**New literature since last update on 19-06-2019**

Single-leg cycling increases limb-specific blood flow without concurrent increases in normalised power output when compared with double-leg cycling in healthy middle-aged adults.


Abstract
This study examined the acute performance, cardiovascular and local muscular responses to perceived exertion-based high-intensity interval exercise using either double- or single-leg cycling. Fifteen healthy middle-aged adults completed, on separate occasions, ten 30-s double-leg intervals interspersed with 60 s passive recovery and twenty (ten with each leg) 30-s single-leg intervals interspersed with 60 s passive recovery. Impedance cardiography, blood pressure, muscle oxygenation and total haemoglobin content (near-infrared spectroscopy), oxygen consumption and power output were measured throughout each session. Normalised to the lean mass used during each trial, single-leg cycling resulted in lower power output (single-leg: 8.92±1.74 W kg⁻¹ and double-leg: 10.41±3.22 W kg⁻¹; p<0.05) but greater oxygen consumption (single-leg: 103±11 mL kg⁻¹ min⁻¹ and double-leg: 84±21 mL kg⁻¹ min⁻¹; p<0.01) and cardiac output (single-leg: 1407±334 mL kg⁻¹ min⁻¹ and double-leg: 850±222 mL kg⁻¹ min⁻¹; p<0.01), compared with double-leg cycling. Mean arterial pressure (double-leg: 108±11 mmHg and single-leg: 102±10 mmHg), change in total haemoglobin content (double-leg: 8.76±10.65 µM cm s⁻¹ and single-leg: 13.42±4.10 µM cm s⁻¹) and change in tissue oxygenation index (double-leg: -4.51±3.56% and single-leg: -3.97±3.91%) were not different between double-leg and single-leg cycling. When compared to double-leg cycling, single-leg cycling elicited a higher cardiac output relative to the lean mass, but this did not result in greater power output. The dissociation between blood availability and power output is consistent with an ageing model characterised by a decrease in local oxygen delivery and distribution capability.

Time course of sensorimotor cortex reorganization during upper extremity task accompanying motor recovery early after stroke: An fNIRS study.

Abstract
**BACKGROUND:**
The acute phase of stroke is accompanied by functional changes and interplay of both hemispheres. However, our understanding of how the time course of upper limb functional motor recovery is related to the progression of brain reorganization in the sensorimotor areas remains limited. This study aimed to assess the time course of hemodynamic patterns of cortical sensorimotor areas using functional near infrared spectroscopy (fNIRS) and motor recovery within three months after a stroke.
METHOD:
Eight right-handed first ischemic/hemorrhagic stroke patients (60±8 years, 3 women) with mild to severe hemiparesis were examined with repetitive fNIRS measurements and motor recovery tests (Fugl-Meyer score) during two months. Hemodynamic changes over the ipsilesional and contralesional sensorimotor areas were collected from a multi-channel fNIRS system during intermittent isometric muscle contractions at self-selected submaximal force levels for each arm. Lateralization index was computed to evaluate the changes in the interhemispheric balance between the cortical sensorimotor areas.

RESULTS:
Lateralization index values during non-paretic arm movements showed no significant changes over time in patients and were comparable to those observed in eight healthy controls. Paretic-arm movements were associated early with a bilateral cortical activity before shifting to ipsilesional patterns (p<0.01). Progressive lateralization observed over the two months (p<0.05) evolved concomitantly with an increase in the Fugl-Meyer score (p<0.001).

CONCLUSIONS:
Cortical reorganization monitoring using fNIRS during the first weeks after stroke may be applied for assessing progressive brain plasticity in addition to clinical measures of performance.

Methodological considerations for near-infrared spectroscopy to assess mitochondrial capacity after spinal cord injury.
Ghatas MP, Holman ME, Gorgey AS.

Abstract
Background: Skeletal muscle mitochondrial activity is reduced by ~50-60% after SCI, resulting in impaired energy expenditure, glucose utilization and insulin sensitivity. Near-infrared spectroscopy (NIRS) is a non-invasive tool that can be used to assess mitochondrial capacity. Objectives: (1) Highlight methodological limitations impacting data acquisition and analysis such as subcutaneous adipose tissue (SAT) thickness, movement artifacts, inadequate muscle stimulation, light interference, and ischemic discomfort. (2) Provide technical considerations to improve data acquisition and analysis. This may serve as guidance to other researchers and clinicians using NIRS. Study Design: cross-sectional observational design. Settings: Clinical research medical center. Participants: Sixteen men with 1> year post motor complete SCI. Methods: NIRS signals were obtained from right vastus lateralis muscle utilizing a portable system. Signals were fit to a mono-exponential curve. Outcome Measures: Rate constant and $r^2$ values for the fit curve, indirectly measures mitochondrial capacity. Results: Only four participants produced data with accepted rate constants of 0.002-0.013 s$^{-1}$ and $r^2$ of 0.71-0.87. Applications of studentized residuals ≥2.5 resulted in sparing data from another four participants with rate constants of 0.010-0.018 s$^{-1}$ and $r^2$ values ranging from 0.86-0.99. Conclusions: Several limitations may challenge the use of NIRS to assess mitochondrial capacity after SCI. Acknowledging these limitations and applying additional data processing techniques may overcome the discussed limitations and facilitate data sparing.
Superficial femoral artery blood flow with intermittent pneumatic compression of the lower leg applied during walking exercise and recovery.
Zuj KA, Prince CN, Hughson RL, Peterson SD.

