

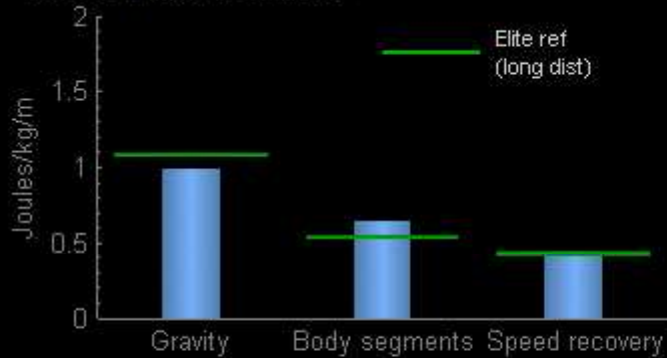
Test results for Diogo Custódio

Date: 17 Dec 2018 Time: 11:47 AM Speed: 15 km/h

Note from your service provider:
No note written

RUNNING PERFORMANCE @ 15 km/h

MECHANICAL WORK



ELASTIC EXCHANGE

Excellent: >35%
Good: 25-35%
Average: 15-25%
Poor: <15%



ECONOMY

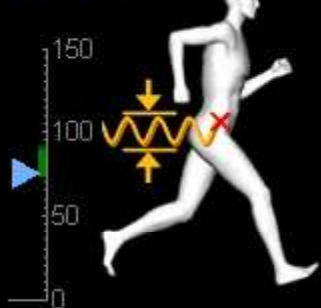
2.94
Joules/kg/m



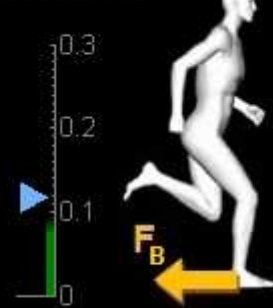
Stride Parameters



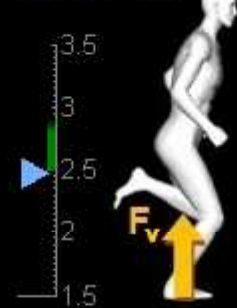
Vertical Displacement
75.1 mm



Braking Force (max)
0.12 Fv



Vertical Force (max)
2.46 BW



Lateral Force (max)
0.024 Fv



Stride Rating: **3.8 / 5.0**

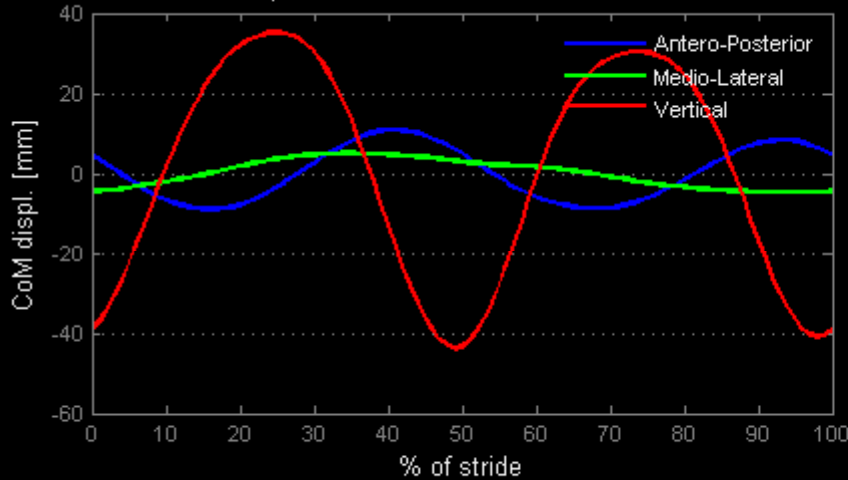


Test results for Diogo Custódio

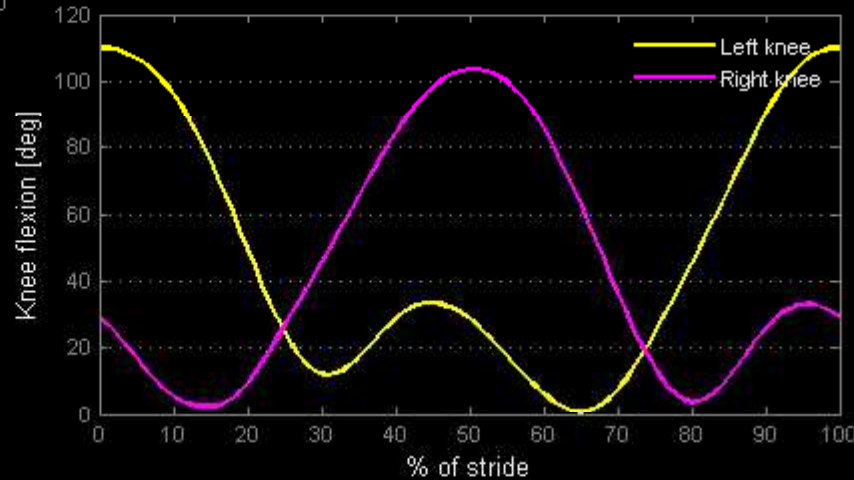
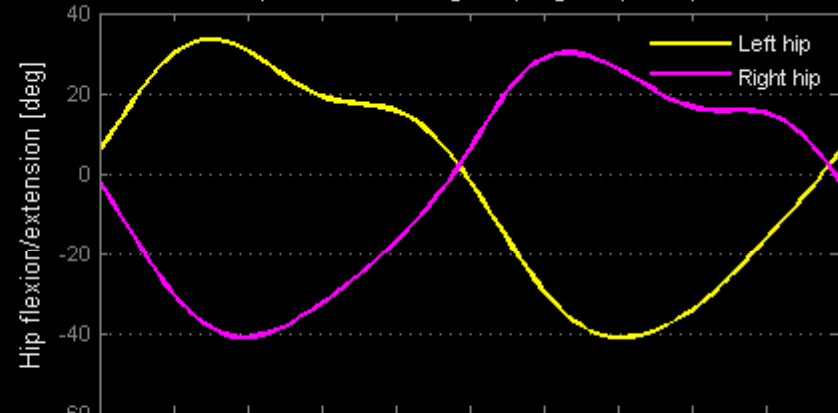
