Gaitup
make sense of motion

Running white paper

Description of Running Performance

Running is one of the world's most popular sports. Runners increase velocity with efficient movements based on many factors working in concert. Runners can optimize their practice to both improve performance and reduce risk of injury. Runners statistically injure themselves 30 to 59 times per 1000 hours of practice (Buist et al, 2010). PhysiRun helps compare athletes in different sessions using different training aids like shoes, for example. Runners using PhysiRun can also compare themselves to elite runners with graphic visuals. PhysiRun helps you to:

- Select running shoes
- Improve training
- Speed rehabilitation
- Reduce risk of injury

Shoes analysis

Training analysis

Rehabilitation

Injury risk

Protocol recommendations

Testing specifications

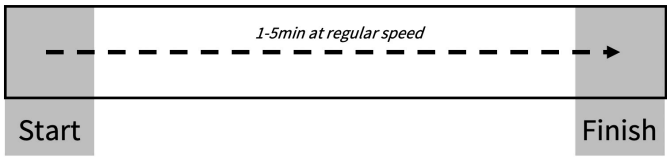
✓ Running speeds between 10 to 20 km/h
✓ Sensors fixed to shoes laces

Protocol #1: Standard running analysis

Use this standard protocol to rapidly collect all essential runner data (1) outdoors, or (2) indoors. Adapt the distance and time based on need.

Outdoor protocol

Maintain regular speed on flat ground for 1 to 5 minutes. For proper calibration, stand still on level ground before running.



Stand still on a flat ground before running for calibration.

Indoor protocol

Maintain regular speed on the treadmill for 1 to 5 minutes. For proper calibration, stand still on the treadmill before running.

Stand still on the treadmill for calibration.

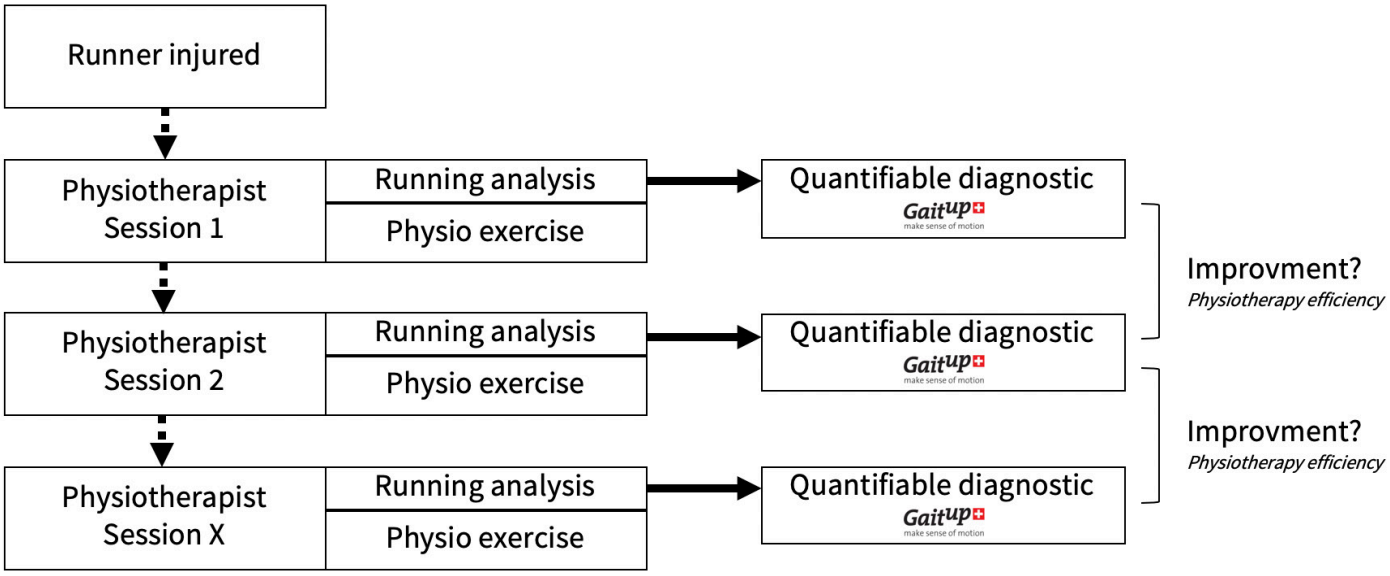
We recommend three analysis at slow, medium and fast speeds to generate three profiles for the same runner.