Abstract
The purpose of this study was to determine if muscle blood flow during walking exercise and post-exercise recovery can be augmented through the application of intermittent compression of the lower legs applied during the diastolic phase of the cardiac cycle. Results from four conditions were assessed: no compression (NoComp), compression during walking (ExComp), compression during post-exercise recovery (RecComp), and compression applied throughout (AllComp). Superficial femoral artery (SFA) blood flow was measured (Doppler ultrasound) during rest and post-exercise recovery. Mean arterial blood pressure (MAP, finger photoplethysmography) was used to calculate vascular conductance as VC = SFA flow / MAP. Near infrared spectroscopy measured changes in oxygenated (O$_2$Hb) and deoxygenated (HHb) hemoglobin concentration throughout the test. Compression during exercise increased SFA blood flow measured over the first 15s of post-exercise recovery (AllComp: 532.2±123.1mL/min; ExComp: 529.8±99.2mL/min) compared to NoComp (462.3±87.3mL/min, p<0.05) and corresponded to increased VC (NoComp: 4.7±0.9mL/min/mmHg vs. ExComp: 5.5±1.0mL/min/mmHg, p<0.05). Similarly, compression throughout post-exercise recovery also resulted in increased SFA flow (AllComp: 190.5±57.1mL/min; RecComp: 158.7±49.1mL/min vs. NoComp: 108.8±28.5mL/min, p<0.05) and vascular conductance. Muscle contractions during exercise reduced total hemoglobin with O$_2$Hb comprising ~57% of the observed reduction. Compression during exercise augmented this reduction (p<0.05) with O$_2$Hb again comprising ~55% of the reduction. Total hemoglobin was reduced with compression during post-exercise recovery (p<0.05) with O$_2$Hb accounting for ~40% of this reduction. Results from this study indicate that intermittent compression applied during walking and during post-exercise recovery enhanced vascular conductance during exercise and elevated post-exercise SFA blood flow and tissue oxygenation during recovery.

Physiological adaptations to repeated sprint training in hypoxia induced by voluntary hypoventilation at low lung volume.
Woorons X, Millet GP, Mucci P.

Abstract
PURPOSE:
This study investigated the effects of repeated-sprint (RS) training in hypoxia induced by voluntary hypoventilation at low lung volume (RSH-VHL) on physiological adaptations, RS ability (RSA) and anaerobic performance.

METHODS:
Over a 3-week period, eighteen well-trained cyclists completed six RS sessions in cycling either with RSH-VHL or with normal conditions (RSN). Before (Pre) and after (Post) the training period, the subjects performed an RSA test (10×6-s all-out cycling sprints) during which oxygen uptake \[ \text{[Formula: see text]} \] and the change in both muscle deoxyhaemoglobin (\(\Delta[\text{HHb}]\)) and total haemoglobin (\(\Delta[\text{THb}]\)) were measured. A 30-s Wingate test was also performed and maximal blood lactate concentration ([La]_{max}) was assessed.

RESULTS:
At Post compared to Pre, the mean power output during both the RSA and the Wingate tests was improved in RSH-VHL (846±98 vs 911±117 W and 723±112 vs 768±123 W, p<0.05) but not in RSN (834±52 vs 852±69 W, p=0.2; 710±63 vs 713±72 W, p=0.68). The average \[ \text{[Formula: see text]} \] recorded during the RSA test was significantly higher in RSH-VHL at Post but did not change in RSN. No change occurred for \(\Delta[\text{THb}]\) whereas \(\Delta[\text{HHb}]\) increased to the same extent in both groups. \([\text{La]}_{\text{max}}\) after the Wingate test was higher in RSH-VHL at Post (13.9±2.8 vs 16.1±3.2 mmol L\(^{-1}\), p<0.01) and tended to decrease in RSN (p=0.1).

CONCLUSIONS:
This study showed that RSH-VHL could bring benefits to both RSA and anaerobic performance through increases in oxygen delivery and glycolytic contribution. On the other hand, no additional effect was observed for the indices of muscle blood volume and O\(_2\) extraction.

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Put on your (fNIRS) thinking cap: Frontopolar activation during augmented state creativity.
Tempest GD, Radel R.

Abstract
Thinking creatively requires the ability to consciously augment creative insight through processes such as analogical reasoning and relational cognition. Prior work has examined augmented states of creativity using a modified verb generation task which requires brief engagement in attempts to think creatively during MRI. In this study, we employed the verb generation task to examine augmented creative states and frontopolar cortex activation in a less-constrained setting using functional near infrared spectroscopy (fNIRS). Participants (n = 29) were presented with a noun and were required to think of an associated verb. In 50% of the trials, participants were instructed to ‘think creatively’ (cued condition) as opposed to stating the first or most prominent verb that came to mind (uncued condition). The task was administered in French to native speakers. Hemodynamic responses were recorded over the frontopolar cortex using fNIRS. The relatedness of the noun-verb pairs was calculated and other measures of creativity (the Alternate Uses Test, Compound Remote Associate Test and the Biographical Inventory of Creative Behaviors) were recorded. We showed that in the
cued condition, semantic scores were higher (indicating more creative responses), positively associated with other measures of creativity, and changes in oxygenated hemoglobin were larger and more extensive in the left frontopolar cortex, than in the uncued condition. Our findings support the use of the verb generation task (administered in French) to augment creative states and provides further validation of the use of the task to capture creativity (i.e., processes involved in generating creative responses through distant associations). We highlight the use of fNIRS to measure associated regional changes in frontopolar cortex activity during augmented states of creativity.

LOCAL EXERCISE DOES NOT PREVENT THE AORTIC STIFFENING RESPONSE TO ACUTE PROLONGED SITTING: A RANDOMIZED CROSS-OVER TRIAL.

Evans WS1, Stoner L2, Willey Q2, Kelsch E2, Credeur DP3, Hanson ED4.


