h/p/cosmos®

biomechanics

gaitway® 3d

highly accurate 3 component force measurement Fz, Fy, Fx

powered by

Arsalis

ahead of time®

Highly accurate 3 component force measurement Fz, Fy, Fx

Gait analysis can provide important information about someone's kinematic and kinetic motion patterns, risk of falling and balance capabilities. Motion laboratories worldwide utilise tools such as 2D or 3D motion capturing systems, EMG, pressure distribution insoles or platforms and force plates to qualify and quantify the overall movement, especially in walking or running. The new h/p/cosmos gaitway® 3d is a powerful, innovative and accurate system in biomechanics not only for analysis but also offering on-line biofeedback for corrections in clinical gait rehabilitation and athletic running applications.

gaitway® 3d

gaitway® 3d is an instrumented treadmill designed jointly by h/p/cosmos and Arsalis. It measures the ground reaction forces in three directions and the position of the centre of pressure and comes in three different different running deck sizes: 150/50, 170/65 or 190/65cm. each size is optimized for a range of speeds.

The gaitway® 3d offers a rigid construction to record optimal quality signals. The functionalities include a patient weighing scale, a recording of the ground reaction forces at rates up to 10 kHz, left and right force measurement for the vertical force during walking and an extensive list of biomechanical parameters of normal and pathological gaits.

The system also offers biofeedback for gait rehabilitation and performance training. Digital start/stop input triggers, digital sync output and analog signal output allow the integration of the gaitway® 3d instrumented treadmill with e.g. EMG and motion analysis systems. The gaitway® 3d software is designed for Windows 7, 8 & 10. Automatic updates allow an easy expansion of the functionalities and customer support.

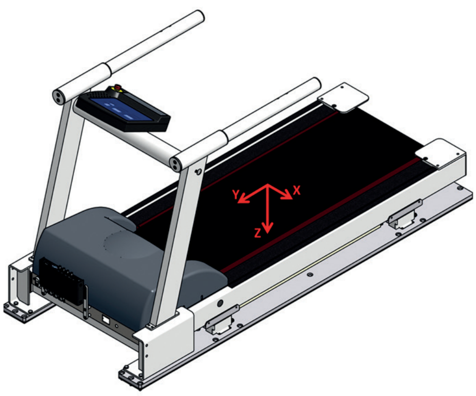
3 component force measurement, Fz, Fy, Fx during running (left) and walking (right) on the gaitway® 3d

Force plates

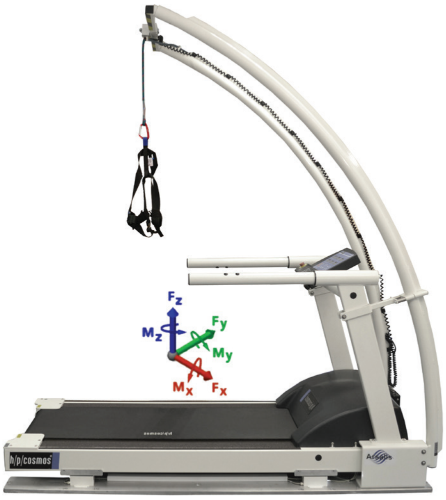
The evaluation of the external forces acting upon each lower limb may be required, for example to estimate the joint forces and moments developed at the ankle, knee and hip by the inverse dynamic method. The most common ways to measure forces is to use force platforms or instrumented treadmills.