Protocol #2: Running analysis during a race

Use PhysiRun to evaluate your technique and performance during your race up to 50 km. Work with a coach to improve your biomechanical efficiency, and compare your performance year over year on the same course.

Protocol #3: Running analysis during rehabilitation

Use PhysiRun to quantify and evaluate improvements each week during physical therapy.



General performance

Parameters	Definition	Explanation	Application
 **Vertical impact** Unit : g	Vertical impact is the vertical impact force of the foot at time of ground contact.	Upon contact with the ground, a runner's body receives vertical impact forces and shock vibrations (Mercer et al, 2003). While jogging, this impact force is approximately double body weight.	
 **Horizontal impact** Unit : g	Horizontal impact is the antero-posterior impact force produced when the runner's foot makes contact with the ground.	Often called braking force, horizontal impact acts opposite to the running direction. The higher the braking force, the more the runner will lose speed every time his or her foot makes contact with the ground.	
 **Peak swing** Unit : deg/sec	Peak swing is the maximum angular velocity of the foot in air.	A high velocity leg swing increases cadence, which increases speed for a fixed amplitude (aka stride length).	
 **Vertical stiffness** Unit : kN/kg	Vertical stiffness describes the stiffness of your body during ground contact (Farley & Gonzalex, 1996).	A high vertical stiffness suggests a higher capacity to store and release elastic energy. Increases in vertical stiffness correlate to better running economy (Butler et al, 2003).	
 **Asymmetry** Unit : %	Asymmetry is the ratio of ground contact times between the left and right feet.		

Temporal

Parameters	Definition	Explanation	Application
 **Contact time** Unit: ms	Contact time is the duration of ground contact for each stride (aka duration of stance phase). It starts at initial contact, when the foot strikes ground, and finishes when the toe lifts off.	Contact time is a direct performance indicator: the higher the performance, the lower the contact time (Mann et al 1986; Kyrolainen et al, 2001; Kugler et al, 2010).	
 **Flight time** Unit: ms	Flight time is how long the foot is in the air.	Flight time can impact running efficiency by increasing muscular recovery time or by limiting vertical oscillations (Lauzon et al, 2013; Hebert-Loisier, 2015).	
 **Cadence** Unit: Step/min	Cadence is the frequency of steps, measured as the number of steps per minute (Morin et al, 2007).	Cadence depends on contact and flight times. Identify the optimal cadence-amplitude ratio of each athlete to optimize his or her stride. (derrick et al, 1998; Heidersheit et al, 2012).	
 **Stride time** Unit: sec	Stride time is the time between consecutive ground contacts of the same foot.	Stride time tends to decrease as velocity increases (Mann et al, 1986).	

Spatial

Parameters	Definition	Explanation	Application
 **Foot Strike Angle** Unit: deg	Foot strike angle is the vertical angle between the foot and the ground during heel strike.	This parameter determines the running pattern. The higher the angle, the more the runner has a heel impact. On the contrary, the more negative the impact, the more likely the runner is a forefoot runner.	
 **Pronation at initial impact** Unit : deg	Pronation is a subtalar eversion and forefoot abduction (Nicola et Jewison, 2012). PhysiRun measures the eversion angle of the rearfoot at impact.	Positive angles indicate pronation, while negative angles indicate supination. In running, it is important to control this angle to reduce effort on the body and align work of muscles and tendons to their preferential axes.	
 **Lift off angle** Unit: deg	Lift off angle is the angle between the ground and the foot at the end of the propulsive phase, just before the foot leaves the ground, at toe off.	The propulsive phase is the principal action enabling runner forward movement. This parameter is key to estimate runner efficiency. If the lift off angle is acute, the runner “doesn’t leave the ground” and loses stride amplitide. If the lift off angle is too big, the runner becomes less efficient as the center of mass is moved excessively vertical (Magness, 2014).	

Glossary

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 STD indicates the values are all located in a small range, while a high STD indicates 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, PhysiRun does not calculate CV unless more than 10 cycles are recorded.