

Temporal Distance Calculations for Gait

Visual3D calculates a set of for temporal and distance information based on a set of 4 gait events (Right and Left Heel Strike and Toe Off). These spatiotemporal metrics are part of the common cohort of [Gait Parameters](#).

Notes:

- If the Events do not exist, the metrics will return values of zero.
- If a Right and Left foot segment do not exist, stride length and stride width cannot be computed.
- The treadmill unit vector refers to the Anterior Direction of walking.

Metric_Compute_Temporal_Distance

```
Metric_Compute_Temporal_Distance
! /GLOBAL_RESULT_METRIC_FOLDER=TEMPORAL_DISTANCE
! /CALCULATE_PER_FILE=FALSE
! /CREATE_ALL_INSTANCES=FALSE
! /RIGHT_FOOT_LOCATION=KINETIC_KINEMATIC::RFT::ProxEndPos
! /LEFT_FOOT_LOCATION=KINETIC_KINEMATIC::LFT::ProxEndPos
! /HEIGHT=METRIC::PROCESSED::HEIGHT
/RHS_EVENT=RHS
/LHS_EVENT=LHS
/RTO_EVENT=RTO
/LTO_EVENT=LTO
! /STRICT_EVENT_SEQUENCE_VALIDATION=FALSE
! /INCLUDE_EVENTS=
! /EXCLUDE_EVENTS=
! /EVENT_INSTANCE=0
! /COMPUTE_SPEED=TRUE
! /COMPUTE_STATUSES_PER_SECOND=TRUE
! /COMPUTE_STRIDE_WIDTH=TRUE
! /COMPUTE_STRIDE_LENGTH=TRUE
! /COMPUTE_CYCLE_TIME=TRUE
! /COMPUTE_STEP_LENGTH=TRUE
! /COMPUTE_STEP_TIME=TRUE
! /COMPUTE_STANCE_TIME=TRUE
! /COMPUTE_SWING_TIME=TRUE
! /COMPUTE_STEPS_PER_MINUTE=TRUE
! /COMPUTE_STRIDES_PER_MINUTE=TRUE
! /COMPUTE_DOUBLE_LIMB_SUPPORT_TIME=TRUE
! /COMPUTE_RIGHT_INITIAL_DOUBLE_LIMB_SUPPORT_TIME=TRUE
! /COMPUTE_RIGHT_TERMINAL_DOUBLE_LIMB_SUPPORT_TIME=TRUE
! /TREADMILL_SPEED=
! /LEFT_TREADMILL_SPEED=
```

! /TREADMILL_DIRECTION=

Temporal Distance Dialog

Edit Temporal Distance Properties

Files for computing temporal distance

☐ Calculate For Each File

☐ Calculate For All Cmo Globals

☐ Create All Instances

- The default command will create average temporal distance values for the ACTIVE files and results can be found in the GLOBAL workspace

- **Calculate For Each File:** Calculate average values across entire trial

- **Create All Instances:** value for each sequence (multiple values per trial)

NOTE: To use the Calculate For Each File option, Calculate for Each Trial must be selected as well.

Right Foot Location

KINETIC_KINEMATIC::RFT::ProxEndPos

Left Foot Location

KINETIC_KINEMATIC::LFT::ProxEndPos

Height

METRIC::PROCESSED::HEIGHT

- If the user would like to define temporal distance metrics using a signal other than the default signal (such as the proximal end of the foot), the user can select a different signal (such as the heel target).

- The height is used to calculate [statures/second](#)

Temporal Distance Item Properties

☐ Use strict event label sequence validation

Left Heel Strike Label

LHS

Left Toe Off Label

LTO

Right Heel Strike Label

RHS

Right Toe Off Label

RTO

Select Temporal Distance Items to report

COMPUTE_CYCLE_TIME

COMPUTE_STEP_LENGTH

COMPUTE_STEP_TIME

COMPUTE_STANCE_TIME

COMPUTE_SWING_TIME

COMPUTE_STEPS_PER_MINUTE

COMPUTE_STRIDES_PER_MINUTE

COMPUTE_DOUBLE_TIME_SUPPORT_TIME

- The event labels may be changed to any events desired.