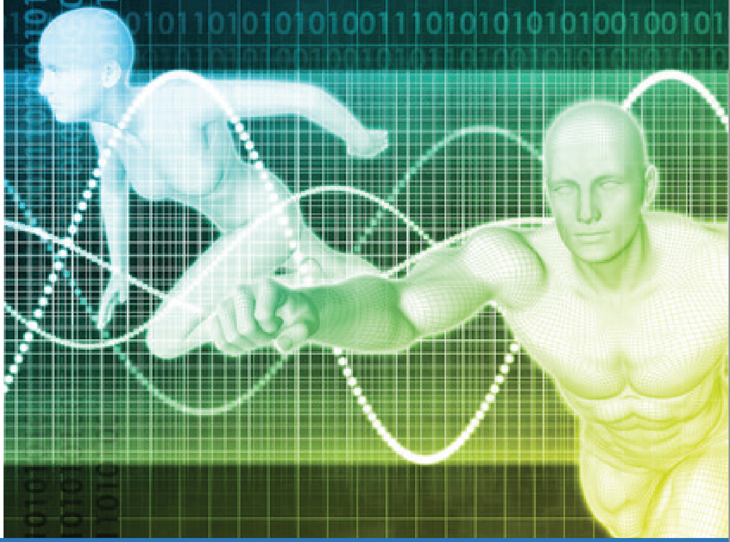
Force platforms can accurately measure the six forces and moment components, but while they offer a lower initial investment, they have some disadvantages. For accurate data collection, it is crucial for the subject to hit the platform, with only one foot. Results will be inaccurate if the subject missee the platform, placed only one part of the foot on it or touched the plate with both feet. This compels the subject to visually place the feet correctly on the force plates. As a result, kinematic and kinetic parameters and especially the variability of the step length will be affected (MEURISSE et al, 2016). OGGERO and colleagues (1998) reviewed their trials, and found that only 25% of their subjects would require three or less trials to obtain an accurate trial of one foot.

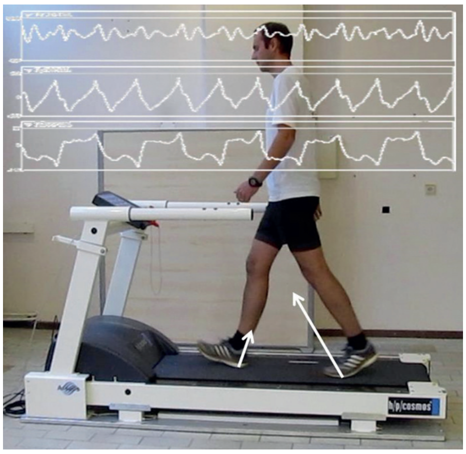
Getting sufficient data for both feet can be therefore very challenging, time consuming, fatiguing and frustrating for investigators and patients and decreases the efficiency of a laboratory. Additionally, a setup utilising force plates requires more space in order to reach and keep a certain speed before hitting the plate. Nevertheless, force plates have to be mounted evenly into the floor, either in a pit our surrounded by a platform, which makes it very difficult to install retrospectively into an existing facility.

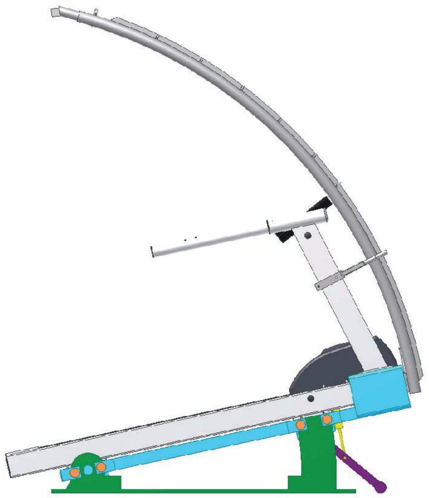


A fall prevention system for a number of patients while they are walking is another crucial demand. The safety arch with harness and chest belt can be installed on the gaitway treadmill series easily and provides the necessary safety and comfort for patients, therapists and scientists to walk as naturally as possible without the fear of falling.

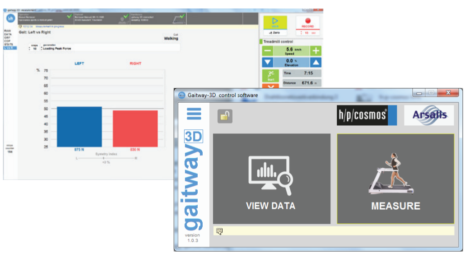








gaitway® with optional elevation



Instrumented treadmills

Nowadays there are different commercial instrumented treadmills available with different specifications. For example, pressure distribution platforms can be integrated underneath the belt of the treadmill. The pressure distribution, various gait and running parameters, COP, foot rotation, pronation, supination, gait symmetry as well as the vertical force can be calculated with the help of this technology (e.g. ZEBRIS).