Abstract
Prolonged sitting has been shown to promote endothelial dysfunction in the lower legs. Further, it has been reported that simple sitting-interruption strategies, including calf raises, prevent leg endothelial function. However, it is unclear whether prolonged sitting affects central cardiovascular health, or whether simple sitting interruption strategies prevent impaired central cardiovascular health.

PURPOSE:
This study sought to answer two questions: in young, healthy adults (i) does prolonged sitting (3h) lead to increased aortic stiffness? and (ii) do intermittent calf raises exercises to prevent pooling, also prevent aortic stiffening?

METHODS:
Twenty young, healthy participants (21.7±2.5 y, 70% F, 25.5±6.1 kg/m²) were randomized to 3 h of sitting with (CALF) or without (CON) 10 calf raises every 10 min. Aortic stiffening (carotid-femoral pulse wave velocity, PWV) was measured in the supine position pre- and post-sitting. Venous pooling during sitting was estimated with total hemoglobin (tHB) concentration using near-infrared spectroscopy.

RESULTS:
There were no condition x time interactions. Following 3 h of sitting, PWV significantly increased (0.30±0.46 m/s, p <0.001). There was no condition effect for PWV (p=0.694), indicating the intermittent calf rises did not preserve central cardiovascular health. tHb was not significantly affected by sitting (p=0.446) but was 1.9 μM higher for CON vs. CALF (p=0.106).

CONCLUSIONS:
Sitting increases aortic stiffness in young, healthy individuals, a process that may be influenced by lower extremity blood pooling. Calf raises, which have been reported to preserve vascular function in the legs, do not appear to provide sufficient stimulus for maintaining central cardiovascular health.
Development of a near-infrared spectroscopy interface able to assess oxygen recovery kinetics in the right and left sides of the pelvic floor.

Macnab A, Stothers L, Deegan E.


Abstract

Near-infrared spectroscopy (NIRS) muscle oxygenation data are relied on in sports medicine. Many women with urinary incontinence (UI) have dysfunctional pelvic floor muscles (PFMs) but their evaluation lacks such measures; a transvaginal NIRS interface would enable the PFM to be interrogated. Paired miniature fiber-optic cables were configured on a rigid foam insert so their emitter detector arrays with an interoptode distance of 20 mm apposed the right and left inner sides of a disposable clear plastic vaginal speculum, and linked to a standard commercial NIRS instrument. Measurement capability was assessed through conduct of three maximum voluntary contractions (MVCs) and one sustained maximum voluntary contraction of the PFM with calculation of HbDiff (½RT), a validated muscle reoxygenation kinetic parameter. In all four asymptomatic controls, mean age 40, mean BMI 21.4, MVCs were associated with changes in PFM oxyhemoglobin (O<sub>2</sub>Hb), deoxyhemoglobin (HHb) concentration, and their difference (HbDiff) comparable to those in voluntary muscle sports medicine studies. NIRS data during recovery (reoxygenation) allowed calculation of HbDiff (½RT). New techniques are called for to evaluate UI. This NIRS interface warrants further development as the provision of quantitative reoxygenation kinetics offers more comprehensive evaluation of patients with PFM dysfunction.

Exercise Intensity Influences Prefrontal Cortex Oxygenation during Cognitive Testing.

Moriarty T, Bourbeau K, Bellovary B, Zuhl MN.


Abstract

Activation changes in the prefrontal cortex (PFC) regions have been linked to acute exercise-induced improvements in cognitive performance. The type of exercise performed may influence PFC activation, and further impact cognitive function. The present study aimed to compare PFC activation during cognitive testing after moderate-intensity, high intensity, and yoga exercises, and to determine if PFC activation is linked to cognitive performance. Eight subjects (four male and four female), aged 35 ± 5 completed a control, high intensity, moderate intensity, and yoga exercises followed by administration of a cognitive task (NIH Toolbox Fluid Cognition). Left and right PFC activation (LPFC and RPFC, respectively) were evaluated by measuring hemoglobin difference (Hbdiff) changes during post-exercise cognitive assessment using functional near infrared spectroscopy (fNIRS). Activation during the cognitive test was higher in the LPFC after moderate intensity exercise compared to control, high intensity, and yoga (5.30 ± 6.65 vs. 2.26 ± 2.40, 2.50 ± 1.48, 2.41 ± 2.36 μM, p < 0.05, respectively). A negative relationship was detected between LPFC and processing speed after exercise. PFC activation did not align with cognitive performance. However, acute exercise,
regardless of type, appeared to alter neural processing. Specifically, less PFC activation was required for a given neural output after exercise.

Effects of repeated long-duration water immersions on skeletal muscle performance in well-trained male divers.
Myers CM, Kim JS, Florian JP.

Abstract
PURPOSE:
The objective of this study was to examine the effects of repeated long-duration water immersions (WIs) at 1.35 atmospheres absolute (ATA) on neuromuscular performance in load bearing and non-load bearing muscle groups.

METHODS:
During a dive week (DW), fifteen well-trained male divers completed five consecutive 6-h resting dives with 18-h surface intervals while breathing compressed air at 1.35 ATA. Skeletal muscle performance assessments occurred immediately before and after each WI, and 24 and 72 h after the final WI. Exercise assessments included maximum voluntary isometric contraction (MVIC), maximal isokinetic (IK) contraction, maximum handgrip strength (MHG). Surface electromyography measured neuromuscular activation of the quadriceps, biceps brachii (BB), and brachioradialis.