- Selecting **Strict Event Label Sequence** will create temporal distance measures for events that occur within a gait cycle. For example Swing Time which occurs between RTO and RHS will only be calculated if the event sequence is RHS+RTO+RHS.

- Explanations of the calculations of the temporal distance items can be found [here](#).

Range of Frames from which the temporal distance metrics are computed

Defined Events

FP3_Y

FP3_Y_ENSURE

LHS

LOFF

LON

LTO

RHS

RHS_BTWN

RKFlex_Max

>>

<<

>>

<<

Event Sequence Instance

0

Exclude sequences containing these events

- **Event Instance:** 0 indicates all instances, 1 indicates the first event sequence

- **Exclude Sequence:** Creating an event BAD would exclude the trial during which the event occurred

Treadmill Direction is the Path of Progression Along the Treadmill Belt

☐ Use Split Belt Speeds

Direction

Speed

Results Folder

TEMPORAL_DISTANCE

- The treadmill unit vector refers to the direction the subject would have been progressing in the lab if there were no treadmill

- Speed (positive), (left/right/average) stride and step length, and statures/second are dependent on belt speed

Wiki Documentation Site - <https://has-motion.com/wiki/>

Results Folder TEMPORAL_DISTANCE	- The result folder may have any name and will be a subfolder of the METRIC folder.
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Report TD Horizontal Chart

Temporal Distance Data

Speed	1.29 m/s	0.00 st/s
Stride	Wid(2) 0.135±0.003m	Len(2) 1.314±0.041m
Cycle Time	Computed: 1.03 s	Actual (2) 1.02±0.03 s
Measure±StdDev (Count)		Measure±StdDev (Count)
Left : 0.637±0.041 m (2)	Step Length	Right : 0.627±0.000 m (1)
Left : 0.50±0.03 s (2)	Step Time	Right : 0.52±0.00 s (1)
Left Stance 0.62±0.00 s (1)	Stance/Swing Time	Left Swing 0.42±0.00 s (1)
Right Stance 0.60±0.00 s (1)	Stance/Swing Time	Right Swing 0.40±0.00 s (1)
Left : 0.62±0.00 s (1)	Stance Time	Right : 0.60±0.00 s (1)
Left : 0.42±0.00 s (1)	Swing Time	Right : 0.40±0.00 s (1)
Double Limb Support Time (3)		0.21±0.01 s
Right Initial Double Limb Support Time (1)		0.10±0.00 s
Right Terminal Double Limb Support Time (2)		0.11±0.01 s

Report TD Vertical Chart

This chart has the option of linking to a control data set. **Control Data Folder**

The name of the metric is the same as the Temporal Distance metric signal names created automatically for the report (only the suffix MEAN is removed)

There are many ways to create these GLOBAL METRIC signals, but many labs have numbers hard coded.

The following example will create a metric signal with 3 components (mean, min, max)

Evaluate_Expression

```

/EXPRESSION=VECTOR(113.6,99.6,127.6)
! /SIGNAL_TYPES=
! /SIGNAL_FOLDER=ORIGINAL
! /SIGNAL_NAMES=
/RESULT_TYPES=METRIC
/RESULT_FOLDERS=CONTROL_TEMPORAL_DISTANCE
/RESULT_NAME=STEPS_PER_MINUTE
! /APPLY_AS_SUFFIX_TO_SIGNAL_NAME=FALSE
;