Furthermore an optometric system like the Optogait (MICROGATE) can be embedded and measures timing and positioning parameters. Measuring forces with strain gauge or piezo-electric load cells, however, is considered to be state of the art and the gold standard in a biomechanical lab. Force measuring treadmills became increasingly common in bio-mechanical laboratories as an alternative to over ground gait analysis, because they allow for measurement of repetitive strides, require less laboratory space and facilitate the measurement of ground reaction forces through the embedded force plates (SLOOT et al., 2014).

The initial higher investment will be balanced by a quicker data acquisition and an improved efficiency of the laboratory. Also notable is the possibility to easily regulate the constant speed of the treadmill, ranging from the gait of an elderly individual to a sprinting healthy athlete.

Especially when it comes to pathological gait and clinical applications such as locomotion therapy, a treadmill is an indispensable tool. Unlike force plates, an instrumented treadmill can record an unlimited number of steps in a safe environment (harness for fall prevention and/or unweighting for partial body weight) on a treadmill. Combined with biofeedback and additional gait support via the robowalk® expander system, a modern instrumented treadmill is by far superior to conventional force plates in almost all gait applications.

Split-belt and fore-aft arranged treadmills

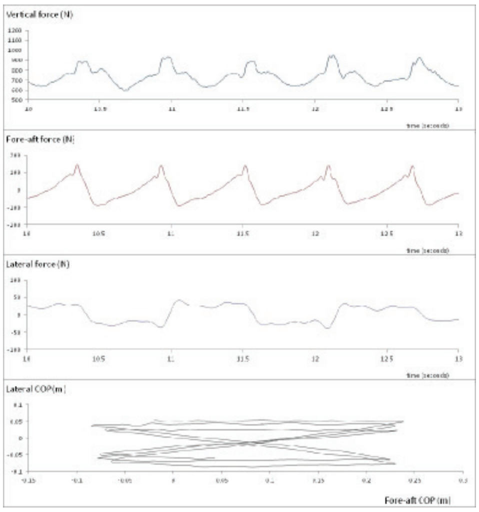
Because of the occurrence of the double contact phase in human walking, some manufacturers of force measuring treadmills followed the idea of measuring separately the forces under the left and the right foot. Some feature a side-by-side and some a fore-aft arrangement of two independent belts with force plates. In both cases, the belt of the treadmill is split, which requires a specific position for the subject on the treadmill, in order to measure the forces distinctly.

This forced position inhibits free and natural movement on a treadmill. For instance, ALTMAN and coworkers (2012) found that the gait width was widened by 3.7 cm, on a side-by-side split-belt treadmill. Moreover, a correlation between this alteration and a reduction in peak knee and hip adduction angle was found.

This may have resulted from the more constrained foot placement required as subjects attempted to keep one foot on each belt. They also noted that the 4 mm gap between the belts on the treadmill used in their study is quite narrow compared to the 1-2 cm gaps of most other split-belt treadmills.

With gaps 3 to 4 times as wide, the effect on base of gait is likely to be even greater, which will have a more significant effect on kinematics at a possibly medically important level. In addition, ZENI and HIGGINSON (2010) concluded in their research, that step width might be the largest concern when using a split-belt treadmill. Furthermore, initial anxiety when walking on a split-belt treadmill, can cause an unnatural gait pattern.

biomechanics



Single belt treadmill

The gaitway® 3d is different and consists of one large single platform that does not have a split belt. It is available in different running deck sizes like 150/50, 170/65 and 190/65 cm. As running consist of single contact phases (just one foot on the ground at a time) the treadmill is perfect to measure forces also at higher speeds. The ample running surface encourages a natural running position. Moving slightly forward or sideward does not affect the measurement accuracy.

Also when walking on the treadmill, the subjects do not need to worry about the position. They are not required to place the heel on the front belt, nor are they forced to hit the right belt with the right foot and vice versa. When walking on a single platform, the load cells will measure a sum of left and right limb forces, but only in the double stance phase. A dedicated algorithm can decompose this sum. The procedure was published some years ago and improved in subsequent years (DAVIS & CAVANAGH, 1993; DIERICK et al, 2004; MEURISSE et al, 2016, RAISON et al, 2005). This algorithm is validated now for both healthy and clinical gait and published in highly rated journals. Someone might say, an algorithm is a mathematical model and all models have their weaknesses. It is true, but the relative error is almost negligible, compared to those resulting from unnatural walking pattern on a split belt treadmill or on regular force plates. For example, MEURISSE et al (2016) validated this algorithm at 374 steps of healthy and 437 steps of clinical gait. Their median of the relative error was 1.8% for the healthy and 2.5% for the clinical gait between the reconstructed and real measured forces. The reconstructed and the real ground reaction forces during double contact phase are strongly correlated for both healthy and clinical gait data.

