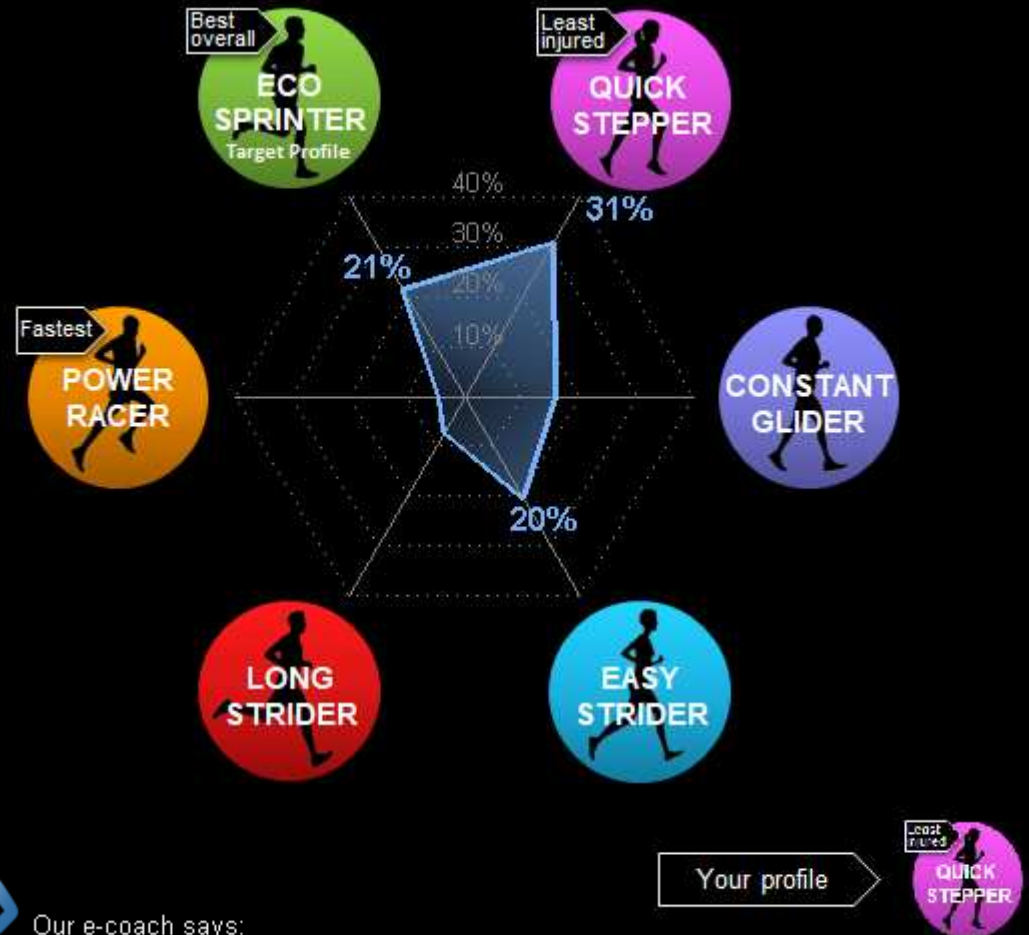


Test results for Sergio Santos

Date: 14 May 2020 Time: 10:00 AM Speed: 15 km/h



Our e-coach says:

This is an efficient stride with low injury risk. As speed increases, however, it eventually becomes costly to move the legs so fast. Consider to strengthen gluteus and hamstrings muscles by speedwork and uphill running for more powerful propulsion and longer strides, while keeping overstride under control.

Note from your service provider:

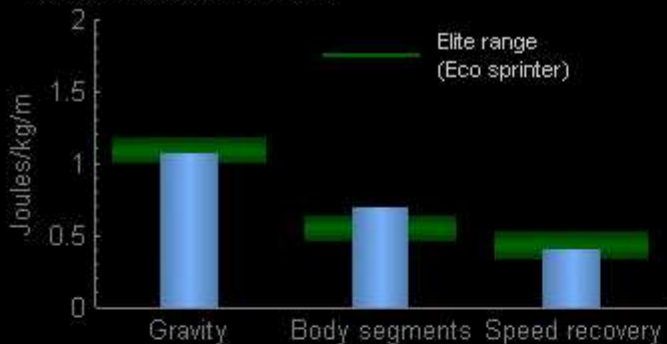
No note written

Test results for Sergio Santos

Date: 14 May 2020 Time: 10:00 AM Speed: 15 km/h

RUNNING PERFORMANCE @ 15 km/h

MECHANICAL WORK



ELASTIC EXCHANGE

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



ECONOMY

3.03
 Joules/kg/m



● Runner Profile ○ Stride Parameters

- ▶ = Current value
- ▶ = Reference value
- = Elite range (Eco sprinter)
- ✗ = Center of Mass

