)	---	---	sec
Durata (Emi)Passo DX:	0.70	sec (60.6%)	---	---	sec
Durata del Rotolamento [% del ciclo del passo]	62.7	%	60.31 (±1.7)	60.31 (±1.7)	%
Durata del Rotolamento SX [% del ciclo del passo]	54.8	%	---	---	%
Durata del Rotolamento DX [% del ciclo del passo]	70.6	%	---	---	%
Durata dello Swing [% del ciclo del passo]	36.6	%	39.6 (±1.9)	39.6 (±1.9)	%
Durata dello Swing SX [% del ciclo del passo]	45.2	%	---	---	%
Durata dello Swing DX [% del ciclo del passo]	28.0	%	---	---	%
Durata del Doppio Appoggio [% del ciclo del passo]	13.1	%	9.4 (±2.3)	9.6 (±4.6)	%
Durata del Singolo Appoggio [% del ciclo del passo]	36.6	%	41 (±2)	41 (±2)	%

Using AFO2 (Fig.2c):

Misure Rilevate:			Val.Normalità(Uomini)	Val.Normalità(Donne)	
Velocità:	61.2	mt/min	77.4 (±9.48)	71.4 (±10.2)	mt/min
Cadenza Passi:	51.8	strides/min	52.8 (±3.8)	55.8 (±4.4)	strides/min
Lunghezza del Passo	1.19	m	1.46 (±0.130)	1.28 (±0.154)	m
Lunghezza (Emi)Passo SX:	0.66	m (54.9%)	50%	50%	%
Lunghezza (Emi)Passo DX:	0.54	m (45.1%)	50%	50%	%
% Lungh.Passo/Altezza	70.1	%	84.7 (±6.1)	80.7 (±9.1)	%
Durata Ciclo del Passo	1.16	sec	1.14 (±0.08)	1.08 (±0.08)	sec
Durata (Emi)Passo SX:	0.48	sec (41.5%)	---	---	sec
Durata (Emi)Passo DX:	0.68	sec (58.8%)	---	---	sec
Durata del Rotolamento [% del ciclo del passo]	61.4	%	60.31 (±1.7)	60.31 (±1.7)	%
Durata del Rotolamento SX [% del ciclo del passo]	54.0	%	---	---	%
Durata del Rotolamento DX [% del ciclo del passo]	68.7	%	---	---	%
Durata dello Swing [% del ciclo del passo]	37.0	%	39.6 (±1.9)	39.6 (±1.9)	%
Durata dello Swing SX [% del ciclo del passo]	44.3	%	---	---	%
Durata dello Swing DX [% del ciclo del passo]	29.7	%	---	---	%
Durata del Doppio Appoggio [% del ciclo del passo]	12.1	%	9.4 (±2.3)	9.6 (±4.6)	%
Durata del Singolo Appoggio [% del ciclo del passo]	37.0	%	41 (±2)	41 (±2)	%

Conclusions: in this case it is possible to notice, compared to the basal conditions, the increase of the spontaneous walking speed due to the use of leg/foot dynamic brace (AFO1-2) with which it is possible to observe a significant tendency to a normalization of the phases duration (stance and

swing). There are no significant differences between AFO1 and AFO2, in this case the clinician can decide which kind of device prescribe based on clinical parameters matched with the biomechanical ones.

Case 3:

Evaluation of different motor performances between a subject affected by Parkinson's disease belonging to Hohen Yahr 4.5/5 Class and another one belonging to Hohen Yahr 2/5.

Aim of the assessment: check and quantification of the level of impairment of gait cycle, comparison between patients having a similar diagnosis but at a different level of neurological and functional impairment.

