control. Indeed, muscles are engaged to react to those stimuli to regain balance and avoid falling. This study aimed to investigate postural control and lower limb and trunk muscle activity during unexpected perturbations of the support base.
Methods: Ten healthy subjects (F = 5; 24.00 ± 1.49yrs; 1.66 ± 0.06 m; 59.80 ± 7.33 kg) volunteered to the study. They were assessed on a force platform screwed over a servo-controlled, electrically driven movable plate combining the following settings: direction (forward (FW) and backward (BW)), displacement (25 mm, 50 mm, and 100 mm), and ramp rate (100 mm/s and 200 mm/s). The subjects underwent two sets of 12 trials, randomly combining the plate settings. From the centre of pressure (CoP) anterior–posterior trajectory of the 2.5 s time window after the perturbation occurred, the first peak (FP), the maximal oscillations (ΔCoPMax), and the standard deviation (PPV) of the CoP trajectory were calculated. The surface electromyography (s-EMG) of the tibialis anterior, gastrocnemius lateralis, rectus femoris, biceps femoris, rectus abdominis, and erector spinae was recorded within the same time window to calculate the co-contraction index (CCI) of the leg, thigh, and trunk.
Results: CoP displacement was influenced by ramp rate and direction. In detail, a higher ramp rate determined higher FP and ΔCoPMax values ($p < 0.001$). Similarly, BW direction produced greater FP ($p < 0.01$) and ΔCoPMax ($p < 0.05$) values. FP was also affected by longer displacement ($p < 0.01$). PPV increased along with displacement ($p = 0.001$) and ramp rate ($p < 0.001$). CCI values were globally lower when displacement increased ($p < 0.001$). Moreover, a significant increase in the leg CCI ($p < 0.001$) in the FW direction was observed, whereas this difference was not present in the thigh and trunk CCI.
Conclusions: The greater values of FP and ΔCoPMax in the BW than FW could depend on the foot–ankle complex that allows for a greater CoP displacement toward the tiptoes. The higher CCI values of the leg in the FW condition increased the ankle joint stiffness accounting for the reduced displacement of the CoP towards the heels.
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Alterations in single-leg drop jump kinematics and ground reaction forces after a subject-adapted fatiguing protocol

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Purpose: Neuromuscular fatigue reduces the capacity to produce force and alters motor strategies during dynamic movements. Whether these altered strategies increase the risk of musculoskeletal injuries is still unclear [1]. Here we investigate whether fatigue may be a risk factor for anterior cruciate ligament (ACL) rupture, one of the most common injuries during sport activity.
Methods: Fifteen healthy male volunteers performed four repetitions of single leg drop jump, before and after a fatiguing session on a cycle ergometer until exhaustion. This exercise was adapted to the fitness level of each participant by setting its intensity to 10% above their individual anaerobic thresholds, previously identified by means of cardiopulmonary exercise tests. Sagittal joint angles and the maximum weight-normalized vertical ground reaction force (vGRF) before and after cycling were compared using two-ways repeated measure ANOVA for both legs, evaluating whether the cycling exercise induced motor alterations typically associated with an increased risk of ACL injury.
Results: The cycling session caused a significant reduction of jump height for both legs (Δ = − 1.1 ± 0.4 cm, mean ± standard error; $p = 0.02$). Movement kinematics was also significantly affected by the fatiguing exercise for both legs. Post-cycling there was a reduction of hip flexion during ground contact after dropping (Δ = − 3 ± 1°, $p = 0.01$) and at heel strike after jumping (Δ = − 2.8 ± 1°, $p = 0.02$). There was a significant reduction of knee flexion at heel strike after both dropping (Δ = − 2.9 ± 0.7°, $p < 0.001$) and jumping (Δ = − 3.5 ± 0.7°, $p < 0.001$). Finally, there was a significant reduction of ankle dorsiflexion during ground contact after dropping (Δ = − 1.7 ± 0.5°, $p = 0.007$). The fatiguing session also caused a significant reduction of vGRF after dropping (Δ = − 0.18 ± 0.07 N/kg, $p = 0.03$).
Conclusions: The reduced hip and knee flexion that we observed post-cycling are motor strategies typically associated with an increased risk of ACL rupture [2]. The reduced ankle dorsiflexion may also load the ACL under the action of the ankle plantarflexor muscles. These kinematic alterations therefore suggest an increased risk of ACL injury after fatigue. Nonetheless, the unexpected reduction of vGRF at landing may reduce internal knee forces. Additional analyses on joint moments and muscle activity will be performed to further detail these results.
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The acute effects of wobble board performance on hand tremor: how much is it functional?

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Purpose: A range of wearable sensors has been used to capture human movements such as fine motor skills. Specifically, inertial measurements unit (IMU) have been used for the assessment of physical symptoms such as Hand Tremor (HTR), crucial to perform fine motor skills. Although training proved to be effective in improving HTR, little is known on the acute effects of specific hand exercises on HTR. Therefore, this study aimed to investigate the acute effects of 30 min hand exercises on HTR also in relation to sex.
Methods: 16 healthy subjects (Men(M) = 10; Women(W) = 6; age: 25.4 ± 2.9yrs) were asked to sit on a chair and extend their dominant upper limb forward with an IMU fixed under the palm at the middle finger level while resting the contralateral limb on the armrest. HTR was recorded for 10 s PRE and POST hand exercises. The exercises comprised four 15 s trials (antero-posterior, medio-lateral, clockwise, counterclockwise) performed on a computerized wobble board (WB), with a 30 s recovery period in between. The trained limb was positioned at a 90° on the WB placed on a table, and a monitor displaying the real-time performance of the WB was positioned at eye level.