Date: 17 Dec 2018 Time: 11:47 AM Speed: 15 km/h

GAIT CHARACTERISTICS @ 15 km/h

Displacement of the Center of Mass



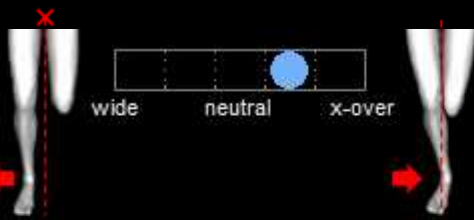
Hip and Knee angles (sagittal plane)



Frontal Plane Alignment

Step Separation

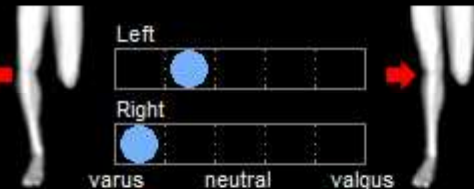
19 mm



Knee Alignment @ mid-stance

Left: **0.0°**

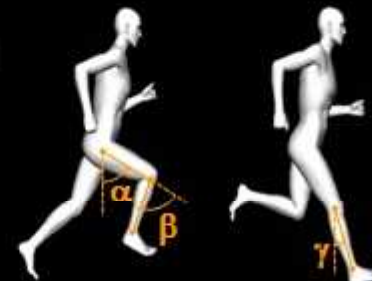
Right: **-1.4°**



Sagittal Plane Parameters

Parameter	Mean (Left/Right)	ref. Mean (L/R)	Elite Mean	diff Elite
Max Thigh Flexion [deg]	31.8 (33.5/30.1)		36.5	-4.7
Max Thigh Extension [deg]	41.1 (41.2/41.1)		29.7	11.5
Shank angle @ touch-down [deg]	5.8 (2.8/8.9)		1.7	4.1
Knee Flexion @ touch-down [deg]	10.8 (14.8/6.8)		17.2	-6.4
Max Knee Flexion @ stance [deg]	33.3 (33.5/33.1)		37.8	-4.5
Max Knee Flexion @ swing [deg]	106.8 (110.0/103.6)		112.1	-5.3