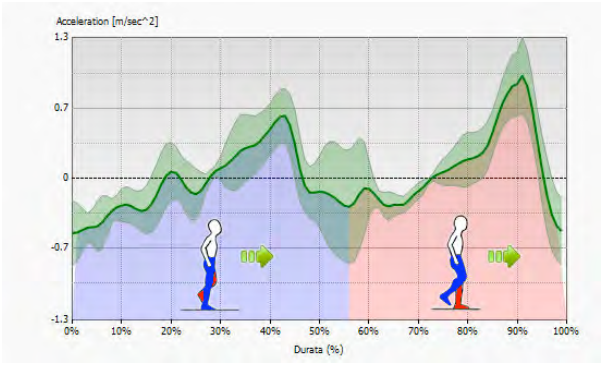
In a patient affected by a Hohen Yahr 4.5/5 class of Parkinson's disease, has been performed a G-Walk test obtaining (Fig.3a):

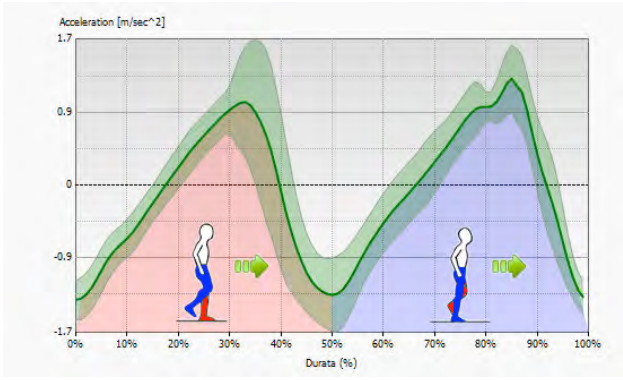
Misure Rilevate:			Val.Normalità(Uomini)	Val.Normalità(Donne)	
Velocità:	25.9	mt/min	77.4 (±9.48)	71.4 (±10.2)	mt/min
Cadenza Passi:	37.8	strides/min	52.8 (±3.8)	55.8 (±4.4)	strides/min
Lunghezza del Passo	0.68	m	1.46 (±0.130)	1.28 (±0.154)	m
Lunghezza (Emi)Passo SX:	0.33	m (48.5%)	50%	50%	%
Lunghezza (Emi)Passo DX:	0.35	m (51.5%)	50%	50%	%
% Lungh.Passo/Altezza	45.9	%	84.7 (±6.1)	80.7 (±9.1)	%
Durata Ciclo del Passo	1.59	sec	1.14 (±0.08)	1.08 (±0.08)	sec
Durata (Emi)Passo SX:	0.92	sec (57.8%)	---	---	sec
Durata (Emi)Passo DX:	0.66	sec (41.3%)	---	---	sec
Durata del Rotolamento [% del ciclo del passo]	58.6	%	60.31 (±1.7)	60.31 (±1.7)	%
Durata del Rotolamento SX [% del ciclo del passo]	66.8	%	---	---	%
Durata del Rotolamento DX [% del ciclo del passo]	50.4	%	---	---	%
Durata dello Swing [% del ciclo del passo]	41.0	%	39.6 (±1.9)	39.6 (±1.9)	%
Durata dello Swing SX [% del ciclo del passo]	33.0	%	---	---	%
Durata dello Swing DX [% del ciclo del passo]	48.9	%	---	---	%
Durata del Doppio Appoggio [% del ciclo del passo]	8.5	%	9.4 (±2.3)	9.6 (±4.6)	%
Durata del Singolo Appoggio [% del ciclo del passo]	41.0	%	41 (±2)	41 (±2)	%

In a subject affected by the Hohen Yahr 2/5 Parkinson's disease (Fig.3b):

