Influence of transient vibrations on fatigue and muscle damage

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Rationale	Running induces high amplitude ground reaction forces and soft tissue vibrations which have often been described in the literature (Play et al. 2022). According to many authors, these shocks and vibrations can have negative effects on the muscles of the lower limbs, inducing fatigue, pain and loss of function and, through their accumulation, increasing the risk of injury (Ehrström et al., 2018; Khassetarash et al., 2019). However, it is impossible to separate the effects of shocks and vibrations from those of the muscular contractions inherent in the running movement. In order to isolate the effects of impact and vibration from those of the contractions required for movement, it is necessary to devise an experimental procedure that minimises the muscular activity required for joint movement. To do this, we designed an inertial ergometer that reproduces the shocks and vibrations generated during running.
Aims	The primary objective will be to assess the influence of transient vibrations on fatigue and muscle function. The secondary objective will be to explore the role of the dose of exposure to transient vibrations, through variations in the number of impacts and the properties of the foot/ground interface.
Research plan	Interventional, controlled, multicentre, randomised study
Protocol and data treatments	The experiment will take place over a familiarisation period (1h30), during which the volunteers will be introduced to the ergometer and the evaluation of neuromuscular function, followed 2 to 4 weeks later by two measurement periods. The subjects will be randomly divided into 4 groups, each following its own protocol. Day 1 of the experiment (Day 1: PRE, vibration protocol 1, 2, 3 or 4, POST) will last 2.5 hours. Day 2 (Day 2: POST48) will take place 48 hours after Day 1 and will last 1 hour.

	Vibration protocol 1 will consist of transient vibrations equivalent to 10 minutes running downhill at 10km/h (600 foot impacts with the ground at 0.6x body weight after frequency decomposition of the signal). The foot-ground interface will be standardised. Vibration protocol 2 will be identical except for the number of impacts equivalent to 15min of running (n= 900). Protocol 3 will be identical to protocol 1 except for the more cushioned foot-ground interface. Finally, protocol 4 will be identical to protocol 1, with a slightly higher impact intensity (0.7x body weight) corresponding to a slightly faster run (12km/h). During the PRE, POST and POST48 tests, neuromuscular function (maximum contraction with nerve stimulation), ultrasound measurement, perceived fatigue, perceived pain and damage (blood dosage except POST) will be assessed.
Assessment criteria	Main : - Vibrations of the gastrocnemi medialis & vastii lateralis: accelerometer measurements -Acute and delayed neuromuscular fatigue of the right and left vastii lateralis: isometric force tests with nerve stimulation. - Secondary : - Muscular damage to the vastii lateralis: Ultrasound. - Muscle damage by blood tests -Muscular activity of the gastrocnemius medialis & vastii lateralis: surface electromyography measurements -Fatigue and pain perceived using standardised scales.