Symmetry Rating



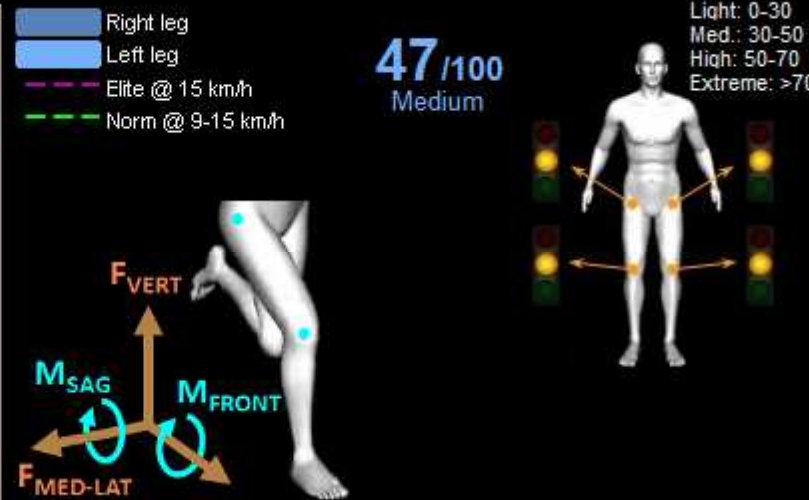
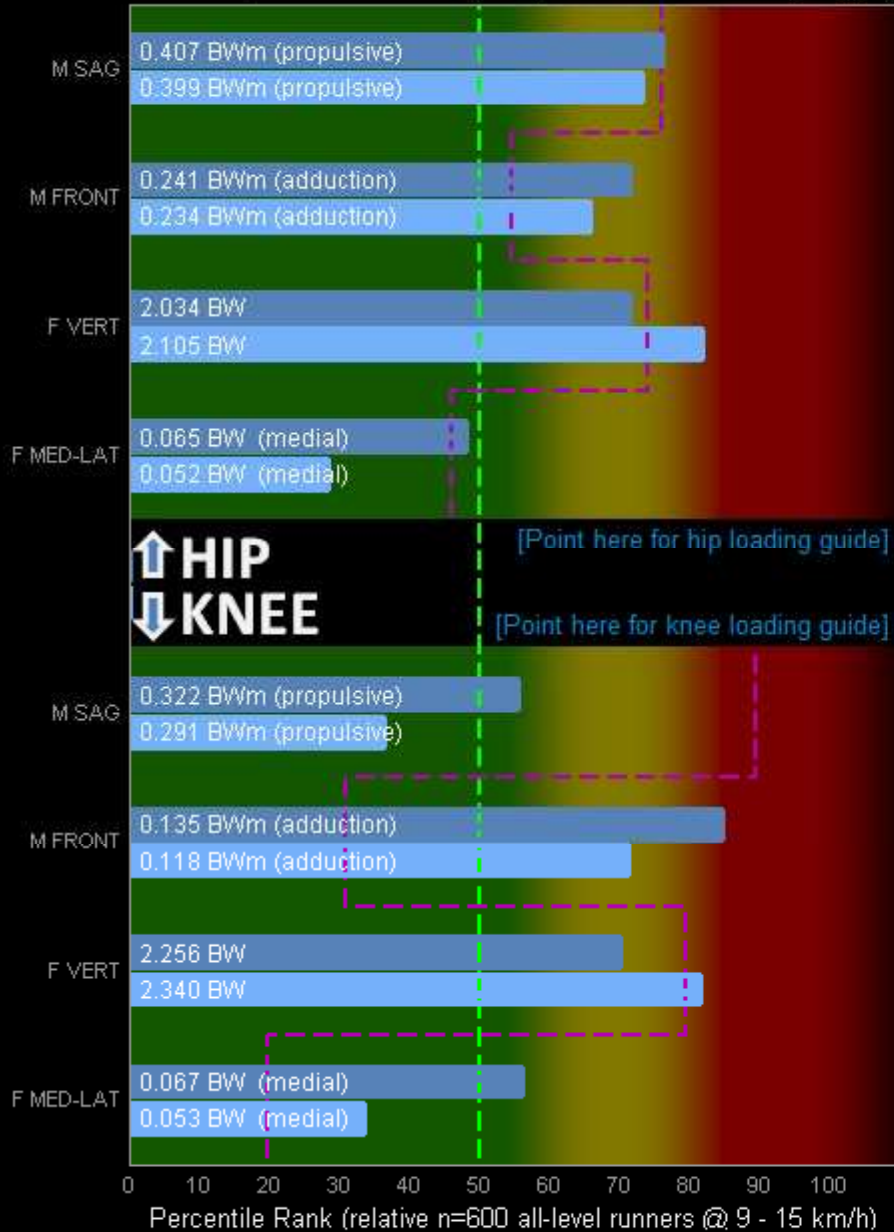
α = Hip flex/ext
 β = Knee flexion
 γ = Shank angle