Misure Rilevate:			Val.Normalità(Uomini)	Val.Normalità(Donne)	
Velocità:	52.5	mt/min	77.4 (±9.48)	71.4 (±10.2)	mt/min
Cadenza Passi:	45.8	strides/min	52.8 (±3.8)	55.8 (±4.4)	strides/min
Lunghezza del Passo	1.15	m	1.46 (±0.130)	1.28 (±0.154)	m
Lunghezza (Emi)Passo SX:	0.57	m (49.9%)	50%	50%	%
Lunghezza (Emi)Passo DX:	0.57	m (50.1%)	50%	50%	%
% Lungh.Passo/Altezza	75.4	%	84.7 (±6.1)	80.7 (±9.1)	%
Durata Ciclo del Passo	1.31	sec	1.14 (±0.08)	1.08 (±0.08)	sec
Durata (Emi)Passo SX:	0.65	sec (49.3%)	---	---	sec
Durata (Emi)Passo DX:	0.66	sec (50.7%)	---	---	sec
Durata del Rotolamento [% del ciclo del passo]	62.6	%	60.31 (±1.7)	60.31 (±1.7)	%
Durata del Rotolamento SX [% del ciclo del passo]	61.4	%	---	---	%
Durata del Rotolamento DX [% del ciclo del passo]	63.9	%	---	---	%
Durata dello Swing [% del ciclo del passo]	35.3	%	39.6 (±1.9)	39.6 (±1.9)	%
Durata dello Swing SX [% del ciclo del passo]	36.5	%	---	---	%
Durata dello Swing DX [% del ciclo del passo]	34.2	%	---	---	%
Durata del Doppio Appoggio [% del ciclo del passo]	13.6	%	9.4 (±2.3)	9.6 (±4.6)	%
Durata del Singolo Appoggio [% del ciclo del passo]	35.3	%	41 (±2)	41 (±2)	%

From the pelvic cinematic point of view, there are some relevant differences as it is possible to see from picture 3c (HY 4.5/%) and picture 3d (HY 2/5) :





Conclusions: In this case it is possible to notice important differences in the two performances. In particular, BTS G-WALK system is extremely sensitive to detect temporal and spatial differences between the two patients belonging to two different functional categories of a same disease condition. The system is reliable in the individuation of the motor impairment, sensitive in detecting qualitative and quantitative differences in a patient affected by neurodegenerative diseases. From

this point arise also the possibility to monitor constantly and easily the evolution of the disease and its consequences.

Case 4:

Motor performance evaluation in a patient affected by Parkinson's disease belonging to Hohen Yahr 3/5 class in two gait re-educational conditions: overground free walking vs. treadmill walking.

Aim of the assessment: quantitative evaluation of the adaptation level to different rehabilitative conditions; gait cycle over treadmill qualitative monitoring.

In a subject affected by Parkinson's disease (HY 3/5 class), has been performed a gait analysis overground obtaining these results through BTS G-WALK test (Fig.4a):

Misure Rilevate:			Val.Normalità(Uomini)	Val.Normalità(Donne)	
Velocità:	48.1	mt/min	77.4 (±9.48)	71.4 (±10.2)	mt/min
Cadenza Passi:	49.7	strides/min	52.8 (±3.8)	55.8 (±4.4)	strides/min
Lunghezza del Passo	0.97	m	1.46 (±0.130)	1.28 (±0.154)	m
Lunghezza (Emi)Passo SX:	0.48	m (49.1%)	50%	50%	%
Lunghezza (Emi)Passo DX:	0.49	m (50.9%)	50%	50%	%
% Lungh.Passo/Altezza	54.8	%	84.7 (±6.1)	80.7 (±9.1)	%
Durata Ciclo del Passo	1.21	sec	1.14 (±0.08)	1.08 (±0.08)	sec
Durata (Emi)Passo SX:	0.61	sec (50.4%)	---	---	sec
Durata (Emi)Passo DX:	0.60	sec (49.8%)	---	---	sec
Durata del Rotolamento [% del ciclo del passo]	61.1	%	60.31 (±1.7)	60.31 (±1.7)	%
Durata del Rotolamento SX [% del ciclo del passo]	60.9	%	---	---	%
Durata del Rotolamento DX [% del ciclo del passo]	61.3	%	---	---	%
Durata dello Swing [% del ciclo del passo]	37.1	%	39.6 (±1.9)	39.6 (±1.9)	%
Durata dello Swing SX [% del ciclo del passo]	37.2	%	---	---	%
Durata dello Swing DX [% del ciclo del passo]	37.1	%	---	---	%
Durata del Doppio Appoggio [% del ciclo del passo]	11.9	%	9.4 (±2.3)	9.6 (±4.6)	%
Durata del Singolo Appoggio [% del ciclo del passo]	37.1	%	41 (±2)	41 (±2)	%

Over treadmill walking (Fig.4b):

