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Gait Analyser

Description of Walking Performance

This brochure will help you to understand clearly the parameters described in the report of the Gait Analyser, provide you with tips to implement the walking trials, and support you for the interpretation of the walking performances of your patients. Some parameters have been shown to be relevant and interesting for patients with particular conditions. The following pictograms will suggest them to you:

Parkinson

Stroke

Elderly

Cerebral Palsy

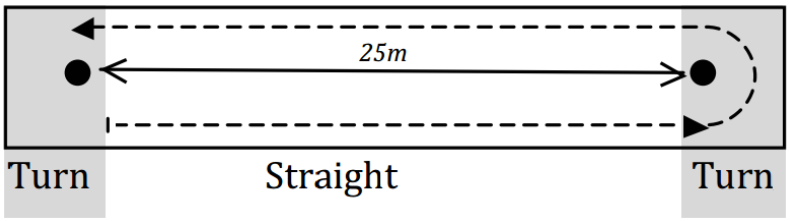
Orthopaedic

⚠ *Note: These pictograms are provided for information purposes and should not be considered as diagnostic. They are based on independent findings from the literature but may not reflect an exhaustive evaluation of motor symptoms of the above-mentioned mobility diseases.*

Walking protocol recommendations

In general, if you wish to study several types of walking exercises, it is better to record one file per exercise, instead of diverse types of exercises in a single file. This will allow clearer statistical understanding of the walking performances for each exercise.

Here is a very simple typical gait test that can be performed in a corridor. The distance can be shortened if required by the subject's disability, or extended to better study long-term stride-to-stride fluctuations:



If you wish to evaluate accurate forward gait performances without extrinsic variations due to turns and initiation & termination, these should be discarded; tick "Discard Turns" and "Discard Initiation & Termination" (we recommend to discard two steps for initiation and termination – Yuancheng J. et. al 1993) in the option menu of the software prior to performing data analysis.

To study walking movement during the figure of eight exercise, do not discard the turns.

⚠ *Note that the following descriptions are relevant when the patient walks freely.*

⚠ *The algorithm is robust for gait activity on flat ground, not for stair climbing, walking on slopes, running, or any other type of activity.*

Essentials

Speed, the walking stride velocity is the mean speed of forward walking, calculated in meters per second.

When no specific instructions are given during the gait test, walking speed reflects spontaneous self-selected speed of the subject, and thus provides a general information about his/her walking performance. In addition to the colour code provided by the software, the following table gives typical figures related to gait speed:

Gait Speed (m/s)	Interpretation
> 1.30	Comfortable speed for Men up to their 70s, Women up to their 50s*
> 1.25	Comfortable speed for Women up to their 70s*
> 1.22	Sufficient speed to cross the street **
< 0.6	Predicts future risks of falls & hospitalizations***

* Bohannon et al., 1997 ** Langlois et al., 1997 *** Studenski et al., 2003

It has been shown that 5 years survival rate can be predicted from gait speed, age, and gender for patients above 65 y.o. (Studenski et al., 2011).

⚠ Speed can also be normalized to gender and/or height in order to compare different groups of subjects.

Variability is the coefficient of variation of cycle duration in percent.

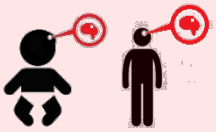
Young and healthy elderly have been shown to have a typical variability around 2 to 3% (Hausdorff et al., 1998). Lower variability can be interpreted as “rigidity”, whereas higher variability can be seen as “instability”.

This parameter has been shown to be interesting in particular to evaluate Parkinson’s disease progression (Hausdorff et al. 2006, Hausdorff et al. 2009), and to predict the risk of fall for elderly patients (Hausdorff et al., 2001).

⚠ Note that this parameter is only significant in a protocol where the subject walks freely for a substantial duration (typically more than 20 cycles) (Lindemann et al., 2008).

Symmetry is the ratio of swing times which compares the time in the air for the two feet, in percent.

It has been shown that mean swing time ratio is the most significant parameter to study symmetry. It has been shown to be typically around 1.02% for healthy people, and around 1.23% stroke patients (Patterson et al., 2012)



This parameter has been shown to be interesting to evaluate the functional progression of gait in patients with Stroke (Petterson et al., 2008). It has also been studied in children with Cerebral Palsy (Prosser et al., 2010)

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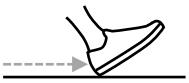
Temporal

Cycle time is the absolute time when the heel strikes the ground. If you are recording a trial with several exercises of particular duration (30s, 1mn,…), it can help you find the moment where the patient changes exercise within the entire trial.



Cycle duration is the duration of one cycle. The two feet should have similar cycle durations. If they don't, it may be that the patient presents a shuffling gait.

Cadence is the number of cycles in a minute. Cadence is different from speed, since a small person may have to walk with a higher cadence to have the same speed than a much taller person. Cadence has been shown to be a stable parameter over age (Winter et al., 1990).

Stance is the portion of the cycle during which part of the foot touches the ground. Normal stance is around 60% of gait cycle duration. Stance can be divided into three phases: Loading, Foot flat and Push. Frail patients tend to increase their stance for safety.

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Swing is the portion of the cycle during which the foot is in the air and does not touch the ground. Normal swing is about 40% of gait cycle duration. Swing may be increased for example when there is an important lateral excursion (circumduction) and its asymmetry may be associated with limping. See "**Symmetry**" in essentials.