Test results for Diogo Custódio

Date: 17 Dec 2018 Time: 11:47 AM Speed: 15 km/h

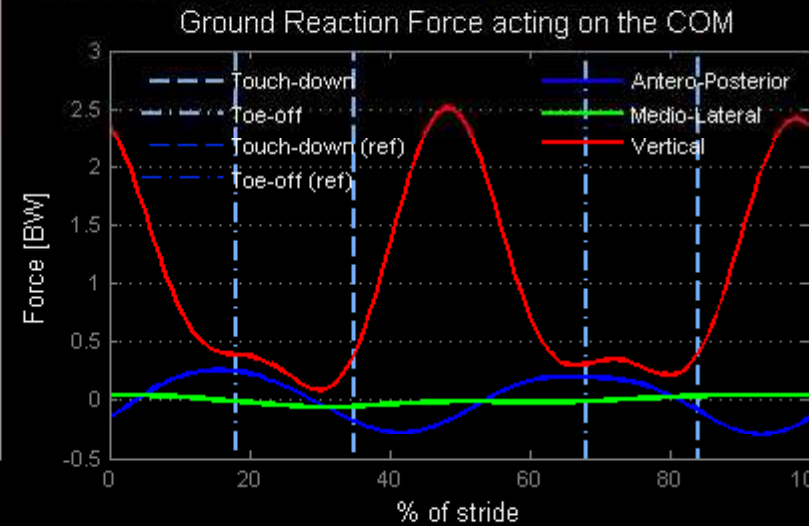
GAIT CHARACTERISTICS

Joint Torques and Forces (max, normalized to bodyweight)



Loading Property	value	ref. value
Max loading @ joint	Right Knee (M FRONT)	
Left/right preference [%]	48.4/51.6	
Bilateral asymmetry [%]	4.2	

Symmetry Rating: ★★★★★☆



Correlation chart: loading vs stride parameters

- Hip Sagittal Moment (M SAG)**
- increases with Max hip extension
 - decreases with Overstride
 - decreases with Forward lean

- Hip Frontal Moment (M FRONT)**
- decreases with Step width
 - increases with Vertical displacement

- Hip Vertical Force (F VERT)**
- increases with Vertical displacement
 - increases with Knee flex @swing
 - decreases with Cadence

- Hip Mediolateral Force (F MEDLAT)**
- increases with Step width
 - increases with Body length

- Knee Sagittal Moment (M SAG)**
- decreases with Shank angle @landing
 - increases with Knee flex @landing
 - increases with Vertical displacement

- Knee Frontal Moment (M FRONT)**
- decreases with Step width
 - increases with Knee varus alignment
 - decreases with Cadence

- Knee Vertical Force (F VERT)**
- increases with Vertical displacement
 - increases with Max knee flex @swing
 - decreases with Cadence

- Knee Mediolateral Force (F MED-LAT)**
- increases with Shank angle @landing
 - increases with Step width



Mechanical Work (W)

Unit: Joules/kg/m = energy cost per kilo body mass during 1 meter of forward transport

Total mechanical work: $W_{tot} = W_{gravity} + W_{segments} + W_{speed}$

$W_{gravity}$ = work to elevate the body against gravity

- ✓ Decreases with reduced **vertical displacement**
- ✓ Decreases with running speed

$W_{segments}$ = work to reposition the body segments

- ✓ Decreases with reduced **cadence**
- ✓ Increases quadratically with running speed