Subjects were instructed to maintain a motion marker within a target zone, displayed on the screen, for as long as possible during each trial. The IMU's Acceleration (A) data on the z axis were downloaded using a USB connecting cable with proprietary software. Linear repeated mixed models were utilized to examine the effects of WB exercises on subject's Az axis HTR, in relation to sex. Significance level was set at $p < 0.05$.

Results: The analysis showed a significant main effect ($p < 0.034$) for sex on the Az axis, with M showing higher values than W. Specifically, significant differences were found between sex in PRE (M: 3.18 ± 0.4 cm/s^2; W: 2.65 ± 0.2 cm/s^2; p = 0.039) and POST (M: 3.23 ± 0.4 cm/s^2; W: 2.63 ± 0.2 cm/s^2; p = 0.013) evaluations. However, hand exercises led to distinct patterns in Az at different time points, with M increasing their HTR, and W decreasing it.

Conclusions: In line with the literature, findings showed that M had higher HTR than W. Although the implementation of training interventions to improve fine motor skills in healthy individuals is essential, future studies should evaluate the acute effects on gesture accuracy to understand whether this increase in HTR in M is a limiting factor on the performance of fine motor skills or a physiological adjustment that could improve precision and accuracy.

A pilot study on the neuromuscular excitation during indoor static skydiving

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Purpose. Indoor skydiving originated as a safe environment for military paratroopers and then became a training field to practice human flight under controlled conditions. Individual and collective competitions have been recently proposed, requiring the athletes to perform a combination of four fundamental body postures to execute a coded choreography moving in all the directions. The increasing interest in such discipline deserves a comprehensive physiological evaluation of this sport, including the assessment of the neuromuscular excitation. The present study describes the muscular excitation during the four fundamental static positions.

Methods. Nine expert indoor skydiving instructors (8/1 M/F; age 31±6 yr; body mass: 70.0±10.5 kg; stature: 1.74±0.08 m; mean ± standard deviation (SD)) participated in this study. The surface EMG signal was recorded on the anterior deltoid (AD), posterior deltoid (PD), pectoralis major (PM), latissimus dorsi (LD), rectus abdominis (RA), erector spinae (ES), rectus femoris (RF), and biceps femoris (BF), for each of the four fundamental positions: SUPINE, PRONE, SIT, head down (HD). Heart rate was recorded to assess the activity effort intensity. The EMG signal root mean squared (RMS) was determined and the neuromuscular load (NeLo, i.e., the sum of RMS of all muscles divided by muscles number), was determined as index of the general neuromuscular excitation. A one-way ANOVA RM evaluated the differences among positions. A correlation analysis was conducted to detect co-excitations. The statistical significance level was set to alpha = 0.05.

Results. Heart rate indicated SUPINE and HD as the least and the most challenging postures (85.3±8.4 and 132.3±19.7 bpm, respectively, $p<0.05$). SIT and HD were the most demanding postures in terms of NeLo (22.7±10.6 and 32.2±6.6 mV respectively, $p<0.05$) due to the higher engagement of LD, ES, RF and BF ($p<0.05$ vs SUPINE and PRONE). Noticeably, while SUPINE and PRONE required a uniform muscles excitation, SIT and HD presented signs of excitation variability, specifically in lower body muscles. Correlation analysis detected some co-excitations, likely to stabilize the shoulders and hip joints.

Conclusions. Attention should be given to the training of lower body muscles to facilitate the adoption and maintenance of SIT and HD postures. Nonetheless, both AD and PD should be carefully trained to stabilize the shoulder joint.

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Biomechanics and Motor Control.

Perception and reproduction of an illusory movement: a comparison between old and young participants using motion analysis

Purpose: Proprioception is the capability to sense the position and the movement of the body. The main contributors to this capacity are the muscle spindles, although several peripheral and central structures are involved. Some of these structures can be altered by the aging process. Using a vibro-tactile stimulus it is possible to elicit a kinaesthetic illusion of movement (KI), which can activate the muscle spindles as well as the sensory and motor areas in the brain. The aim of this study was to explore the differences in proprioception between old and young populations by assessing through KI the conscious perception of movement and the illusory experience.

Methods: Participants sat on a chair with both arms on a table, fixed in the same position with an adjustable brace. To induce a KI of wrist flexion, a mechanical vibrator was placed on the extensor retinaculum of participants' dominant wrist. Seven different frequencies of vibration were used: 50 Hz, 60 Hz, 70 Hz, 80 Hz, 90 Hz, 100 Hz, 110 Hz. During the vibro-tactile stimulation, subjects were asked to reproduce the illusory movement with the contralateral wrist and rate on a VAS scale the vividness of the illusion, the amount of movement perceived and its fluidity. Qualisys motion capture system was used to record the movement. To assess differences between old and young participants, the kinematic parameter of angular displacement and velocity were considered, as well as the scores related to the subjective perception of the KI.

Results: Eighteen subjects were recruited and divided in two groups based on their age; the young group (11 females, 1 male, mean age ± SD = 27.83 ± 5.32 years), the old group (3 females, 3 males, mean age ± SD = 69.3 ± 3.8 years). Angular displacement and angular velocity were significantly higher in old than in young subjects and increased as the frequency of vibration increased. The subjective scores of vividness of illusion, amount of movement and fluidity increased as the frequency increased in young but not in old people.

Conclusions: Differences between old and young participants were reported in both the kinematic parameters of the reproduced movement and in the experience of the illusory sensation of movement. These preliminary findings suggest that aging alters the perception of movement evoked by a vibro-tactile stimulation. Further data are needed to better characterize this phenomenon.