RESULTS:
MVIC torque of knee extensors and BB decreased by 6% (p=0.001) and 2% (p=0.014), respectively, by WI 3. Maximal IK torque of knee extensors increased by 11 and 5% post-WI on WIs 3 and 5 (p<0.001) with greater neuromuscular activation post-WI than pre-WI (p<0.001). Maximum IK elbow flexion torque did not change throughout the DW with BB neuromuscular activation greater post-WI than pre-WI (p<0.001). MHG force output was 4% greater post-WI than pre-WI (p<0.001) with increased brachioradialis activation through 72-h post-WI (p<0.001). All muscle performance metrics returned baseline levels by 72-h post-WI.

CONCLUSION:
Our findings indicate that repeated WIs caused noticeable decrements in neuromuscular activation and performance of load bearing muscles on WI 3 while full recovery was observed by 72-h post-WI.

Effects of Resting, Consecutive, Long-Duration Water Immersions on Neuromuscular Endurance in Well-Trained Males.
Myers CM, Kim JS, Musilli M, McCully K, Florian JP.

Abstract
Purpose: This study examined the effects of repeated long-duration water immersions (WIs) at 1.35 atmospheres absolute (ATA) on neuromuscular endurance performance. We hypothesized that, following 5 days of consecutive, resting, long-duration WIs, neuromuscular endurance performance would decrease. Methods: Fifteen well-trained, male subjects completed five consecutive 6-h resting WIs with 18-h surface intervals during the dive week while breathing compressed air at 1.35 ATA. Skeletal muscle endurance performance was assessed before and after each WI, and 24 and 72 h after the final WI. Muscular endurance assessments included 40% maximum handgrip endurance (MHE) and 50-repetition maximal isokinetic knee extensions. Near infrared spectroscopy was used to measure muscle oxidative capacity of the vastus lateralis and localized muscle tissue oxygenation of the vastus lateralis and flexor carpi radialis. Simultaneously, brachioradialis neuromuscular activation was measured by surface electromyography. Results: A 24.9% increase ($p = 0.04$) in the muscle oxidative capacity rate constant ($k$) occurred on WI 4 compared to baseline. No changes occurred in 40% MHE time to exhaustion or rate of fatigue or total work performed for the 50-repetition maximal isokinetic knee extension. The first quartile of deoxygenated hemoglobin concentration showed a 6 and 35% increase on WIs 3 and 5 ($p = 0.026$) with second quartile increases of 9 and 32% on WIs 3 and 5 ($p = 0.049$) during the 40% MHE testing when compared to WI 1. Conclusion: Our specific WI protocol resulted in no change to muscular endurance and oxygen kinetics in load bearing and non-load bearing muscles.

The Association between Prefrontal Cortex Activity and Turning Behavior in People with and without Freezing of Gait.

Belluscio V, Stuart S, Bergamini E, Vannozzi G, Mancini M.


Abstract

Turning elicits Freezing of Gait (FoG) episodes in people with Parkinson’s disease (PD) and is thought to require higher cortical control compared to straight ahead gait. Functional near infrared spectroscopy (fNIRS) has been used to examine prefrontal cortex (PFC) activity while walking, but the relationship between PFC activity and turn performance remains unclear. The aim of this pilot study was to examine PFC activity during turning in PD and healthy controls, and to investigate the association between PFC activity and turning. Thirty-two subjects, 15 freezers (PD + FoG) and 17 non-freezers (PD - FoG), and 8 controls were asked to perform a 2-min turning-in-place test under single-task (ST) and dual-task (DT) conditions. Each participant wore an fNIRS system to measure changes in oxyhemoglobin, as measure of PFC activity, and inertial sensors to quantify turning. Our results show a significant group ($p = .050$), task ($p = .039$), and interaction ($p = .047$) for the PFC activity during turning. Specifically, PD + FoG show higher PFC during turning compared to the other groups; PFC activity during DT is overall different compared to ST with an opposite trend in PD + FoG compared to controls and PD - FoG. In addition, higher PFC is associated with worse FoG in PD + FoG ($r = 0.57, p = .048$) and with lower number of turns in PD - FoG ($r = -0.70, p = .002$). The increased PFC activity in PD and the association between higher PFC activity and poorer turning performance may be a sign of poor movement automaticity in PD. Although further investigations are required, these pilot findings may guide development of personalized treatments to improve motor automaticity in PD.
Prefrontal Cortex Activation During Dual Task With Increasing Cognitive Load in Subacute Stroke Patients: A Pilot Study.
Hermand E, Tapie B, Dupuy O, Fraser S, Compagnat M, Salle JY, Daviet JC, Perrochon A.

Abstract
Stroke patients often exhibit difficulties performing a cognitive task while walking, defined as a dual task (DT). Their prefrontal cortex (PFC) activity is higher in DT than in single task (ST). The effects of an increasing load on PFC activity during DT in subacute stroke patients remains unexplored. Our objective was to assess the effects of N-back tasks (low/high load) on cerebral activity, gait parameters, and cognitive performances. Eleven subacute stroke patients (days post-stroke 45.8 ± 31.6) participated in this pilot study (71.4 ± 10 years, BMI 26.7 ± 4.8 kg.m⁻², Barthel index 81.8 ± 11.0). Patients completed a ST walk, and 4 conditions with 1-back (low load) and 2-back (high load): STlow, SThigh, DTlow, and DThigh. Overground walking was performed at a comfortable pace and -N-back conditions were carried out verbally. Both gait (speed, stride variability) and cognitive (rate of correct answers) performances were recorded. Changes in PFC oxyhemoglobin (ΔO₂Hb) and deoxyhemoglobin (ΔHHb) were measured by functional near infrared spectroscopy (fNIRS). Results showed an increase of ΔO₂Hb while walking, which was not augmented by cognitive loads in DT. Walking speed was reduced by low and high cognitive loads in DT compared to ST walk (P < 0.05), but was not different between DTlow and DThigh. Cognitive performances were negatively impacted by both walking (P < 0.05) and cognitive load (between "low" and "high," P < 0.001). These data highlight a "ceiling" effect in ΔO₂Hb levels while walking, leaving no available resources for simultaneous cognitive tasks, during the early recovery period following stroke. In these patients, cognitive, but not motor, performances declined with a higher cognitive load.