W_{speed} = work to recover speed loss

- ✓ Decreases with reduced **overstride/braking**
- ✓ Increases with running speed

- ✓ **Best work strategy at high speeds is to lower cadence to suppress $W_{segments}$ since it grows quadratically with speed**



Elastic Exchange (ϵ)

Unit: % = fraction of total work stored and released as "free" elastic energy in muscles and tendons

ϵ = elastic energy exchange coefficient

- ✓ Increases with increased **vertical force** and reduced **contact time**
- ✓ Increases slightly with speed
- ✓ **Best strategy for improved elastic exchange is to employ a "bouncy" stride with low overstride.**
- ✓ **Maximum elastic exchange you can get is 50 %.**



Running Economy (RE)

Unit: Joules/kg/m = energy cost per kilo body mass during 1 meter of forward transport

$$RE = W_{tot} \times (1 - \epsilon)$$

- ✓ **Running economy is the most important factor for long distance running performance**
- ✓ **Minimised total work and maximised elastic exchange yield best running economy!**

Cadence



The number of steps per minute. Take shorter steps to reduce joint loading and prevent injuries. Take longer steps (without overstriding) to improve economy at higher speeds as it reduces $W_{segments}$. Tall (short) runners have lower (higher) optimal cadence.

Contact Time



The time each foot spends in contact with the ground. Make this time as short as possible for best running economy. Contact time can be improved by running drills and similar exercises that promote the elastic response from muscles and tendons.

Forward Lean



The forward lean angle of the trunk relative the vertical axis. A forward lean of 2-5 degrees is optimal. Smaller angles increases braking and larger angles obstruct elastic energy storage in the core muscles.

Overstride



The horizontal distance between the center-of-mass and the ankle when the foot strikes the ground. Excessive distance is called overstride and it causes increased braking and prolonged contact times, both detrimental for running economy.

Vertical Displacement



The range of up and down motion of the center-of-mass. If too small, it results in poor force generation and reduced elastic exchange. If too large, it amplifies $W_{gravity}$, the work done against gravity, and puts higher loads on the joints.

Braking Force



The amount of braking on the center-of-mass during the initial contact phase. Large braking forces cause greater loss of speed and increases W_{speed} , the work needed to recover speed during propulsion. Overstride contributes to increased braking force.

Vertical Force



The force generated to support body weight and launch it back into the air. High peak force generated in short time (a bouncy stride) promotes large elastic energy exchange and improved high speed economy at the expense of increased loading of the joints.

Lateral Force



The force acting sideways on the center-of-mass during ground contact. Large lateral force is associated with broad step width and large side-to-side motion, which makes you travel longer distance than necessary and increases lateral joint loading.

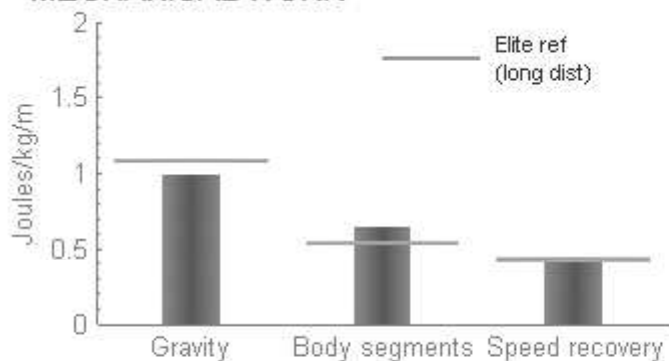
Test results for Diogo Custódio [print friendly copy]

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Note from your service provider:
No note written

RUNNING PERFORMANCE @ 15 km/h

MECHANICAL WORK



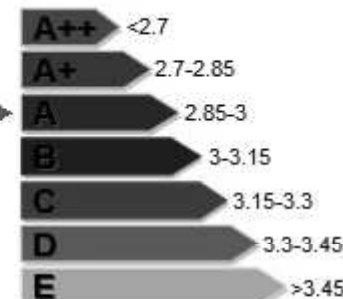
ELASTIC EXCHANGE

Excellent: >35%
Good: 25-35%
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ECONOMY