Strike Type



Pelvic Tilt



Cadence

185 /min



Contact Time

0.231 s



Forward Lean

3.5 °



Overstride

183 mm



Vertical Displacement

71.6 mm



Braking Force (max)

0.096 Fv



Vertical Force (max)

2.31 BW



Lateral Force (max)

0.024 Fv



Stride Rating:

3.4 /5.0

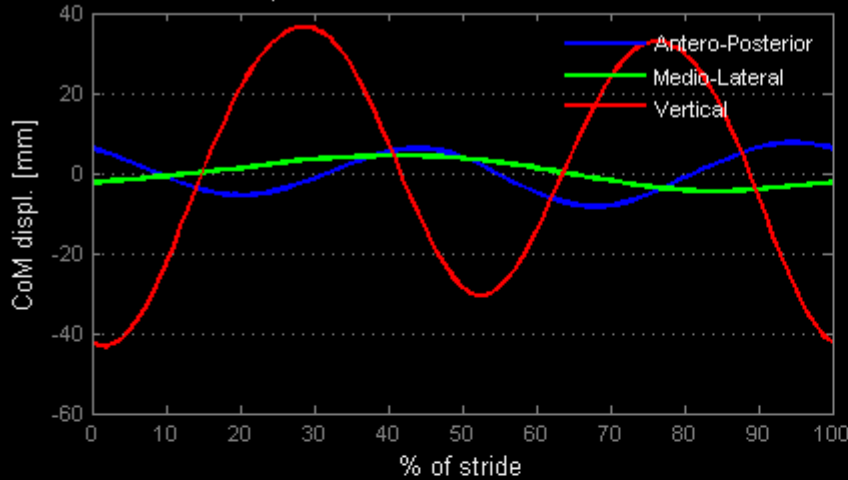


Test results for Sergio Santos

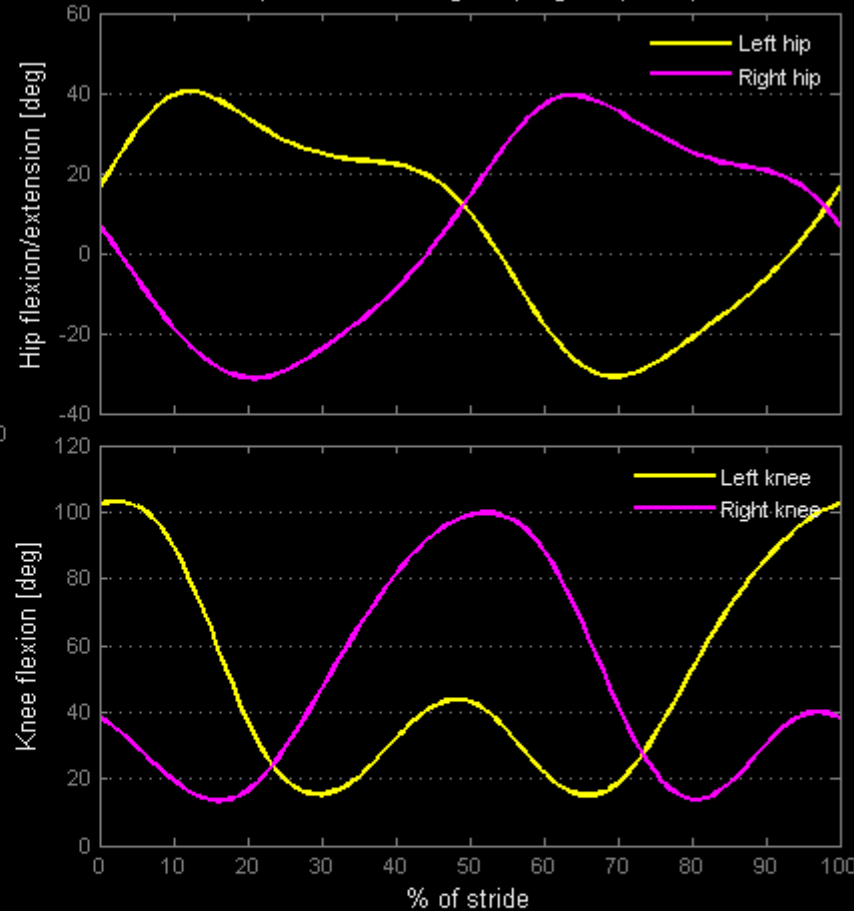
Date: 14 May 2020 Time: 10:00 AM Speed: 15 km/h

GAIT CHARACTERISTICS @ 15 km/h

Displacement of the Center of Mass



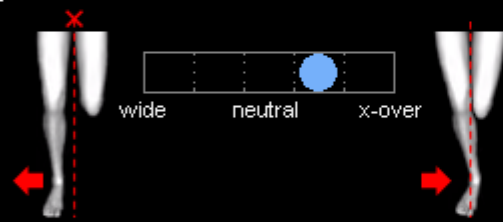
Hip and Knee angles (sagittal plane)