High intensity aerobic exercise does not prime the brain for anodal transcranial direct current stimulation.
Hendy AM, Macpherson H, Nuzum ND, Della Gatta PA, Alexander SE, Hoy KE, Enticott PG, Teo WP.

Abstract

OBJECTIVE:
This pilot, prospective, observational, cohort study aimed to examine, for the first time, the in vivo alterations in the oxygenation of the forearm skeletal muscles and the prefrontal lobes during intermittent exercise in women diagnosed with gestational diabetes mellitus (GDM), during and after pregnancy.

STUDY DESIGN:
Nine pregnant women, diagnosed with GDM, performed a 3-min intermittent handgrip exercise protocol (at 35% of Maximal Voluntary Contraction) during pregnancy (mean 27th gestational week) and following labor (mean 71 weeks). During the protocol, muscle and cerebral oxygenation were assessed with near-infrared spectroscopy. Resting vascular parameters [carotid intima-media thickness (cIMT) and hemodynamic parameters (using rheocardiography)], and hematological/biochemical parameters during pregnancy and after delivery have been compared.

RESULTS:
Although changes were observed in certain hematological parameters (p< 0.05), cIMT and hemodynamic parameters were not altered post-partum. In addition, both muscle and cerebral oxygenation parameters during handgrip were not significantly altered post-partum.

CONCLUSIONS:
Despite significant changes in specific hematological parameters in women with GDM, impairments in muscle and cerebral oxygenation during exercise remained at one year after labor. These results indicate that alterations in vascular parameters and muscle/cerebral oxygenation associated with GDM do not entirely reverse post-partum. Future studies are needed to examine which interventions will lead to improvements in microvascular parameters and prevent type 2 diabetes.

Affect and prefrontal hemodynamics during exercise under immersive audiovisual stimulation: Improving the experience of exercise for overweight adults.
Jones L, Ekkekakis P.

Abstract

OBJECTIVE:
Research on methods of improving the affective experience of exercise remains limited, especially for low-active overweight adults. We investigated the effectiveness of a virtual-reality headset and headphones in improving affective responses over conventionally delivered audiovisual stimulation.

METHODS:
Low-active, overweight adults (16 women, 5 men; age: 34.67 ± 9.62 years; body mass index: 28.56 ± 4.95 kg/m²; peak oxygen uptake for men: 29.14 ± 6.56 mL/kg/min, for women: 22.67 ± 4.52
mL/kg/min, mean ± SD) completed 15-min sessions of recumbent cycling at the ventilatory threshold: (a) high immersion (HI, virtual reality headset and headphones), (b) low immersion (LI, television screen and speakers), and (c) Control. During-exercise pleasure and post-exercise enjoyment were self-reported. Oxygenation of the right dorsolateral prefrontal cortex (dIPFC) was assessed with near infrared spectroscopy.

**RESULTS:**
Higher pleasure was reported during HI than during LI and Control (Condition × Time interaction; \( p < 0.001, \eta^2_p = 0.43 \)). Participants who reported a preference for low exercise intensity showed higher dIPFC oxygenation during Control, but this difference diminished during LI and HI (Condition × Time × Preference interaction; \( p = 0.036, \eta^2_p = 0.10 \)).

**CONCLUSION:**
Compared with conventionally delivered audiovisual stimulation, using a virtual-reality headset strengthens the dissociative effect, further improving affective responses to exercise at the ventilatory threshold among overweight, low-active adults. Presumably by competing with interoceptive afferents at the level of sensory input, audiovisual stimulation may lessen reliance on cognitive efforts to attenuate declining affect, as indicated by lower right dIPFC activity, particularly among participants disinclined toward high exercise intensity.

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**Psycho-physiological responses to perceptually-regulated interval runs in hypoxia and normoxia,**

Hobbins L, Gaoua N, Hunter S, Girard O.

Physiol Behav. 2019 Oct 1;209:112611

Abstract
We investigated whether perceptually-regulated high-intensity intervals in hypoxia are associated with slower running velocities versus normoxia, when physiological responses and exercise-related sensations remain the same. Nineteen trained runners (33.4 ± 9.1 years) completed a high-intensity interval running protocol (4 × 4-min intervals at a clamped perceived rating exertion of 16 on the 6–20 Borg scale, 3-min passive recoveries) in either hypoxic (HYP; FiO2 15.0%) or normoxic (NOR; FiO2 20.9%) conditions. Participants adjusted to a progressively slower running velocity from interval 1–4 (-7.0%), and more so in HYP vs. NOR for intervals 2, 3 and 4 (-4.6%, -6.4% and -7.9%, respectively; \( p < 0.01 \)). Heart rate increased from interval 1–4 (+4.8%; \( p < 0.01 \)), independent of condition. Arterial oxygen saturation was lower in HYP vs. NOR (86.0% vs. 94.8%; \( p < 0.01 \)). Oxyhemoglobin (-23.7%) and total hemoglobin (-77.0%) decreased, whilst deoxyhemoglobin increased (+44.9%) from interval 1–4 (\( p < 0.01 \)), independent of condition. Perceived recovery (-41.6%) and motivation (-21.8%) were progressively lower from interval 1–4, and more so in HYP vs. NOR for intervals 2, 3 and 4 (recovery: -8.8%, -24.2% and -29.3%; motivation: -5.3%, -20.3% and -22.4%, respectively; \( p < 0.01 \)). Perceived breathlessness (+18.6%), limb discomfort (+44.0%) and pleasure (-32.2%) changed from interval 1–4, with significant differences (+21.8%, +11.3% and -31.3%, respectively) between HYP and NOR (\( p < 0.01 \)).
Slower interval running velocities in hypoxia achieve similar heart rate and muscle oxygenation responses to those observed in normoxia when perceptually-regulated, yet at the expense of less favourable exercise-related sensations.