2.94
Joules/kg/m



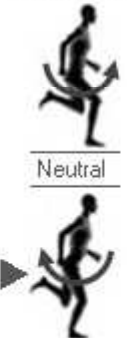
Stride Parameters

- ▶ = current value
- ◀ = reference value
- = elite range (long dist)
- × = center of mass

Strike Type



Pelvic Tilt



Cadence

167 /min



Contact Time

0.239 s



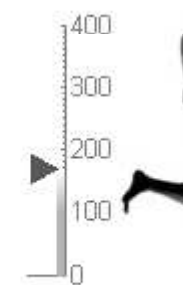
Forward Lean

3.5 °

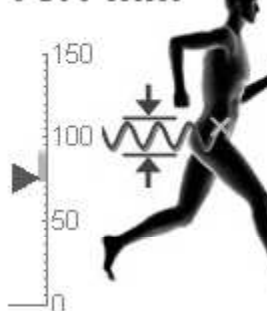


Overstride

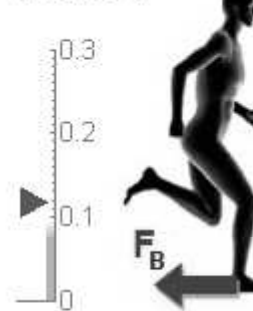
168 mm



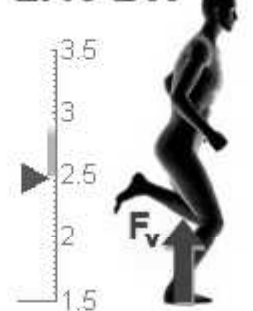
Vertical Displacement
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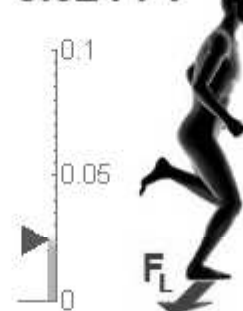
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Lateral Force (max)
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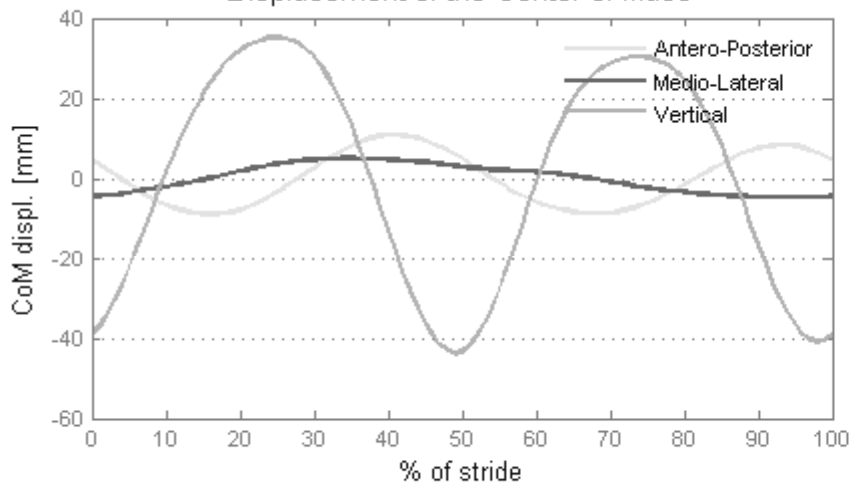