Misure Rilevate:			Val.Normalità(Uomini)	Val.Normalità(Donne)	
Velocità:	75.3	mt/min	77.4 (±9.48)	71.4 (±10.2)	mt/min
Cadenza Passi:	54.1	strides/min	52.8 (±3.8)	55.8 (±4.4)	strides/min
Lunghezza del Passo	1.41	m	1.46 (±0.130)	1.28 (±0.154)	m
Lunghezza (Emi)Passo SX:	0.68	m (48.0%)	50%	50%	%
Lunghezza (Emi)Passo DX:	0.73	m (52.0%)	50%	50%	%
% Lungh.Passo/Altezza	79.6	%	84.7 (±6.1)	80.7 (±9.1)	%
Durata Ciclo del Passo	1.11	sec	1.14 (±0.08)	1.08 (±0.08)	sec
Durata (Emi)Passo SX:	0.60	sec (53.8%)	---	---	sec
Durata (Emi)Passo DX:	0.53	sec (47.7%)	---	---	sec
Durata del Rotolamento [% del ciclo del passo]	60.2	%	60.31 (±1.7)	60.31 (±1.7)	%
Durata del Rotolamento SX [% del ciclo del passo]	62.1	%	---	---	%
Durata del Rotolamento DX [% del ciclo del passo]	58.3	%	---	---	%
Durata dello Swing [% del ciclo del passo]	37.9	%	39.6 (±1.9)	39.6 (±1.9)	%
Durata dello Swing SX [% del ciclo del passo]	36.1	%	---	---	%
Durata dello Swing DX [% del ciclo del passo]	39.7	%	---	---	%
Durata del Doppio Appoggio [% del ciclo del passo]	11.4	%	9.4 (±2.3)	9.6 (±4.6)	%
Durata del Singolo Appoggio [% del ciclo del passo]	37.9	%	41 (±2)	41 (±2)	%

Conclusions: In this case it is possible to notice, compared to overground walking, a spontaneous walking speed increase over treadmill with which is associated an important stride length raise and a respective gait cycle reduction. Collected data show a positive subject adjustment to the treadmill walking confirming the rehabilitative therapy applied.

Chapter 2

STANDARD EVALUATION PROTOCOLS WITH BTS G-WALK

In this chapter some G-Walk application examples are given applied in several neuromotor pathologies.

1 Severe acquired brain lesion outcomes

Inclusion criteria in G-walk evaluation: self selected gait speed at least 0.3m/sec (18m/min, 1.080km/h).

Procedure of test execution: subject in spontaneous neutral standing position, linear walking at least over 8 meters. Ask the patient to walk and cover the distance preset at the spontaneous speed selected and then at the best speed reachable.

BTS G-Walk placing: placed over the trunk at L5 level.

Parameters collected in association with BTS G-Walk gait analysis:: perceived safety during walking (score from 0 to 10, 0= no safety, 10= maximum safety); perceived fatigue during walking (score from 0 to 10, 0= no fatigue, 10= maximum fatigue); perceived pain during walking (score from 0 to 10, 0= no pain, 10= maximum pain); if the path is over 50m, capability to maintain a constant acceleration measuring time intervals every 10m.

Indications: gait analysis over subjects affected by walking deficits due to native or acquired brain lesions of various severity adding the possibility to evaluate at several time intervals or instantaneously in different conditions including: functional responses to several types of orthoses and walkers, adaptation capability to the gait training both in standard conditions and over treadmill with and without partial discharge of body weight, etc.

2 Extra-pyramidal movement disorders (Parkinson's disease, Parkinsonisms, Normal Pressure Hydrocephalus)

Inclusion criteria in G-walk evaluation: self selected gait speed at least 0.3m/sec (18m/min, 1.080km/h).

Procedure of test execution: subject in spontaneous neutral standing position, linear walking at least over 8 meters. Ask the patient to walk and cover the distance preset at the spontaneous speed selected and then at the best speed reachable.

BTS G-Walk placing: placed over the trunk at L5 level.

Parameters collected in association with BTS G-Walk gait analysis:: perceived safety during walking (score from 0 to 10, 0= no safety, 10= maximum safety); perceived fatigue during walking (score from 0 to 10, 0= no fatigue, 10= maximum fatigue); perceived pain during walking (score from 0 to 10, 0= no pain, 10= maximum pain); if the path is over 50m, capability to maintain a constant acceleration measuring time intervals every 10m.