Frontal Plane Alignment

Step Separation

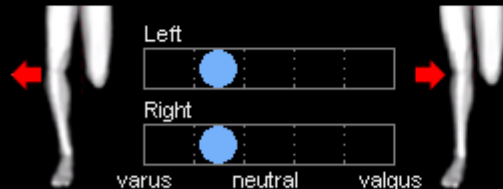
11 mm



Knee Alignment @ mid-stance

Left: **-0.1°**

Right: **-0.1°**



Sagittal Plane Parameters

	Mean (Left/Right)	ref. Mean (L/R)	Elite Mean	diff Elite
Max Thigh Flexion [deg]	39.9 (40.5/39.4)		36.5	3.4
Max Thigh Extension [deg]	31.1 (31.0/31.3)		29.7	1.5
Shank angle @ touch-down [deg]	4.3 (2.8/5.9)		1.7	2.6
Knee Flexion @ touch-down [deg]	18.6 (20.4/16.8)		17.2	1.4
Max Knee Flexion @ stance [deg]	41.9 (43.7/40.0)		37.8	4.1
Max Knee Flexion @ swing [deg]	101.4 (103.1/99.8)		112.1	-10.7
Symmetry Rating	★★★★☆			

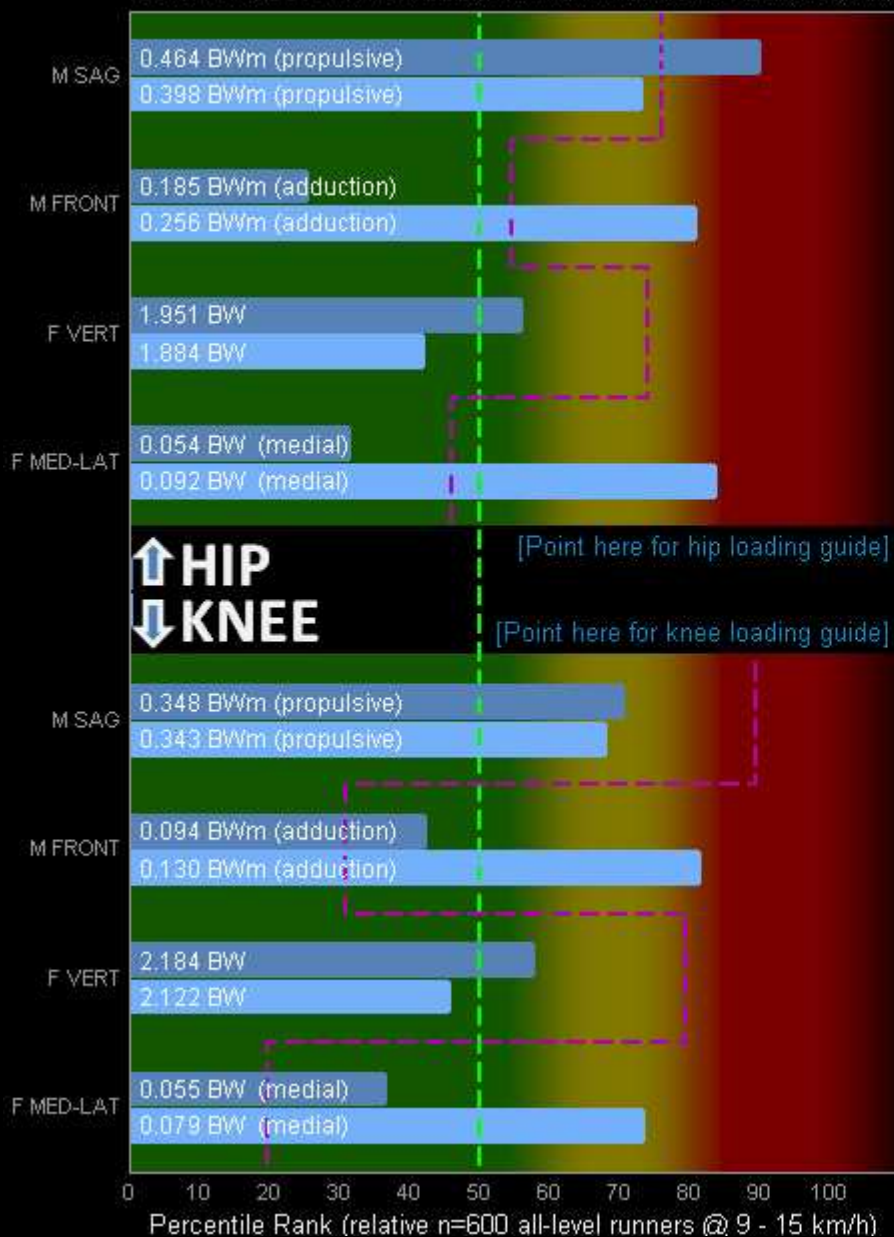


Test results for Sergio Santos

Date: 14 May 2020 Time: 10:00 AM Speed: 15 km/h

JOINT LOADING @ 15 km/h

Joint Torques and Forces (max, normalized to bodyweight)