**Treading on the unknown increases prefrontal activity: A pilot fNIRS study**

Yogev Koren, Yisrael Parmet, Simona Bar-Haim

Gait & Posture, Volume 69, March 2019, Pages 96-100

**Background**

Complex walking conditions (e.g. dual tasking) have been associated with increased prefrontal (PFC) activity. However, most paradigms include a predictable environment, specifically, a predictable walking terrain. In the present study we investigate PFC activity under an unusual walking condition where each foot placement was on unexpected terrain, thus causing a mismatch between visuospatial perception and lower-extremity proprioception.

**Research Objective**

To assess whether PFC activity increases under unstable unpredictable conditions compared to unstable but predictable conditions.

**Methods**

This was a prospective study involving twenty healthy adults. Participants walked in two conditions: unstable but predictable, and unstable and unpredictable. To assess walking stability, both stride-time (ST) and stride-time variability (CV) were measured. To assess PFC activity, two wireless near-infrared spectroscopy devices were used. The group hemodynamic response (GHR) was calculated for each condition. For statistical analysis, a linear-mixed-effects model was used.

**Results**

Walking with unpredictable perturbations did not change the ST ($t=0.51$, $p=0.61$) but significantly increased the parameter CV ($t=11.74$, $p<0.001$). The GHR of both conditions indicated brief per-initiation PFC activity that was similar across conditions. However, when GHRs were calculated relative to normal walking (i.e., the participants’ own shoes), continuous activity was evident. Compared to the predictable condition, the unpredictable condition significantly increased this activity during steady-state walking ($t=2.13$, $p=0.033$).

**Significance**

Observations from the present study suggest that at least two neural components are present in the measured signal—a brief one, occurring per-initiation, and a continuous one, sensitive to the predictability of the terrain. The second component was accompanied by a decrease in walking stability. These results may contribute to our understanding of the control mechanism underlying gait and future planning of rehabilitation protocols.
Chronic high-dose beetroot juice supplementation improves time trial performance of well-trained cyclists in normoxia and hypoxia.
Rokkedal-Lausch T, Franch J, Poulsen MK, Thomsen LP, Weitzberg E, Kamavuako EN, Karbing DS, Larsen RG.

Abstract
Dietary nitrate (NO$_3^-$) supplementation via beetroot juice (BR) is known to improve endurance performance in untrained and moderately trained individuals. However, conflicting results exist in well-trained individuals. Evidence suggests that the effects of NO$_3^-$ are augmented during conditions of reduced oxygen availability (e.g., hypoxia), thereby increasing the probability of performance improvements for well-trained athletes in hypoxia vs. normoxia. This randomized, double-blinded, counterbalanced-crossover study examined the effects of 7 days of BR supplementation with 12.4 mmol NO$_3^-$ per day on 10-km cycling time trial (TT) performance in 12 well-trained cyclists in normoxia (N) and normobaric hypoxia (H). Linear mixed models for repeated measures revealed increases in plasma NO$_3^-$ and NO$_2^-$ after supplementation with BR (both p < 0.001). Further, TT performance increased with BR supplementation (∼1.6%, p < 0.05), with no difference between normoxia and hypoxia (p = 0.92). For respiratory variables there were significant effects of supplementation on VO$_2$ (p < 0.05) and VE (p < 0.05) such that average VO$_2$ and VE during the TT increased with BR, with no difference between normoxia and hypoxia (p ≥ 0.86). We found no effect of supplementation on heart rate, oxygen saturation or muscle oxygenation during the TT. Our results provide new evidence that chronic high-dose NO$_3^-$ supplementation improves cycling performance of well-trained cyclists in both normoxia and hypoxia.

Muscle oxygenation induced by cycling exercise does not accelerate recovery kinetics following exercise-induced muscle damage in humans: A randomized cross-over study.
Abaïdia AE, Cosyns S, Dupont G.

Abstract
The aim of this study was to analyze the effects of inducing muscle oxygenation using an intermittent cycling exercise on recovery kinetics after exercise-induced muscle damage. Ten soccer players performed single-leg knee flexors exercise: 75 eccentric contractions. The day after, subjects performed an intermittent cycling exercise of 12 min (15 s work - 15 s rest) or recovered passively in a balanced and randomized cross-over design. Force, single and double-leg countermovement jumps, muscle soreness, perceived recovery and creatine kinase concentrations were assessed through a 72 h period. Oxygenation during cycling was assessed using Near Infrared Spectroscopy. Results showed an increase in knee flexors oxygenation using
intermittent cycling ($\Delta\text{HbO}_2=70.2\pm19.8\%$ ; $\Delta\text{HHb}=68.2\pm14.1\%$). Possibly small detrimental effect of cycling on eccentric force was found ($ES = -0.58$, 90% CI: -1.33 to 0.17). Small detrimental effects of cycling were found for soreness and perceived recovery. Implementing intermittent cycling exercise the day after muscle damage may be detrimental for recovery.

Vascular and oxygenation responses of local ischemia and systemic hypoxia during arm cycling repeated sprints.
Willis SJ, Peyrard A, Rupp T, Borrani F, Millet GP.

Abstract
OBJECTIVES:
The purpose of this study was to investigate the acute vascular and oxygenation responses to repeated sprint exercise during arm cycling with either blood flow restriction (BFR) or systemic hypoxia alone or in combination.