Stride Rating: **3.8 / 5.0**

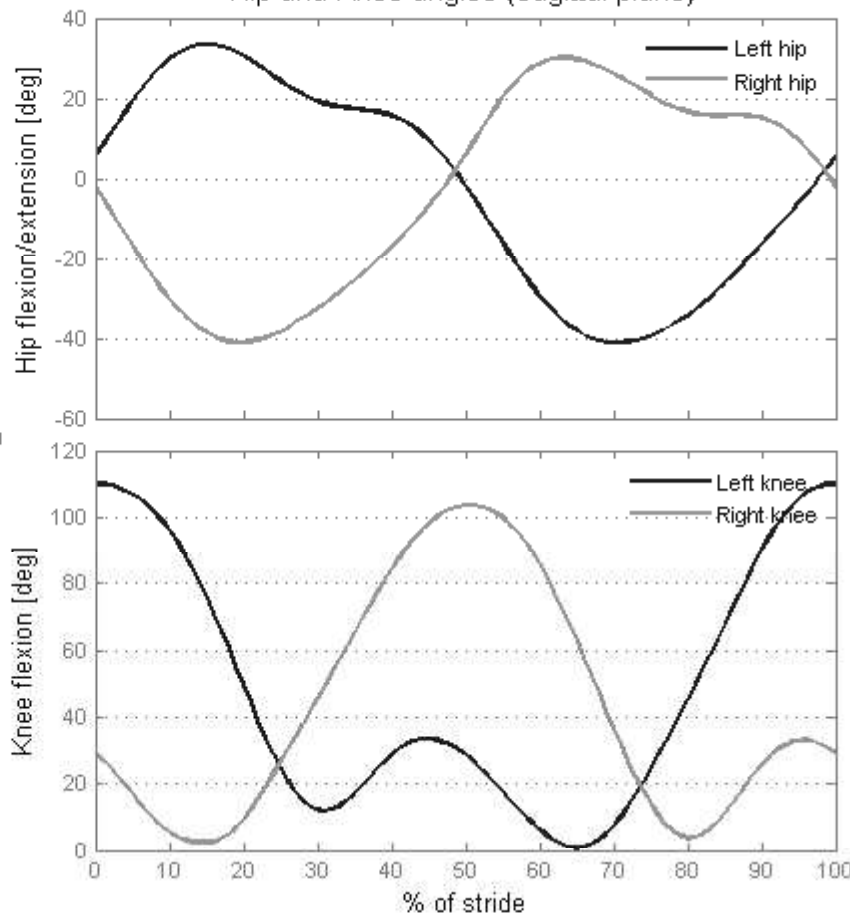


GAIT CHARACTERISTICS @ 15 km/h

Displacement of the Center of Mass

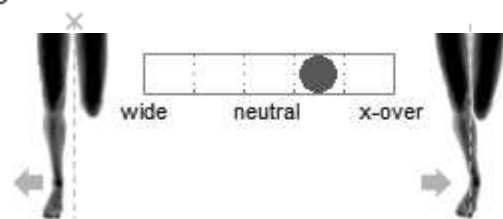


Hip and Knee angles (sagittal plane)



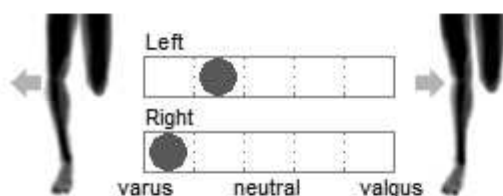
Frontal Plane Alignment

Step Separation
19 mm



Knee Alignment @ mid-stance

Left: **0.0°**



Right: **-1.4°**

Sagittal Plane Parameters

	Mean (Left/Right)	ref. Mean (L/R)	Elite Mean	diff Elite
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Symmetry Rating	★★★★☆			



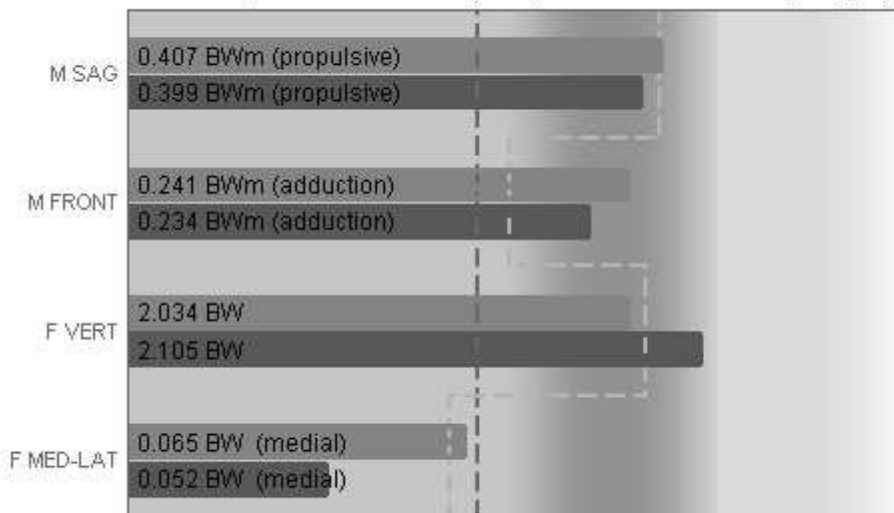
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Test results for Diogo Custódio [print friendly copy]