```

Edit Temporal Distance Properties

Files for computing temporal distance

ALL_FILES

Control Data Folder: METRIC::CONTROL_TEMPORAL_DISTANCE

Right Foot Location: KINETIC_KINEMATIC::RFT::ProxEndPos

Left Foot Location: KINETIC_KINEMATIC::LFT::ProxEndPos

Height: METRIC::PROCESSED::HEIGHT

Temporal Distance Item Properties

☒ Use strict event label sequence validation

Left Heel Strike Label: LHS

Left Toe Off Label: LTO

Right Heel Strike Label: RHS

Right Toe Off Label: RTO

Select Temporal Distance Items to report

- Left Stance Time / Left Swing Time
- Right Stance Time / Right Swing Time
- Left Stance Time / Right Stance Time
- Left Swing Time / Right Swing Time
- Left Cycle Time / Right Cycle Time
- Left Steps per Minute / Right Steps per Minute
- Left Strides per Minute / Right Strides per Minute

Range of Frames from which the temporal distance metrics are computed

Defined Events: END, LHS, LOFF, LON, LTO, RHS, ROFF, RON

Range Instance: 0

Exclude ranges containing these events

Treadmill Speed (m/s) Direction (e.g. UNIT_VECTOR(0,1,0)) ☐ Use Split Belt Speeds

Direction: DERIVED::DIRECTION::RIGHT

Speed: DERIVED::VELOCITY::RIGHT

Report Graph Title: Temporal Distance Data

Pos. Span

Column: 1 1

Row: 1 1

Page: 1

Distance: 3

Time Precision: 2

☐ Table Format

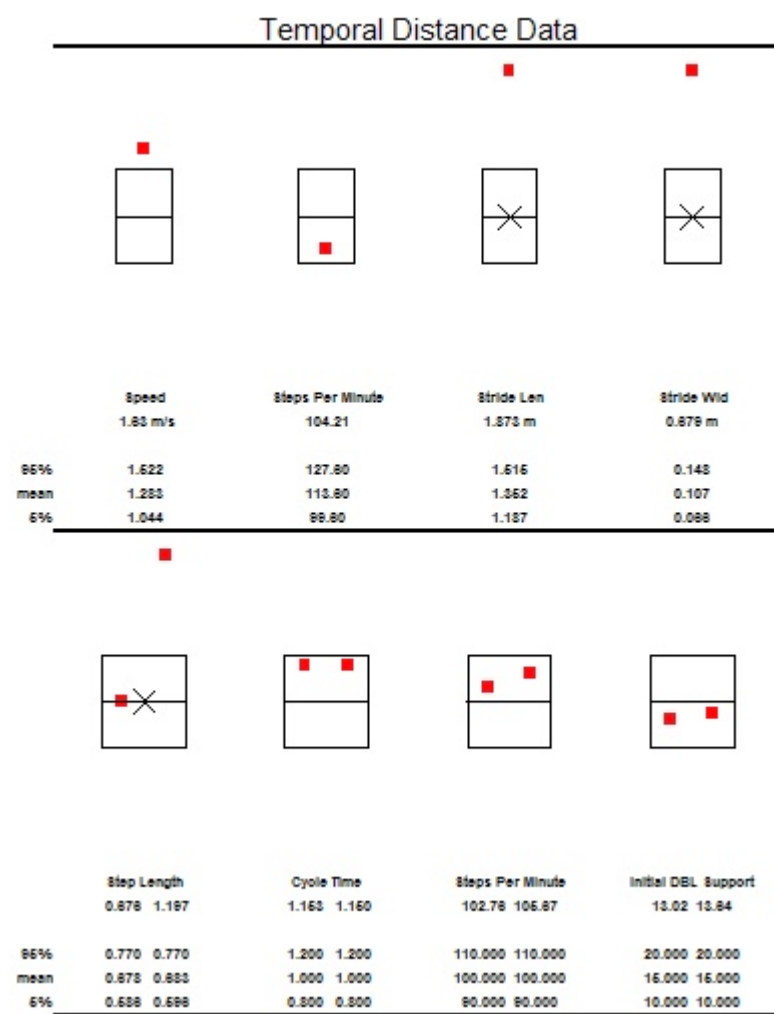
☐ Horizontal Bar Chart Format

☒ Vertical Bar Chart Format

Done Cancel

Note the selection of the Global Control Data Folder near the top of the dialog

Note the selection of the vertical bars at the bottom right of the dialog.