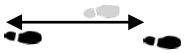
Loading phase is the portion of the stance between the heel strike and the foot being flat on the ground.

Foot-flat phase is the portion of the stance where the foot is fully flat on the ground. Frail patients may tend to increase their foot flat period since it is the most stable (e.g. safer) phase of the walk.

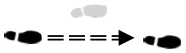
Pushing phase is the portion of the stance between the foot being flat on the ground and the toe leaving the ground at take-off.

Double support is the portion of the cycle where both feet touch the ground. This parameter may increase oppositely to speed, in order to increase patient's stability during walking (longer time spent with both feet still on the ground).

Spatial



Stride Length describes the distance between two successive footprints on the ground, from the heel of a foot to the heel of the same foot, one cycle after. This parameter may be strongly influenced by anthropometric factors: if the subject is tall, he may have a higher stride length.



Stride Velocity is the forward speed of one cycle. It is a general measure of subject's fitness since higher speed is a marker of more confidence and physical ability. See "**Speed**" in essentials.

Peak Angle Velocity is the maximum angular velocity during the swing phase, between max heel clearance and min toe clearance. Measured by the gyroscopes, this parameter is a raw sensor measure which is not subject to any calculation errors. It can be used as a robust asymmetry measure.

Maximal Swing Speed is the maximum forward speed of the foot during swing. This speed is usually obtained around minimal toe clearance and may be seen as a risk factor for obstacle avoidance. The faster it is, the stronger the patient might hit an obstacle. It is usually equal to more than3 times walking speed.

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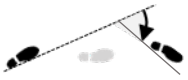
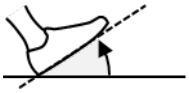
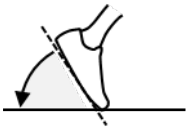


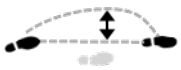
Turning Angle is the angle between two consecutive foot-flat phases of the same foot on a horizontal plane. When this parameter is above 20° for one cycle, it is considered as a turn. It can be discarded to evaluate only straight walking (see "**walking protocol recommendations**"). Many parameters tend to change during turns, and Parkinson patients usually show longer turning time.



Strike Angle is the angle between the foot and the ground at heel strike, on a vertical plane. A low strike angle (e.g. close to 0) is a strong sign of foot drop syndrome.



Lift off Angle is the angle of the foot at the end of the push phase, just at take-off. For patient with osteoarthritis, it is particularly painful to increase this angle and in general, lower values are observed.



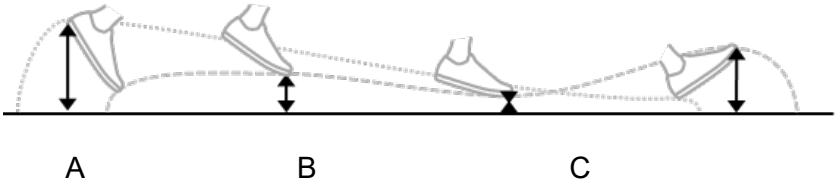
Swing Width is the maximal lateral excursion of the foot during swing phase. It is the maximum lateral distance between the forward path and the real path of the foot. Increased swing width has been shown to be associated with circumduction, and may be observed in patients with neuromotor disorders.

3D Path Length is the length of the real path of the foot during one cycle in 3D space, including both stride length and swing width. Like swing width, this parameter has been used to quantify circumduction.

Clearance

⚠ Note that clearance parameters are accurate when shoe size (not foot size) is entered in the menu of the software prior to performing data analysis.

⚠ Clearance calculation is based on a biomechanical model and may not be estimated in case of severe gait pattern alterations (shuffling etc…), See Mariani et al., 2012 and Dadashi et al., 2014.



A: Max. Heel Clearance is the maximal height above the ground reached by the heel during each cycle.

B: Max. Toe Clearance 1 is the maximal height above the ground reached by the toes just after heel max clearance.

C: Min. Toe Clearance is the minimum height of the toes during swing phase. Low min toe clearance can be seen as an obvious risk for tripping (Begg et al., 2007), and recent work tend to show that its variability may be associated with the risk of fall.

D: Max. Toe Clearance 2 is the maximal height above the ground reached by the toes just before heel strike. A low or a negative max. toe clearance 2 may suggest of a foot drop syndrome.

Statistics

⚠ Note that if you ticked “Discard turns” and/or “Discard Initiation & Termination” in the option menu prior to analysis, turn cycles & cycles of initiation and termination are excluded from the statistical analysis.

Mean is the mean of the parameter among all cycles.

Median is the median (value such that half of all values are higher and the other half lower than this value) of the parameter among all cycles. This measure is more robust against outliers than the mean.

STD, the standard deviation, describes the variation or dispersion of the data from the average. A small SDT indicates that the values are all located in a small range. A high STD indicates a high variability of the parameter. The STD is used for statistical descriptions together with the mean.

IQR, the interquartile range, is also a measure of statistical dispersion, based on quartiles. The IQR is used for statistical descriptions together with the median.

Min is the minimum reached by the parameter amongst all cycles.

Max is the maximum reached by the parameter amongst all cycles.

Ratio is the ratio, for a particular parameter of one foot on the other, it shows whether the two feet behave the same way (~1) or not.

CV, the coefficient of variation is also a measure of dispersion. Note that it is not calculated when less than 10 cycles are recorded.