DESIGN:
The study design was a single-blinded repeated-measures assessment of four conditions with two levels of normobaric hypoxia (400 m and 3800 m) and two levels of BFR (0% and 45% of total occlusion).

METHODS:
Sixteen active participants (eleven men and five women; mean±SD; 26.4±4.0 years old; 73.8±9.8 kg; 1.79±0.07 m) completed 5 sessions (1 familiarization, 4 conditions). During each test visit, participants performed a repeated sprint arm cycling test to exhaustion (10s maximal sprints with 20s recovery until exhaustion) to measure power output, metabolic equivalents, blood flow, as well as oxygenation (near-infrared spectroscopy) of the biceps brachii muscle tissue.

RESULTS:
Repeated sprint performance was decreased with both BFR and systemic hypoxia conditions. Greater changes between minimum-maximum of sprints in total hemoglobin concentration ($\Delta[T\text{Hb}]$) were demonstrated with BFR (400 m, 45% and 3800 m, 45%) than without (400 m, 0% and 3800 m, 0%) (p<0.001 for both). Additionally, delta tissue saturation index ($\Delta\text{TSI}$) decreased more with both BFR conditions than without (p<0.001 for both). The absolute maximum TSI was progressively reduced with both BFR and systemic hypoxia (p<0.001).

CONCLUSIONS:
By combining high-intensity, repeated sprint exercise with BFR and/or systemic hypoxia, there is a robust stimulus detected by increased changes in blood perfusion placed on specific vascular mechanisms, which were more prominent in BFR conditions.
Nasal high flow does not improve exercise tolerance in COPD patients recovering from acute exacerbation: A randomized crossover study.

Prieur G, Medrinal C, Combret Y, Dupuis Lozeron E, Bonnevie T, Gravier FE, Quieffin J, Lamia B, Borel JC, Reychler G.

Background and objective

We hypothesized that by reducing respiratory work and improving gas exchange, nasal high flow (NHF) would improve exercise tolerance in patients with chronic obstructive pulmonary disease (COPD) following respiratory exacerbation.

Methods

This was a monocentric, randomized, controlled crossover study. Patients with severe to very severe COPD carried out two high-intensity constant work-rate exercise tests (CWRET) with and without NHF on two consecutive days. The primary outcome was the mean difference in endurance time between both conditions. The secondary aims included vastus lateralis oxygenation (StO2), dyspnoea, leg discomfort, maximal inspiratory pressure (MIP), transcutaneous CO2 pressure (PtcCO2), respiratory rate (RR), heart rate (HR) and pulsed O2saturation (SpO2), as well as the patients' opinions of the device.

Results

A total of 19 patients were included (mean forced expiratory volume in 1s = 28.7±10.8%, age = 62.1±9.1 years). No significant differences in endurance time during the CWRET were found between the two test conditions (−66.58 (95% CI: −155.9 to 22.7) s, P = 0.12). StO2, PtCO2 and HR were reduced at the end of the exercise with NHF (−2.1% (95% CI: −4.3 to −0.0); −1.3 mm Hg (95% CI: −2.5 to −0.2); −2.7 bpm (95% CI: −5.0 to −0.5), respectively, P ≤ 0.05). No significant differences were found for any of the other secondary outcomes. Half of the patients evaluated the device as being moderately to very uncomfortable.

Conclusion

NHF during exercise did not increase endurance time in patients with COPD following exacerbation.

Central cardiovascular hemodynamic response to unilateral handgrip exercise with blood flow restriction.

Credeur DP, Jones R, Stanford D, Stoner L, McCoy S, Jessee M.

Abstract
**AIM:**
Exercise training with blood flow restriction (BFR) increases muscle size and strength. However, there is limited investigation into the effects of BFR on cardiovascular health, particularly central hemodynamic load.

**PURPOSE:**
To determine the effects of BFR exercise on central hemodynamic load (heart rate-HR, central pressures, arterial wave reflection, and aortic stiffness).

**METHODS:**
Fifteen males (age=25±2 years; BMI=27±2 kg/m², handgrip max voluntary contraction-MVC=50±2 kg) underwent 5-min bouts (counter-balanced, 10 min rest between) of rhythmic unilateral handgrip (1 s squeeze, 2 s relax) performed with a moderate-load (60% MVC) with and without BFR (i.e., 71±5% arterial inflow flow reduction, assessed via Doppler ultrasound), and also with a low-load (40% MVC) with BFR. Outcomes included HR, central mean arterial pressure (cMAP), arterial wave reflection (augmentation index, AIx; wave reflection magnitude, RM%), aortic arterial stiffness (pulse wave velocity, aPWV), and peripheral (vastus lateralis) microcirculatory response(tissue saturation index, TSI%).

**RESULTS:**
HR increased above baseline and time control for all handgrip bouts, but was similar between the moderate load with and without BFR conditions (moderate-load with BFR= +9±2; moderate-load without BFR= +8±2 bpm, p<0.001). A similar finding was noted for central pressure (e.g., moderate load with BFR, cMAP = +14±1 mmHg, p<0.001). No change occurred for RM% or AIx (p>0.05) for any testing stage. TSI% increased during the moderate-load conditions (p=0.01), and aPWV increased above baseline following moderate-load handgrip with BFR only (p=0.012).

**CONCLUSIONS:**
Combined with BFR, moderate load handgrip training with BFR does not significantly augment central hemodynamic load during handgrip exercise in young healthy men.