Indications: gait analysis over subjects affected by walking deficits due to Parkinson's disease at different severity levels adding the possibility to evaluate at several time intervals or instantaneously in different conditions including: functional responses to several types of gait training both in standard conditions and over treadmill with and without partial discharge of body weight, etc.

3 Walking deficits in Multiple Sclerosis

Inclusion criteria in G-walk evaluation: self selected gait speed at least 0.3m/sec (18m/min, 1.080km/h).

Procedure of test execution: subject in spontaneous neutral standing position, linear walking at least over 8 meters. Ask the patient to walk and cover the distance preset at the spontaneous speed selected and then at the best speed reachable.

BTS G-Walk placing: placed over the trunk at L5 level.

Parameters collected in association with BTS G-Walk gait analysis:: perceived safety

during walking (score from 0 to 10, 0= no safety, 10= maximum safety); perceived fatigue during walking (score from 0 to 10, 0= no fatigue, 10= maximum fatigue); perceived pain during walking (score from 0 to 10, 0= no pain, 10= maximum pain); if the path is over 50m, capability to maintain a constant acceleration measuring time intervals every 10m. **Indications:** gait analysis over subjects affected by walking deficits due to demyelinating disease at different severity levels adding the possibility to evaluate at several time intervals or instantaneously in different conditions including: functional responses to several types of gait training both in standard conditions and over treadmill with and without partial discharge of body weight, etc.

ORTHOPAEDIC AND SPORT MEDICINE FIELD

4 Effects of ankle sprain

Inclusion criteria in G-walk evaluation: self selected gait speed at least 0.3m/sec (18m/min).

Procedure of test execution: subject in spontaneous neutral standing position, linear walking at least over 8 meters. Ask the patient to walk and cover the distance preset at the spontaneous speed selected and then at the best speed reachable.

BTS G-Walk placing: placed over the trunk at L5 level.

Parameters collected in association with BTS G-Walk gait analysis:: perceived safety during walking (score from 0 to 10, 0= no safety, 10= maximum safety); perceived fatigue during walking (score from 0 to 10, 0= no fatigue, 10= maximum fatigue); perceived pain during walking (score from 0 to 10, 0= no pain, 10= maximum pain); if the path is over 50m, capability to maintain a constant acceleration measuring time intervals every 10m. **Indications:** gait analysis over subjects affected by walking deficits due to musculoskeletal system traumas at different severity levels adding the possibility to evaluate at several time intervals or instantaneously in different conditions including: functional responses to several

types of gait training both in standard conditions and over treadmill with and without partial discharge of body weight, etc.

5 Patient functional assessment in outcomes of knee sprain and/or surgery

Applicable in patients undergoing surgery for type variable:

- Effects of meniscectomy / meniscal transplantation
- Outcome plastic ligament ACL-PCL
- Outcome of prosthetic surgery

Inclusion criteria in G-walk evaluation: self selected gait speed at least 0.3m/sec (18m/min).

Procedure of test execution: subject in spontaneous neutral standing position, linear walking at least over 8 meters. Ask the patient to walk and cover the distance preset at the spontaneous speed selected and then at the best speed reachable.

BTS G-Walk placing: placed over the trunk at L5 level.

Parameters collected in association with BTS G-Walk gait analysis:: perceived safety during walking (score from 0 to 10, 0= no safety, 10= maximum safety); perceived fatigue during walking (score from 0 to 10, 0= no fatigue, 10= maximum fatigue); perceived pain during walking (score from 0 to 10, 0= no pain, 10= maximum pain); if the path is over 50m, capability to maintain a constant acceleration measuring time intervals every 10m.

Indications: gait analysis over subjects affected by walking deficits due to native or acquired biomechanical vices at different severity levels adding the possibility to evaluate at several time intervals or instantaneously in different conditions including: functional responses to several types of gait training both in standard conditions and over treadmill with and without partial discharge of body weight, etc.