Special feature biofeedback and self-paced mode

Beside being an accurate measurement system, the gaitway® 3d is also an advanced system in gait therapy. Due to a live biofeedback tool, therapists and patients as well as athletes can see their walking and running symmetry for all gait parameters. E.g. a stroke survivor will see the symmetry of the left and right step lengths or loading forces.

Moreover, some assessments and therapy programs require the patient to walk a self-selected speed (e.g. 6 min walking test). The gaitway® 3d offers a selfpaced mode were the treadmill automatically increased or decreased the speed, depending of the subject´s gait pattern.

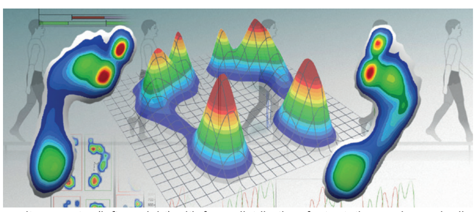
Observations that can be seen by an experienced analyst can be detected by technology. With the external intervention of therapists, orthopedic devices, unweighting systems (h/p/cosmos airwalk® ap) or active gait correction systems like the h/p/cosmos robowalk® expander, someone´s gait or running characteristics can be easily live qualified and step by step normalized.

gait symmetry with bio-feedback left vs. right and on-line active gait correction with robowalk

Optional pressure distribution measurement

Additional value to the gaitway® 3d single belt treadmill developed by h/p/cosmos in co-operation with ARSALIS, can be added by incorporating a pressure distribution platform made by ZEBRIS into the running deck. The pressure distribution assessment adds valuable information such as the COP under each foot during the single and double contact phase, the foot rotation angles and roll off characteristics.

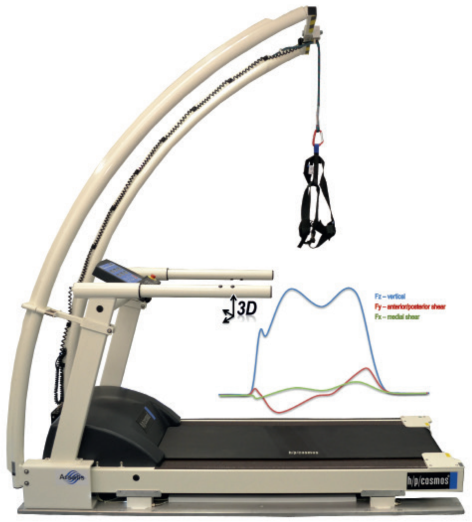
This additional technology in the gaitway® 3d force measuring treadmill is an available option. 3D force measurement plus pressure distribution combined in one system will represent the most advanced treadmill for biomechanics in the world.

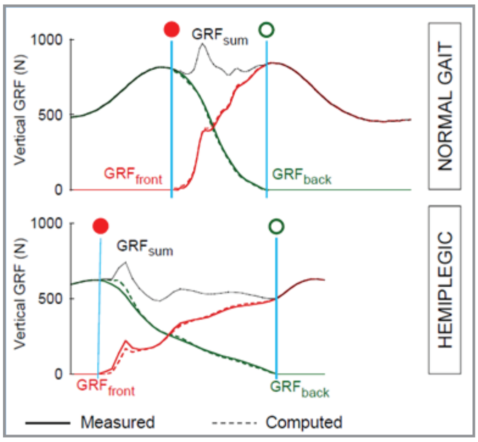


gait symmetry (left vs. right) with force distribution, foot rotation angles and roll off characteristics measured with ZEBRIS pressure distribution option

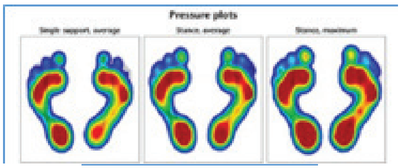
Perfect data from analysis ... and then!?