Metrics Computed

The temporal distance calculations use snippets of the gait cycle to compute averages for each part. If a range is missing, that part will not be calculated.

Stance Time

The stance time for a given side of the body is the portion of the gait cycle when that side's leg is in contact with the ground. It is calculated as the time from that foot's heel strike event to its toe off event.

Right Stance Time = RHS-RTO

Left Stance Time= LHS-LTO

Swing Time

The swing time for a given side of the body is the portion of the gait cycle when that side's leg is not

contacting the ground. It is calculated as the time from that foot's toe off event to its heel strike event.

Right Swing Time= RTO-RHS

Left Swing Time= LTO-LHS

Step Time

The step time for a given side of the body is the portion of the gait cycle between the opposite side's heel strike event and the given side's heel strike event.

Right Step Time= LHS-RHS

Left Step Time= RHS-LHS

Double Limb Support Time

The double limb support time for a gait cycle is the total time where both feet are in contact with the ground. This is the sum of an initial double limb support phase and a terminal double limb support phase.

Right Initial Double Limb= RHS to LTO

Right Terminal Double Limb= LHS to RTO

The global mean double limb support time (stored in the global workspace as METRIC::TEMPORAL_DISTANCE::Double_Limb_Support_Time_Ave) is calculated via a two-step process. First, the mean Right_Initial_Double_Limb_Support_Time and the mean Right_Terminal_Double_Limb_Support_Time are calculated. Second, these two times are then summed to represent the average time spent during the double limb support phases throughout an entire gait cycle. This calculation captures that during a gait cycle there are two phases during which the individual is supported by both limbs: from RHS to LTO and from LHS to RTO.

Note:

Left Initial Double Limb Support (stance) = Right Terminal Double Limb Support (stance)

Left Terminal Double Limb Support (stance) = Right Initial Double Limb Support (stance)

Cycle Time

Cycle time is computed as an actual and computed. Actual uses the actual stride length / stride time. Computed speed uses the average of all the parts of the gait cycle which are seen, and sums up the parts. This is more accurate since more parts are used in the computation, and can provide a measure even if a full stride is not present in the data (RHS-RHS or LHS-LHS).

Flight Time

Flight time is the average time from LTO to RHS (ensuring no LHS or RTO events occur between LTO and RHS) and RTO to LHS (ensuring no RHS or LTO events occur between RTO and LHS).

Left flight time is calculated from LTO to RHS.

Right flight time is calculated from RTO to LHS.

Stride Length

Stride length is the distance between proximal end position of the foot at ipsilateral heel strike to the proximal end position of the foot at the next ipsilateral heel strike. Stride length and width requires a walking direction to be computed, so at least 1 completed stride needs to be present.

Right Stride Length

Right Stride length is defined as the length of the Right Stride vector from the Proximal End of the Right Foot Segment at successive RHS events

Right Stride Length Count is the number of Right Strides.

Left Stride Length

Left Stride length is defined as the length of the Left Stride vector from the Proximal End of the Left Foot Segment at successive LHS events.

Left Stride Length Count is the number of Right Strides.

Stride Length Count

Stride Length Count is the sum of Right Stride length Count and Left Stride Length Count.

Treadmill

If the person is walking on a treadmill, the distance travelled by the belt is added to the measured distance.

Stride Width

Stride width is the medio-lateral distance between proximal end position of the foot at ipsilateral heel strike to the proximal end position of the foot at the next contralateral heel strike. Calculated by

taking a stride vector, and the step in between, and computing the cross product (distance between the stride vector and the opposing step (heel) position

Left Stride Width is the perpendicular distance from the proximal end of the Left foot segment to the Right Stride vector.

Right Stride Width is the perpendicular distance from the proximal end of the Right foot segment to the Left Stride vector.