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GAIT CHARACTERISTICS

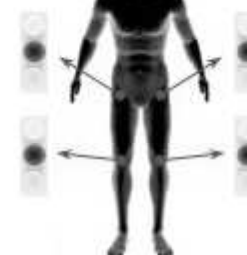
Joint Torques and Forces (max, normalized to bodyweight)



Right leg
 Left leg
 - - - Elite @ 15 km/h
 - - - Norm @ 9-15 km/h

47/100
Medium

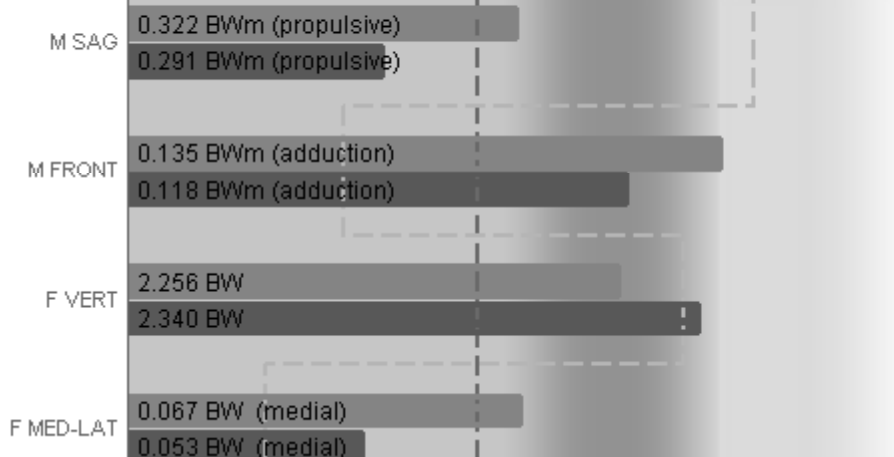
Light: 0-30
Med.: 30-50
High: 50-70
Extreme: >70



↑ HIP
 ↓ KNEE

[Point here for hip loading guide]

[Point here for knee loading guide]



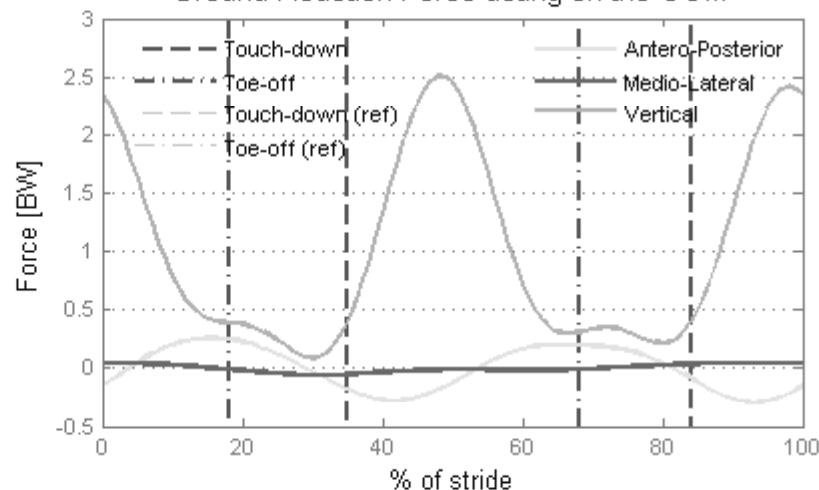
Loading Property

Property	value	ref. value
Max loading @ joint	Right Knee (M FRONT)	
Left/right preference [%]	48.4/51.6	
Bilateral asymmetry [%]	4.2	

Symmetry Rating

★★★★☆

Ground Reaction Force acting on the COM



Correlation chart: loading vs stride parameters

- Hip Sagittal Moment (M SAG)**
 - increases with Max hip extension
 - decreases with Overstride
 - decreases with Forward lean
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- Knee Mediolateral Force (F MED-LAT)**
 - increases with Shank angle @landing
 - increases with Step width

Percentile Rank (relative n=600 all-level runners @ 9 - 15 km/h)