Nowadays sophisticated analysis tools are available delivering tons of data, graphs, tables and charts indicating asymmetries, imbalances and various problems.
The great challenge that comes after that is, to perform gait correction. For active gait correction h/p/cosmos developed the visual on-line biofeedback and the robowalk expander system, which help patients and therapists to transform the knowledge from the analysis data to a better gait of patients and higher performance of athletes.

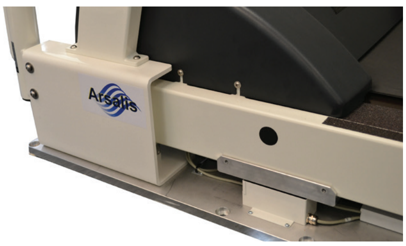




Real (continuous) and reconstructed (dashed) vertical GRFs during double contact. Note that the dashed lines are partially hidden by the continuous lines. The thin continuous line represents the sum of Ffront and Fback (Fsum). The double contact phase is delimited between the front foot contact (plain red circle) and the back foot lift-off (empty green circle)



COP center of pressure, roll-off analysis



Applications

- Biomechanics
- Medical & Sports science and research
- Exercise training in rehabilitation or sports

Functionalities

- Biofeedback to subject
- Data recording & analysis
- Patient evaluation (e.g. for clinical facilities)
- Active gait correction on-line with biofeedback and robowalk®

Measured and computed signals

- Forces in 3 planes / directions (F_z, F_y, F_x)
- Center of pressure (Op_x, Op_y)
- Frictional torque (T_z)
- Belt speed, heart rate

Strengths

- Rigid treadmill construction
- State-of-the-Art sensors
- Lightweight
- Single belt treadmill
- L/R vertical force decomposition algorithm

Opportunities

- Reduction of lab space
- Fast and valid data acquisition
- Increasing technology in health science
- Worldwide distribution network

Biomechanical parameters

- Step length, width, frequency
- Swing / stance durations
- Contact / aerial durations
- Stride asymmetry
- Force peaks (push-off, landing)
- Force vector orientation
- Loading and unloading rate
- Left / right vertical force decomposition
- Many more biomechanical parameters

System performance features

- Extremely wide measuring range
- Excellent measuring accuracy
- Built-in amplifier with acquisition system
- LAN connection
- Control & acquisition Software included
- Start and stop trigger inputs and digital sync output for integration with e.g. EMG and motion analysis systems
- Raw data accessible via interface
- Cost-effective

gaitway® 3d Software allows

- Management of user database
- Control of the treadmill speed
- Monitoring of exercise time, distance and heart rate
- Recording of 3D ground reaction force & treadmill speed
- L/R online decomposition of vertical force
- Automatic updates
- User biofeedback on biomechanical parameters
- Automatic speed control (self-paced mode)

Installation

The base frame will be bolted on the floor. Vibrations of the floor shall be avoided by preferring a location at ground floor without basement and in distance to roads with heavy traffic or railway tracks. Vibrations of handrails and safety arch can be reduced by isolating these components from the main treadmill frame and mount them on a seperate frame.
Installation, commissioning, instruction, maintenance and repair work only to be conducted by h/p/cosmos trained and authorized personnel.

Publications about the gaitway® 3d (short list)

Davis, B. L., & Cavanagh, P. R. (1993). Decomposition of superimposed ground reaction forces into left and right force profiles. Journal of biomechanics, 26(4), 593-597.

Detrembleur, C., & Leemrijse, T. (2009). The effects of total ankle replacement on gait disability: analysis of energetic and mechanical variables. Gait & posture, 29(2), 270-274.

Dierick, F., Penta, M., Renaut, D., & Detrembleur, C. (2004). A force measuring treadmill in clinical gait analysis. Gait & posture, 20(3), 299-303.

Mahaudens, P., Detrembleur, C., Mousny, M., & Banse, X. (2009). Gait in adolescent idiopathic scoliosis: energy cost analysis. European Spine Journal,18(8), 1160-1168.

Meurisse, Dierick, Schepens & Bastien (2016). Determination of the vertical ground reaction forces acting upon individual limbs during healthy and clinical gait. Gait & posture, 43, 245-250.

Pavei, G., Seminati, E., Storniolo, J. L., & Peyré-Tartaruga, L. A. (2016). Estimates of Running Ground Reaction Force Parameters from Motion Analysis. Journal of Applied Biomechanics, 1-21.