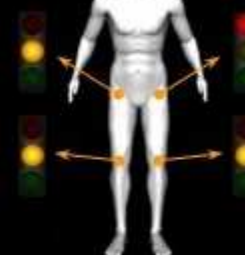


Right leg
Left leg
Elite @ 15 km/h
Norm @ 9-15 km/h



43/100
Medium

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



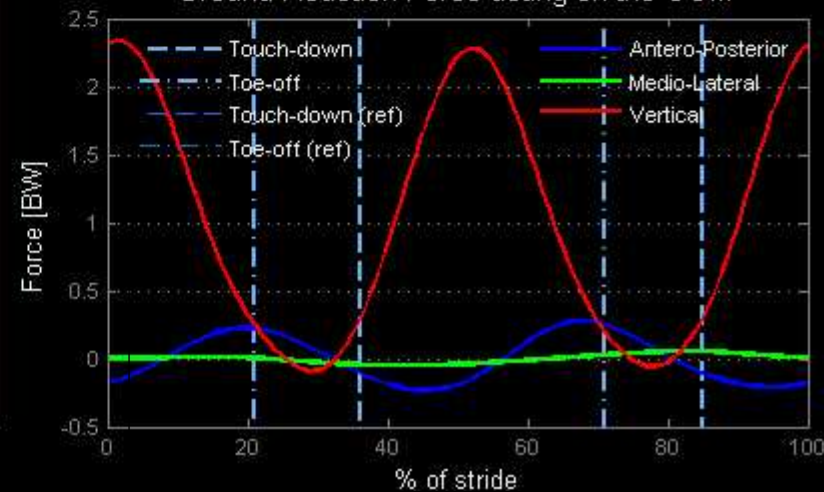
Loading Property

value	ref. value
Max loading @ joint	Right Hip (M SAG)
Left/right preference [%]	53.6/46.4
Bilateral asymmetry [%]	10.8

Symmetry Rating



Ground Reaction Force acting on the COM



Loading vs stride parameter dependence

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 MED-LAT)

- 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

Quick Reference Guide – Runner Profiles

- MotionMetrix's **target profile** for optimal long-distance performance (green elite range fields in app)
- Active compact stride with great elastic bounce
- Best compromise between speed capacity, running economy and injury risk
- Very common profile among elite 5 - 42k runners
- Next lowest injury risk after Quick Steppers



- Rapid footwork with good elastic bounce
- Good economy up to ~16 km/h that then drops due to excessive leg velocity (work to move the segments)
- Gentle loading due to small joint angles and peak forces
- Many top ultra runners and female marathoners belong to this category
- The least injured category among all six



- Profile with highest top speed, very common among middle-distance elite runners
- Long powerful strides with short ground contact
- Stiff springy legs yielding great elastic bounce
- Large vertical peak force acting on the joints
- Highest injury risk, tough on lower leg and calf due to extreme ankle joint power generation

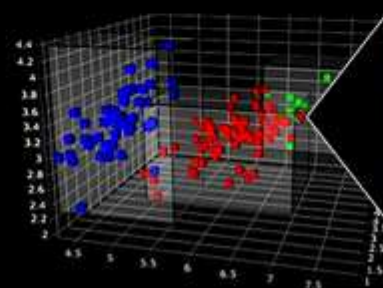
- Short strides with nearly constant ground contact
- Mild joint loading but limited bounce that prevents fast running
- Common among runners with limited flexibility, elasticity or strength
- Many elderly runners in this category
- Slowest category but among the least injured



- Long leaping strides powered by large muscular force
- Excessive overstride and ground contact time
- Common style among strong athletically built runners and mostly male
- Decent sprint capabilities but poor economy due to excessive braking/propulsion
- Next highest injury risk, tough on the knees

- Easygoing style, follows the law of least resistance
- Most common profile among all six
- Characterized by overstride and a tendency to a seated posture
- Soft knee during support, sensitive to different footwear
- Low to average speed capacity and running economy at medium injury risk

Occurrence	6.3%	22.9%	12.8%	11.6%	29.6%	16.80%
10k race time (mean)	40:12	43:42	45:50	49:30	46:30	45:12
10k race time (top 10%)	30:23	32:29	36:15	41:12	36:06	37:20
Injury rate (2 years)	84%	62%	59%	64%	75%	77%
Primary injury sites	1) lower leg 41% 2) calf 28% 3) knee 22%	1) knee 27% 2) foot 21% 3) lower leg 15%	1) knee 46% 2) lower leg 24% 3) calf 23%	1) knee 52% 2) lower leg 21% 3) achilles 17%	1) knee 35% 2) achilles 17% 3) hamstrings 16%	1) knee 37% 2) hamstrings 17% 3) hip 15%
Shoe pref. (light/stable)	75%/25%	63%/37%	55%/45%	30%/70%	15%/85%	10%/90%
Distr (men/women)	55%/45%	44%/56%	39%/61%	31%/69%	61%/39%	65%/35%



The six fundamental runner profiles have been derived by cluster analysis on a large bio-mechanical dataset (N > 1000) of runners. Information about performance and injuries have subsequently been obtained from interviews with runners belonging to the set.



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.

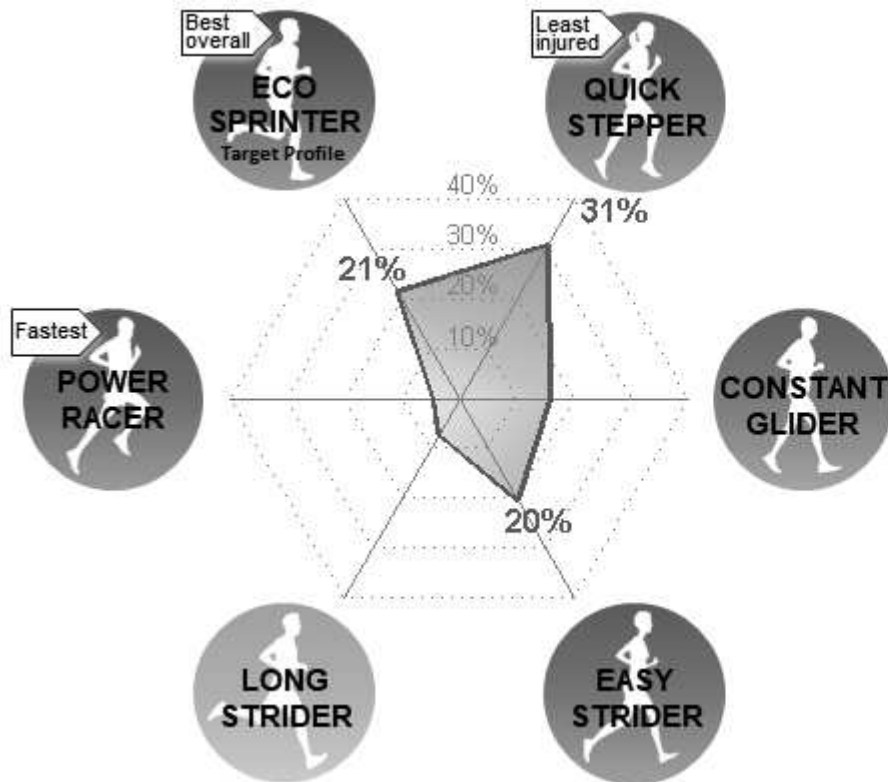
Lateral Force



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 Sergio Santos [print friendly copy]

Date: 14 May 2020 Time: 10:00 AM Speed: 15 km/h



Your profile



Info

- Rapid footwork with good elastic bounce
- Economic up to ~16 km/h, then the leg segment work skyrockets
- Moderate joint loading due to limited leg angles and peak forces
- Common style among the best ultra runners and female marathoners
- The least injured category among the six

Occurrence	12.8%
Distribution (men / women)	39% / 61%
10k race time (mean / top 10%)	45:50 / 36:15
Injury incidence rate (2 years)	59%
Primary injury sites	1) knee 46%
	2) lower leg 24%
	3) calf 24%



Our e-coach says:

This is an efficient stride with low injury risk. As speed increases, however, it eventually becomes costly to move the legs so fast. Consider to strengthen gluteus and hamstrings muscles by speedwork and uphill running for more powerful propulsion and longer strides, while keeping overstride under control.

Note from your service provider:

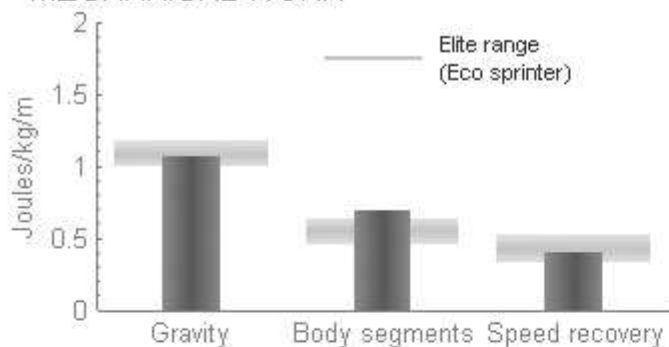
No note written

Test results for Sergio Santos [print friendly copy]

Date: 14 May 2020 Time: 10:00 AM Speed: 15 km/h

RUNNING PERFORMANCE @ 15 km/h

MECHANICAL WORK



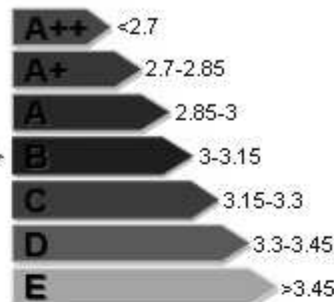
ELASTIC EXCHANGE

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



ECONOMY

3.03
 Joules/kg/m



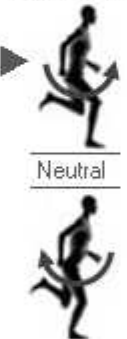
● Runner Profile ○ Stride Parameters

- ▶ = Current value
- ▶ = Reference value
- = Elite range (Eco sprinter)
- × = Center of Mass

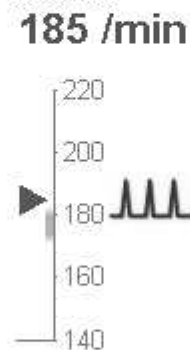
Strike Type



Pelvic Tilt



Cadence



Contact Time



Forward Lean

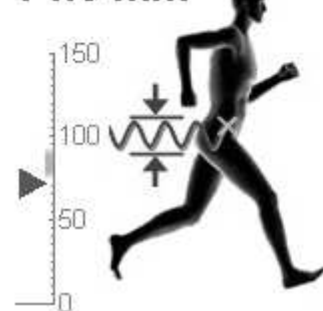


Overstride



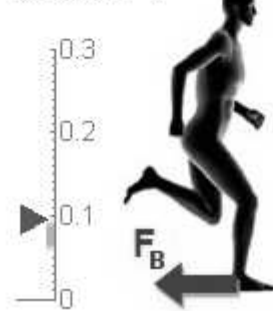
Vertical Displacement

71.6 mm



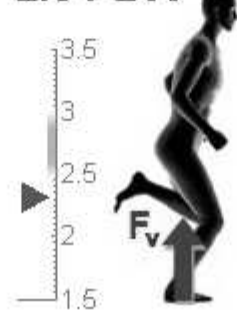
Braking Force (max)

0.096 F_v



Vertical Force (max)

2.31 BW



Lateral Force (max)

0.024 F_v



Stride Rating: **3.4 / 5.0**

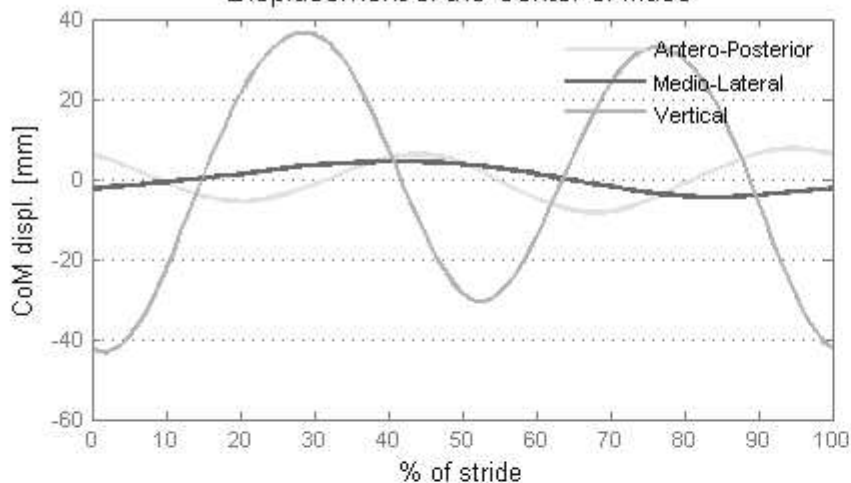
Cadence	★★★★☆
Contact Time	★★★★☆
Forward Lean	★★★★☆
Vertical Displ.	★★★★☆
Overstride	★★★☆☆
Braking Force	★★★★☆
Vertical Force	★★★★☆
Lateral Force	★★★★☆

Test results for Sergio Santos [print friendly copy]

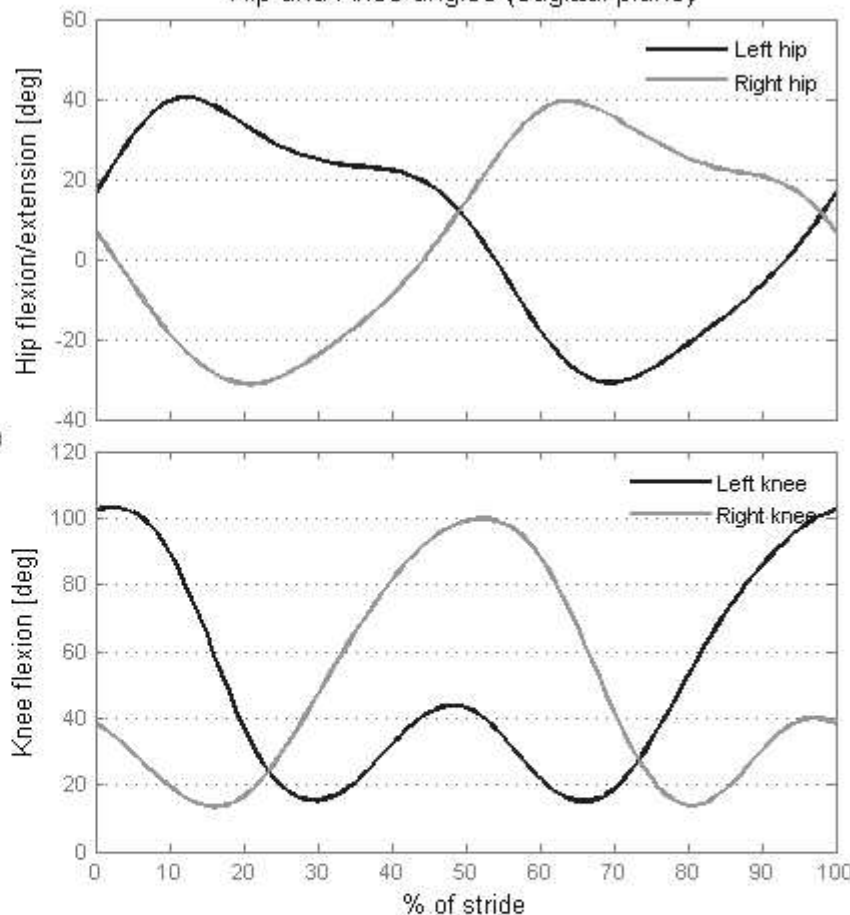
Date: 14 May 2020 Time: 10:00 AM Speed: 15 km/h

GAIT CHARACTERISTICS @ 15 km/h

Displacement of the Center of Mass



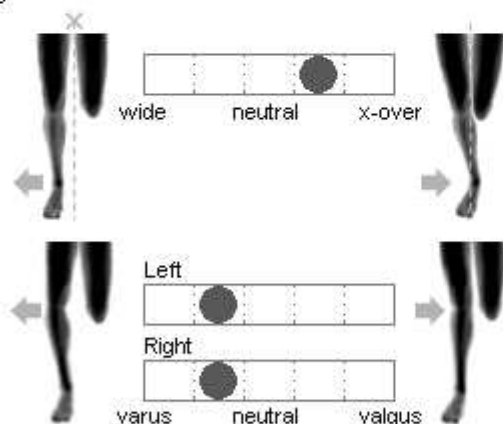
Hip and Knee angles (sagittal plane)



Frontal Plane Alignment

Step Separation

11 mm



Knee Alignment @ mid-stance

Left: **-0.1 °**

Right: **-0.1 °**

Sagittal Plane Parameters

	Mean (Left/Right)	ref. Mean (L/R)	Elite Mean	diff Elite
Max Thigh Flexion [deg]	39.9 (40.5/39.4)		36.5	3.4
Max Thigh Extension [deg]	31.1 (31.0/31.3)		29.7	1.5
Shank angle @ touch-down [deg]	4.3 (2.8/5.9)		1.7	2.6
Knee Flexion @ touch-down [deg]	18.6 (20.4/16.8)		17.2	1.4
Max Knee Flexion @ stance [deg]	41.9 (43.7/40.0)		37.8	4.1
Max Knee Flexion @ swing [deg]	101.4 (103.1/99.8)		112.1	-10.7

Symmetry Rating

★★★★☆



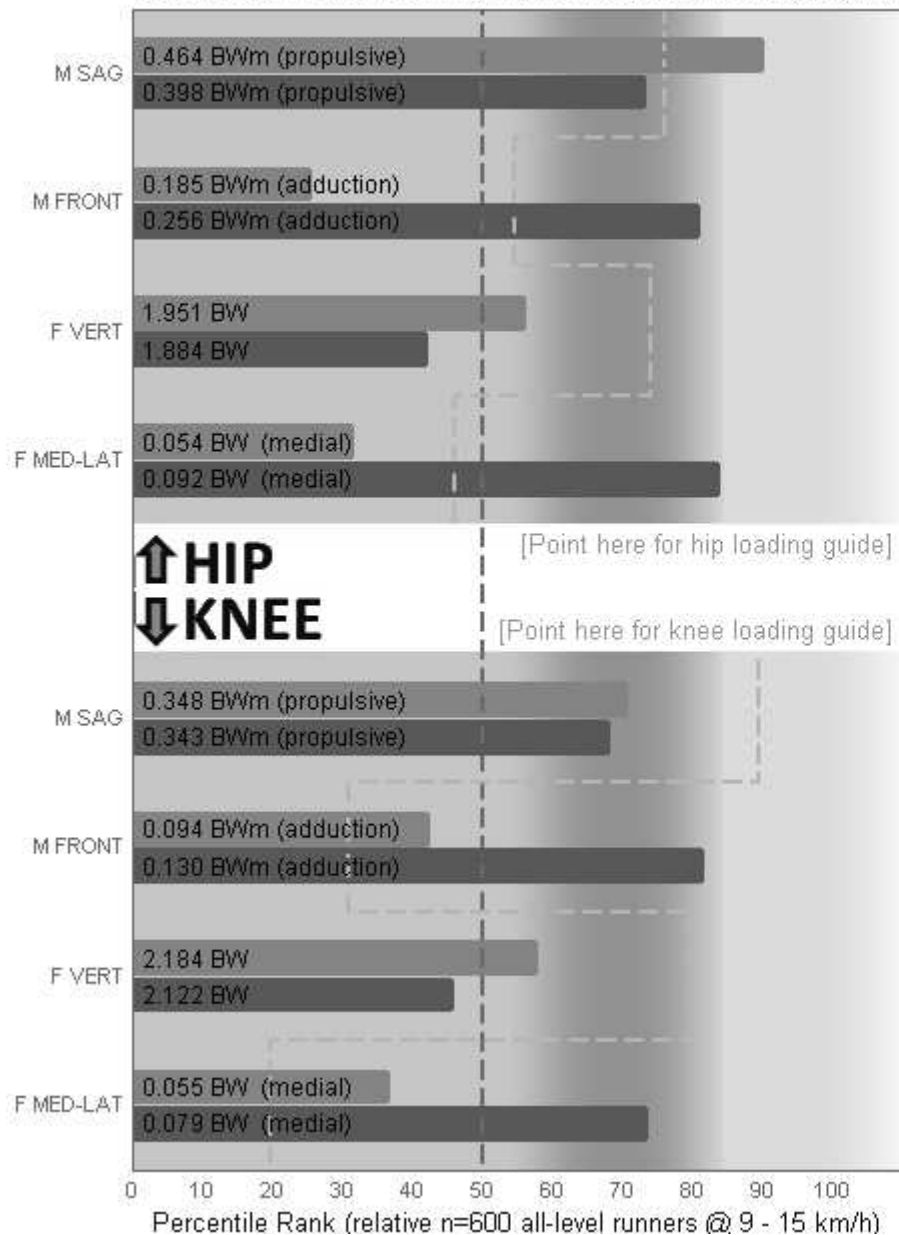
α = Hip flex/ext
 β = Knee flexion
 γ = Shank angle

Test results for Sergio Santos [print friendly copy]

Date: 14 May 2020 Time: 10:00 AM Speed: 15 km/h

JOINT LOADING @ 15 km/h

Joint Torques and Forces (max, normalized to bodyweight)

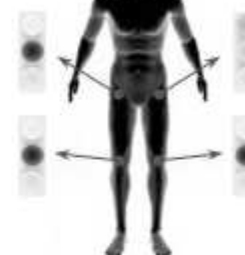


Right leg
 Left leg
 - - - Elite @ 15 km/h
 - - - Norm @ 9-15 km/h

43/100
Medium



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



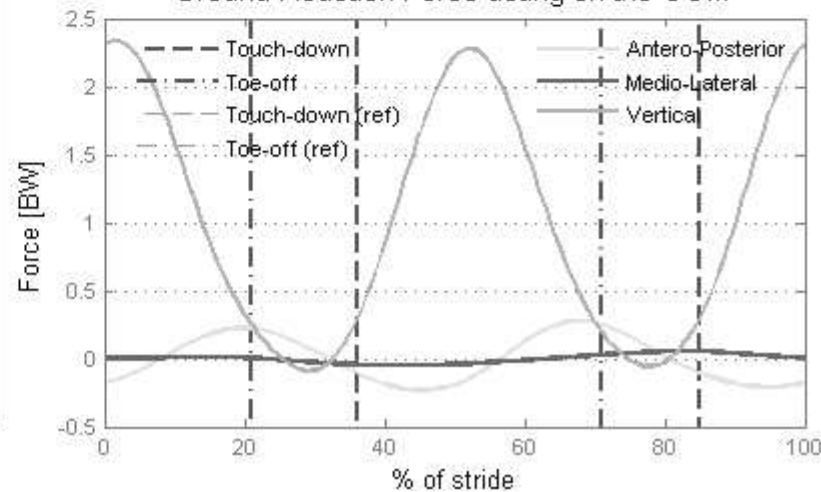
Loading Property

value	ref. value
Max loading @ joint	Right Hip (M SAG)
Left/right preference [%]	53.6/46.4
Bilateral asymmetry [%]	10.8

Symmetry Rating



Ground Reaction Force acting on the COM



Loading vs stride parameter dependence:

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