6 Functional evaluation of athletes during agonistic season

Inclusion criteria in G-walk evaluation: self selected gait speed at least 0.3m/sec (18m/min).

Procedure of test execution: subject in spontaneous neutral standing position, linear walking at least over 8 meters. Ask the patient to walk and cover the distance preset at the spontaneous speed selected and then at the best speed reachable.

BTS G-Walk placing: placed over the trunk at L5 level.

Parameters collected in association with BTS G-Walk gait analysis:: perceived safety during walking (score from 0 to 10, 0= no safety, 10= maximum safety); perceived fatigue during walking (score from 0 to 10, 0= no fatigue, 10= maximum fatigue); perceived pain during walking (score from 0 to 10, 0= no pain, 10= maximum pain); if the path is over 50m, capability to maintain a constant acceleration measuring time intervals every 10m.

Indications: gait analysis over athletes with positive anamnesis not for previous acute traumas or coming from overloads. Evaluations aimed at monitoring load symmetry in sports like running and marathon even on different kinds of fields.

Chapter 3

GLOBAL FUNCTIONAL EVALUATION PROTOCOLS ASSOCIATED TO BTS G-WALK

3.1 Dorsum-lumbar and lumbar rachis

In a multidimensional evaluative model of vertebral column mechanical disturbs (back and low back pain); the following clinical argument could be introduced:

In the area of alteration of structures and body functions:

- Quantify the pain using the **VAS** scale 0-100 (soft <20, mild moderate 20-40, moderate 40-60, moderate severe 40-60 e severe >60)
- Quantify the degree of impaired mobility through measurements of objective data such as fingers-ground distance in trunk forward flexion or lateral flexion. In case there is the necessity to quantify the shortening of hamstring we could indicate the deficiency knee ROM in extension with hip flexed to 90° (patient in supine position).
- Quantify the degree of impairment of trunk and pelvis muscles strength and endurance with a simple lower limbs leak test suspended from the bed (keep trunk pelvis at 180°) or more simply bridge the trunk supine, measuring time expenditure in seconds.
- Activity and participation in ADL impairment (see disability) using Roland Morris scale (range 0-24 with a cut-off at 16 to define a level of severe disability) or Oswestry Disability Index (range 0-100 with cut off: 0 - 20 mild disability, 20-40 moderate, 40-60 severe, 60-80 not able, 80/100 bedridden or simulation)

RESUME OF EVALUATION INDEXES

Evaluated dimension	Measuring device	Range
Pain	VAS	0-100
Mobility	Adams Test or trunk lateral flexion	Distance fingers-ground (cm)
Trunk force/endurance	Bridge position	Time interval (sec)
Activities and participation Impairment	Roland Morris or Oswestry Disability Index	0-24 for Roland 0-100 for Oswestry

3.2 Mobility evaluation scale associated to BTS G-Walk system

BODY AND COGNITIVE FUNCTIONS FIELD

1. Hoehn & Yahr scale (range 0-5) is used in multidimensional evaluation protocols of patients affected by Parkinson's disease also for assessing the effectiveness of pharmacological treatments (Munro Neville 2011).
2. The Tinetti scale (range 0-28, cut off for high fall risk if <19 points) has already proven its reliability and repeatability in the qualitative assessment of mobility and risk of accidental falls in parkinsonian patient (Kegelmeyer 2007, Gray 2009, Brusse 2005).
3. The Rivermead Mobility Index is used for the motor quantitative evaluation both in neurodegenerative disease and in elder people (Busse 2004).
4. Rankin scale
5. Expanded Disability Status Scale
6. Walking Handicap Scale

At the end of functional and clinical evaluation, the rehabilitation program can be created according

the most relevant impairment of BODY FUNCTIONS and STRUCTURES (pain, mobility, force-endurance) verifying that the rehabilitative intervention has its own efficacy over the disability.

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BTS Biomedical

headquarters
viale Forlanini 40
20024 Garbagnate M.se MI
Italy
tel +39 02 366 490 00
fax +39 02 366 490 24

R&D centre
via della Croce Rossa 11
35129 Padova PD
Italy
tel +39 049 981 5500
fax +39 049 792 9260

www.btsbioengineering.com
info@bts.it