Additional References

Altman, Reisman, Higginson & Davis, I. S. (2012). Kinematic comparison of split-belt and single-belt treadmill walking and the effects of accommodation. Gait & posture, 35(2), 287-291.

Davis & Cavanagh (1993). Decomposition of superimposed ground reaction forces into left and right force profiles. Journal of biomechanics, 26(4-5), 593-597.

Oggero, Pagnacco, Morr, Simon & Berme (1998). Probability of valid gait data acquisition using currently available force plates. Biomedical sciences instrumentation, 34, 392-397.

Raison, Detrembleur, Fisette, Penta, Samin & Willems (2005). Determination of ground reaction forces and centres of pressure of both feet during normal walking on a single platform. Computer Methods in Biomechanics and Biomedical Engineering, 8(S1), 227-228.

Sloot, Van der Krogt & Harlaar (2014). Self-paced versus fixed speed treadmill walking. Gait & posture, 39(1), 478-484.

Zeni & Higginson (2010). Gait parameters and stride-to-stride variability during familiarization to walking on a split-belt treadmill. Clinical Biomechanics, 25(4), 383-386.

Specifications h/p/cosmos gaitway® 3d

running machine:	h/p/cosmos stratos® (other models on request)
manufacturer:	h/p/cosmos sports & medical gmbh / Germany
order number:	cos30000va02 (treadmill stratos® sport) cos30000va06 (treadmill stratos® med) cos30003va14 (treadmill stellar® sport) cos30003va18 (treadmill stellar® med) cos30004va03 (treadmill pulsar® med) cos102999_150-50 (upgrade to gaitway® 3d 150/50) cos102999_170-65 (upgrade to gaitway® 3d 170/65) cos102999_190-65 (upgrade to gaitway® 3d 190/65) For medical versions please allow longer delivery times.
running surface:	L: 150 cm W: 50 cm also available L: 170 cm W: 65 cm L: 190 cm W: 65 cm
speed range:	0 ... 22.0 km/h
elevation:	not electr. adjustable, but optionally fixed at e.g. 5% or 10% or 15% or 20%
classification:	scientific instrument device; for medical and therapeutic applications allow longer delivery time
load range on sensors Fx, Fy, Fz:	10 kN
overload (sensors):	24 kN
linearity Fx, Fy: Fz:	 <0.8 % <0.2 %
hysteresis Fx, Fy: Fz:	 <0.8 % <0.2 %

cross-talk Fz → Fx, Fy:	 <2.0 %
drift Fx, Fy, Fz:	 <0.05 N/min
natural frequency Fx: Fy, Fz:	 55 Hz 65 Hz
interfaces:	built-in amplifier ethernet interface analog / digital interface start & stop digital input triggers and digital sync output serial port RS232 for treadmill control via coscom v3 interface
accessories (extra charge):	safety arch fall stop [cos10079] for 150/50] safety arch fall stop [cos10170] for 170&190/65] detachable handrails [cos100742_170-65lt1p] detachable handrails [cos100742_170-65lt3p] science port for raw speed data [cos101277] special speed 0 - 10 km/h 150/50 [cos10000] Special speed 0 - 25 km/h 190/65-3p [cos12995p3p] Special speed 0 - 40 km/h 170/65 [cos10158] Special speed 0 - 45 km/h 190/65-3p [cos10159va06] non-reflecting powder coating [cos102465ralxxxx]
temperature operation temperature storage:	10...40 °C -25...40 °C
operating humidity storage humidity:	30...70 % (non condensing) / 0...95 % (non condensing)
air pressure:	700...1060 hPa (max 3000m altitude)
audible noise:	noise emission LpA < 70 dB(A) (63dB) acc. EN957-6
resolution:	adjustable (12-375 mN/bit)
measurement range:	adjustable (375-12000 N)
sampling rate:	adjustable (100-10.000 Hz)

Contact:

h/p/cosmos sports & medical gmbh
Am Sportplatz 8
83365 Nussdorf-Traunstein
Germany
Phone: +49 86 69 86 42 0
Fax: +49 86 69 86 42 49
Email sales@h-p-cosmos.com
Web: www.h-p-cosmos.com

Dealer stamp: