QUICK GUIDE

The System

MotionMetrix G2 is an advanced system for biomechanical running analysis. It consists of two measurement modules:

- A marker-free 3D motion capture module that accurately detects the position of every joint in your body.
- A sensitive force sensor integrated in the treadmill that picks up every Newton of force that you apply during ground contact, with millisecond time precision.

With MotionMetrix G2 we can precisely capture your unique biomechanical Runner Profile and provide you with unparalleled insights to your running gait as well as helping you find the shoe that brings out the best runner in you.

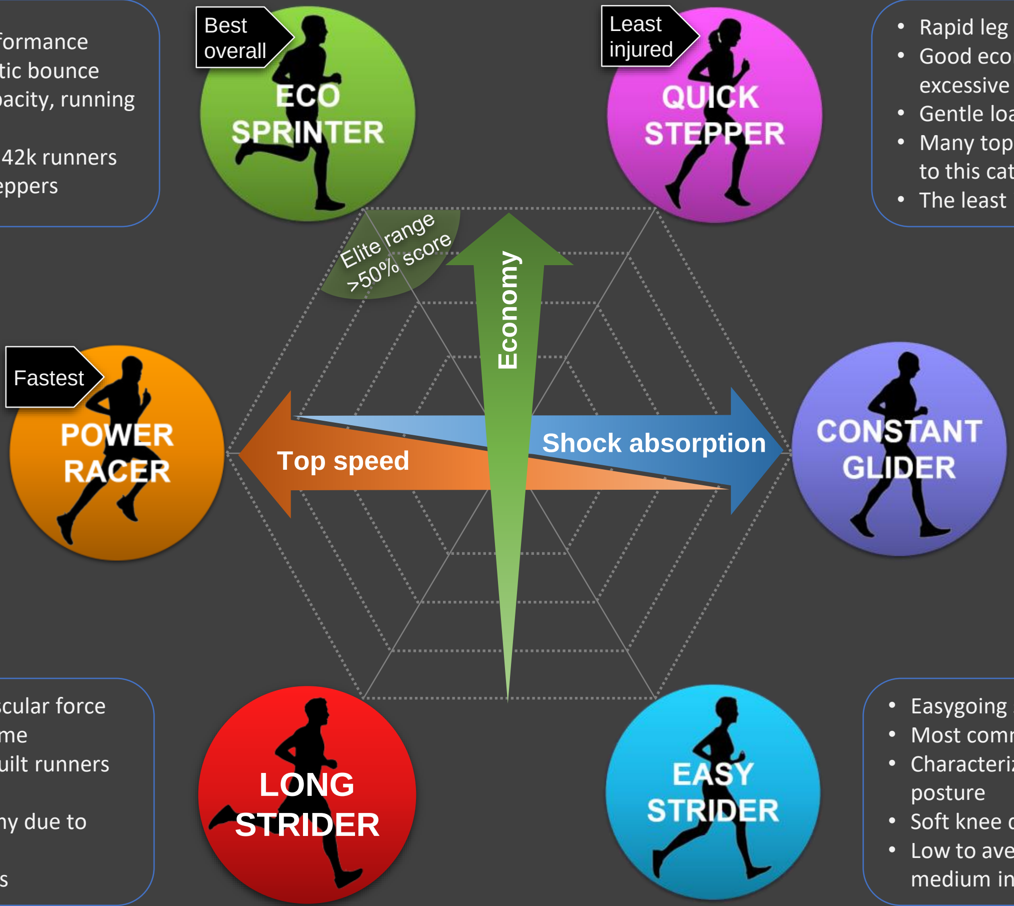
The Test

You just need to step up on the treadmill and run. The system will immediately start to track your movements and the force you apply to the ground. No body markers are needed. On the application screen in front of you, you will see yourself running in a 3D landscape including real time body tracking, ground reaction force and Runner Profile assessment. After a 20 seconds run, your personal web-report is generated where you will find all you need to know about your running mechanics.

Runner Profiles

- Optimal profile for long-distance performance
- 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 leg turnover 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

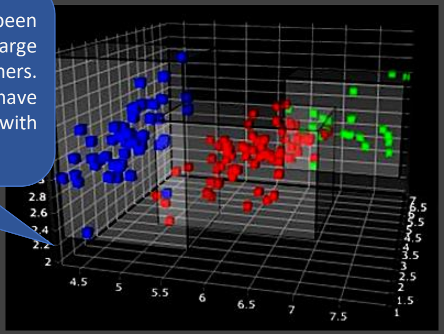
- Short strides with nearly constant ground contact
- Mild joint loading but limited bounce that prevents fast running
- Common among runners with limited flexibility, elasticity or strength
- Many elderly runners in this category
- Slowest category but among the least injured

- 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%	1) knee 27%	1) knee 46%	1) knee 52%	1) knee 35%	1) knee 37%
	2) calf 28%	2) foot 21%	2) lower leg 24%	2) lower leg 21%	2) achilles 17%	2) hamstrings 17%
	3) knee 22%	3) lower leg 15%	3) calf 23%	3) achilles 17%	3) hamstrings 16%	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 MotionMetrix's large biomechanical dataset of over 50 000 runners. Information about performance and injuries have subsequently been obtained from interviews with runners included in the set.



Gait Parameters

The gait parameters below are all key parameters for Running Economy and they also determine which Runner Profile you belong to. The star rating in the report shows how well you perform on each of them relative to the reference which represents the average performance for a group of national level distance runners.

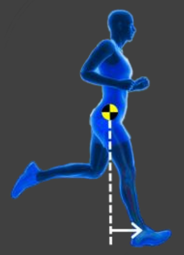
Cadence

The number of steps per minute. Shorter steps reduce joint loading and may prevent injuries. Longer steps (without overstriding) improve economy at higher speeds as it reduces the work to move the limbs. Note that short runners have slightly lower optimal cadence and vice versa for tall runners. L and R indicate left-to-right step and right-to-left step, respectively.

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. L and R represent left and right support phases, respectively.

Overstride

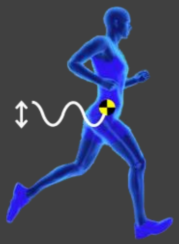


The horizontal distance between the center-of-mass and the ankle when the foot strikes the ground. Excessive overstride causes increased braking and prolonged contact time, both of which are detrimental for running economy.

Forward Lean

The forward lean angle of the trunk relative the vertical axis at mid-stance. A forward lean of 2-5 degrees is optimal. Smaller angles increase braking and larger angles obstruct elastic energy storage in the core muscles. L and R represent left and right mid-stance, respectively.

Vertical Displacement

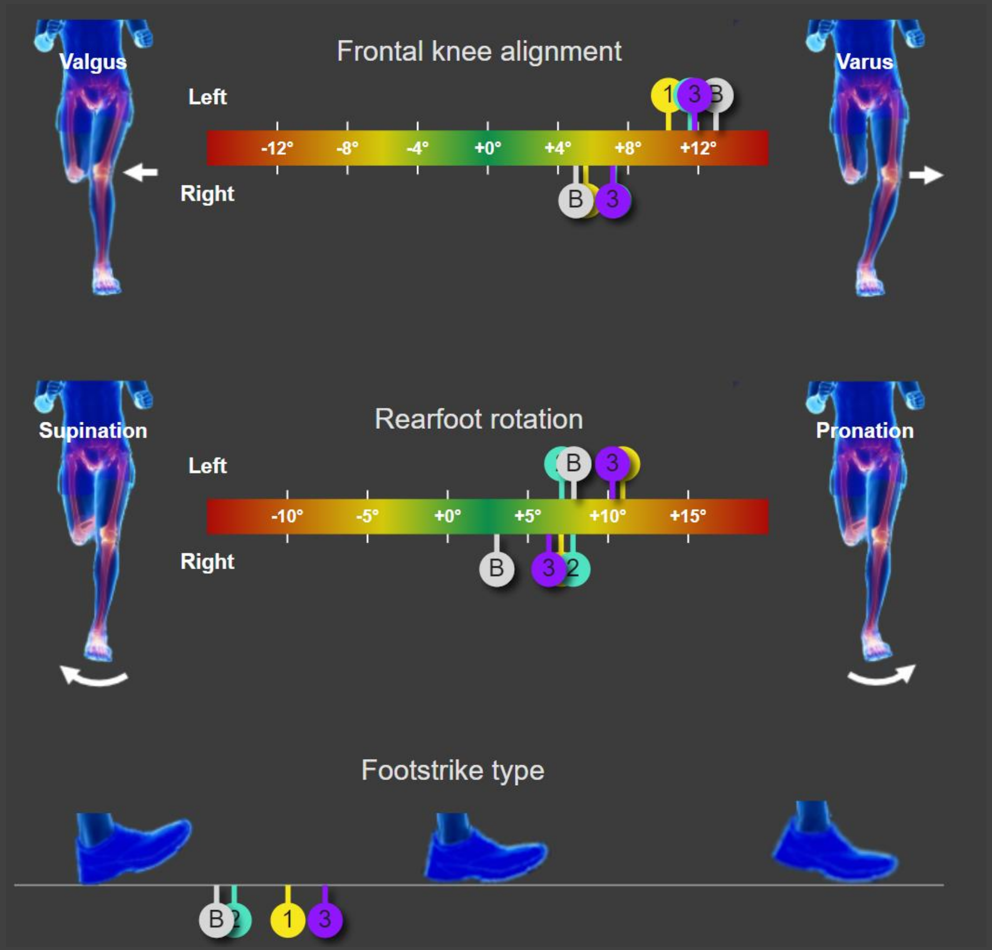


The range of up and down motion of the center-of-mass. If too small, it results in poor force generation and reduced elastic exchange. If too large, it amplifies the work done against gravity, and puts higher loads on the joints. L and R represent the vertical displacement resulting from left and right push-off phases, respectively.

Vertical Force

The vertical ground reaction 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 economy at higher speeds but at the expense of increased loading of the joints.

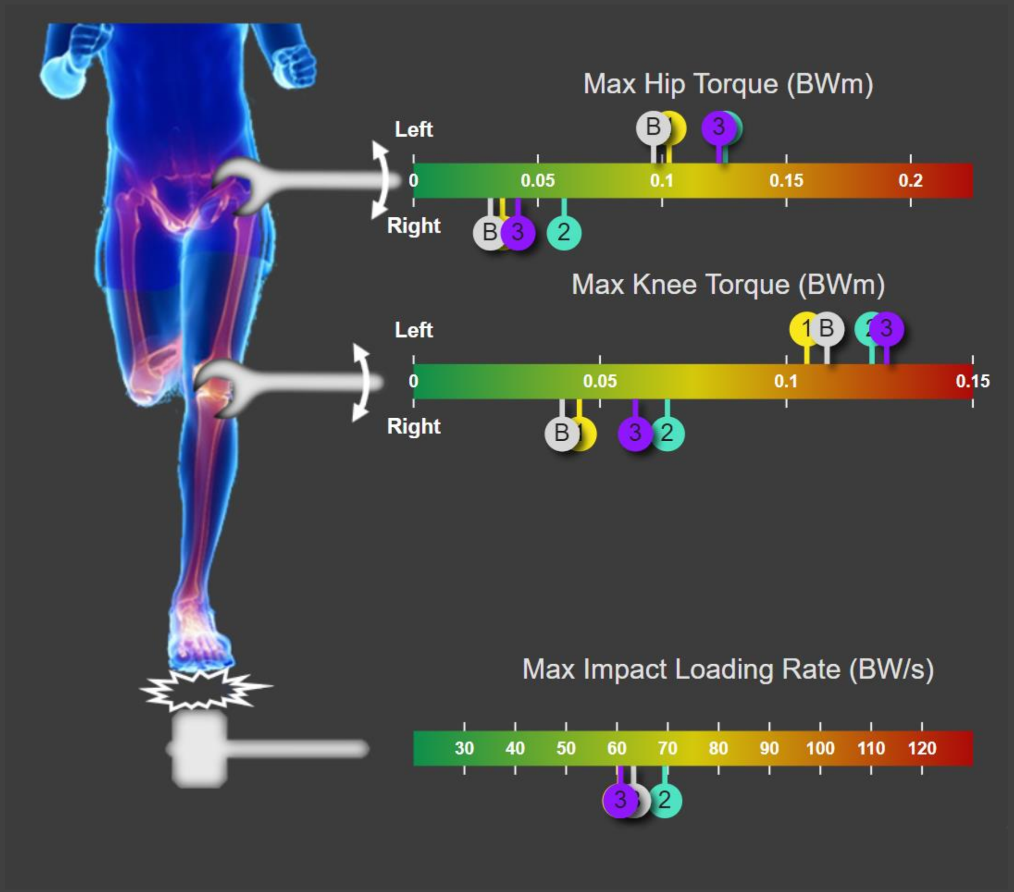
Lower body kinematics and kinetics



The frontal knee alignment is analyzed at mid-stance when the vertical ground reaction force peaks. More valgus alignment will generally yield increased frontal hip torques whereas more varus alignment yields increased knee torques. A change in rearfoot rotation can induce a change in frontal knee alignment.

Here we assess the maximum rearfoot rotation during the stance phase. The rearfoot rotation can vary significantly between shoes depending on their lateral stability and consequently also induce a change in knee and hip alignment. For instance, a runner with knee pain due to excessive varus/valgus alignment may reduce the varus/valgus angle by selecting a shoe that promotes more/less pronation.

Variations in foot landing angle can modify the impact force. A well cushioned shoe will in most cases yield an reduction in the impact loading for heel strikers but not always for mid- or forefoot strikers.



Maximum loading of the lower body occurs at around mid-stance when the ground reaction force reaches its peak value, typically between 2 - 3 bodyweights. While the lower body joints are designed to withstand high torques in the sagittal plane (the plane parallel to the running direction), this is not the case in the frontal plane. This is especially true for the knee, the no 1 injury site for runners. A shoe with improper lateral stability can induce an increased frontal plane torque on the knee or hip and subsequently increase the risk of injury.

When the foot impacts the ground, shock waves are transmitted up through the foot and leg. The harder the impact, the larger the amplitude and frequency of the shock waves. Since the shock waves may cause structural damage, it makes sense to cushion the impact and shoe cushioning plays an important role here. An effective way to analyze the cushioning is to look at how the Impact Loading Rate changes. Higher rate means harder collision and higher risk for structural damage.

Energy Expenditure

Mechanical Work (*W*)

Work to elevate the body center of mass against gravity and to move the body segment.
Unit: Joules/kg/m (energy required to move 1 kilo body mass during 1 meter of forward transport)

The total mechanical work W_{tot} is the sum of these two components:

$W_{gravity}$ = 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

✓ **Best work strategy for high speed running is to lower cadence to suppress $W_{segments}$**

Elastic Exchange (ε)

Fraction of total work stored and released as “free” elastic energy in muscles and tendons. Unit: %

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**
✓ **Maximum elastic exchange you can achieve is 50 %.**

Running Economy (*RE*)

Total mechanical work accounting for elastic energy return. Unit: Joules/kg/m

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

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