We don't actually report (or store) a left and right stride width, but rather an average stride width.

Step Length

Step length is the distance between proximal end position of the contralateral foot at the previous contralateral heel strike to the proximal end position of the ipsilateral foot at the ipsilateral heel strike. This is calculated as the distance in the walking path direction.

If the person is walking on a treadmill, the distance traveled by the belt under the stance foot is added to the measured distance.

Speed

Speed is computed using the actual stride length / actual stride time. If there are no completed strides, no speed can be computed since the stride distance can't be computed using parts.

Statures/Second

Average speed divided by the subject height

Cadence

Cadence is the rate at which a person walks, expressed in steps per minute.

In other words:

Left Steps Per Minute = $60 / \text{Left Step Time}$

Right Steps Per Minute = $60 / \text{Right Step Time}$

Changing the text in the temporal distance chart

In the folder in which you have placed Visual3D.exe, you should find a folder labeled [config](#). Inside this folder you will find a file labeled **custom_text.ini**

The contents of this ini file containing a mapping from the text used internally in Visual3D to the text

that appears in the report graph.

The text appearing to the right of the “=” sign appears in the report.

The default config file looks like this.

Temporal Distance

Step Length Prompt=Left Step Length / Right Step Length

Step Time Prompt=Left Step Time / Right Step Time

Left Side Time Prompt=Left Stance Time / Left Swing Time

Right Side Time Prompt=Right Stance Time / Right Swing Time

Stance Time Prompt=Left Stance Time / Right Stance Time

Swing Time Prompt=Left Swing Time / Right Swing Time

Cycle Time Prompt=Left Cycle Time / Right Cycle Time

Steps per Minute Prompt=Left Steps per Minute / Right Steps per Minute

Strides per Minute Prompt=Left Strides per Minute / Right Strides per Minute

Speed=Speed

Stride=Stride

Width=Wid

Length=Len **Cycle Time**=Cycle Time

Computed=Computed

Actual=Actual

Measure=Measure

StdDev=StdDev

Left=Left

Right=Right

Step Length=Step Length

Step Time=Step Time

Stance Swing Time=Stance/Swing Time

Left Stance=Left Stance

Left Swing=Left Swing

Right Stance=Right Stance

Right Swing=Right Swing

Stance Time=Stance Time

Swing Time=Swing Time

Double Limb Support Time=Double Limb Support Time

Right Initial Double Limb Support Time=Right Initial Double Limb Support Time

Right Terminal Double Limb Support Time=Right Terminal Double Limb Support Time

Flight Time=Flight Time

Subject computation using subject name/prefix parameters

Visual3D is in the process of supporting multiple subjects within the same workspace, and across CMO/Z library workspaces. Older versions of Visual3D will not support the subject prefix extensions of this command.

When using a version of Visual3D prior to implementing multisubject support, Visual3D treats each CMO/Z file as a single subject. In this way, the temporal and distance metrics are computed in the

CMO/Z GLOBAL for the subject processed within that CMO. In the same manner, when computing the temporal and distance metrics across a library of subjects, each CMO/Z is treated as a single subject and then the subject averages are computed across CMO/Z files and placed into the workspace GLOBAL for the overall mean values across subjects.

Visual3D with multisubject support extends these metric calculations to be computed for each subject that is identified in the .C3D parameters SUBJECT section. In this way, the a single CMO/Z GLOBAL will contain the computed metrics for each subject within the CMO/Z file, prefixed with the subject's prefix identifier contained in the .C3D parameters. The GLOBAL of the CMO/Z will also contain an unprefixed set of metrics for the average across the subjects contained inside the CMO/Z file.

When working across CMO/Z files in the CMO/Z library, multisubject support for this command will treat each subject mean in each CMO/Z file as separate subject averages to be included for calculating the temporal and distance metric averages across all the subjects in the CMO/Z library.

Mimicking the Command

Mimicking the Temporal Distance Calculations with Metrics

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