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**The effects of aging and cardiovascular risk factors on microvascular function assessed by near-infrared spectroscopy.**


**Abstract**
This study aimed to evaluate whether NIRS-derived reperfusion rate would detect potential differences in the forearm microvascular responsiveness between young healthy adults, and older adults free from or with cardiovascular disease (CVD) risk factors. Fifteen healthy young (age: 24.8 ± 4.0 years), seventeen older adults free of CVD risk factors (age: 67.0 ± 6.8 years), and twenty-three older adults with CVD risk factors (age: 67.9 ± 8.0 years) participated this study. Individuals underwent a blood draw and vascular occlusion test (30 s of baseline, 5 min of occlusion, and 2 min of reperfusion) and microvascular responsiveness was evaluated by using NIRS-derived tissue oxygen saturation indexes during reperfusion. A significant slower reperfusion rate and lower reperfusion
A low-cost, wireless near-infrared spectroscopy device detects the presence of lower extremity atherosclerosis as measured by computed tomographic angiography and characterizes walking impairment in peripheral artery disease.

Fuglestad MA, Hernandez H, Gao Y, Ybay H, Schieber MN, Brunette KE, Myers SA, Casale GP, Pipinos II.


Abstract

A low-cost, wireless near-infrared spectroscopy device detects the presence of lower extremity atherosclerosis as measured by computed tomographic angiography and characterizes walking impairment in peripheral artery disease.

Fuglestad MA, Hernandez H, Gao Y, Ybay H, Schieber MN, Brunette KE, Myers SA, Casale GP, Pipinos II.


Abstract

Exposure of biological tissue to photobiomodulation therapy (PBMT) seems to increase the oxygen availability and mitochondrial electrochemical activity. With the advancement of new technologies, such as near-infrared spectroscopy (NIRS), information can be obtained about the balance between oxygen utilization and delivery by assessing local oxy- \([\text{O}_2\text{Hb}]\) and deoxy-myohemoglobin \([\text{HHb}]\) concentrations, both measured in micromolars (μM). Consequently, NIRS can be used to study ("in vivo") PBMT effects on the oxidative system, including oxygen availability. Thus, the main objective of the present study was to use NIRS to investigate the acute effects of PBMT by light-emitting diode (LED) on the oxygen delivery and utilization in humans. Twelve healthy young participants were treated with a LED device (850 nm, 50 mW, 2 J) and placebo applied over the proximal third of the flexor carpi ulnaris muscle of the left or right forearm selected in a random order. The LED was applied in direct contact with skin and the device was switched on for 40 s in 4 different interventions (I₁, I₂, I₃ and I₄) with a 3-min interval between interventions. The placebo condition was considered as the period before the first PBMT. The NIRS device was used to evaluate the relative changes in \([\text{O}_2\text{Hb}]\) and \([\text{HHb}]\) before and after placebo and interventions. We found that PBMT statistically increased the \([\text{O}_2\text{Hb}]\) in 0.39 μM. These results demonstrate the potential of PBMT to increase oxygen availability.
BACKGROUND:
Patients with peripheral artery disease (PAD) who experience intermittent claudication report a range of symptoms. Patients with symptoms other than classically described intermittent claudication may be at the highest risk for functional decline and mobility loss. Therefore, technologies allowing for characterization of PAD severity are desirable. Near-infrared spectroscopy (NIRS) allows for measurements of muscle heme oxygen saturation ($StO_2$) during exercise. We hypothesized lower extremities affected by PAD would exhibit distinct NIRS profiles as measured by a low-cost, wireless NIRS device and that NIRS during exercise predicts walking limitation.

METHODS:
We recruited 40 patients with PAD and 10 control participants. All patients with PAD completed a computed tomographic angiography, 6-minute walk test, and a standardized treadmill test. Controls completed a 540-second treadmill test for comparison. $StO_2$ measurements were continuously taken from the gastrocnemius during exercise. Variables were analyzed by Fischer's exact, $\chi^2$, Wilcoxon rank-sum, and Kruskal-Wallis tests as appropriate. Correlations were assessed by partial Spearman correlation coefficients adjusted for occlusive disease pattern.

RESULTS:
Patients with PAD experienced claudication onset at a median of 108 seconds with a median peak walking time of 288 seconds. The baseline $StO_2$ was similar between PAD and control. The $StO_2$ of PAD and control participants dropped below baseline at a median of 1 and 104 seconds of exercise, respectively ($P < .0001$). Patients with PAD reached minimum $StO_2$ earlier than control participants (119 seconds vs 522 seconds, respectively; $P < .001$) and experienced a greater change in $StO_2$ at 1 minute of exercise (-73.2% vs 8.3%; $P < .0001$) and a greater decrease at minimum exercise $StO_2$ (-83.4% vs -16.1%; $P < .0001$). For patients with PAD, peak walking time, and 6-minute walking distance correlated with percent change in $StO_2$ at 1 minute of exercise ($r = -0.76$ and -0.67, respectively; $P < .001$) and time to minimum $StO_2$ ($r = 0.79$ and 0.70, respectively; $P < .0001$).

CONCLUSIONS:
In this initial evaluation of a novel, low-cost NIRS device, lower extremities affected by PAD exhibited characteristic changes in calf muscle $StO_2$, which differentiated them from healthy controls and were strongly correlated with walking impairment. These findings confirm and expand on previous work demonstrating the potential clinical value of NIRS devices and the need for further research investigating the ability of low-cost NIRS technology to evaluate, diagnose, and monitor treatment response in PAD.

Optical Imaging of Brain Motor Cortex Activation During Wrist Movement Using Functional Near-Infrared Spectroscopy (fNIRS),
Alalvandi M, Riahi Alam N, Sharini H.
Arch Neurosci. Online ahead of Print ; 6(Brain Mapping):e90089

Abstract
Background: Optical imaging has attracted the researcher’s attention in recent years as an uncompromising and efficient method to measure the changes in brain cortex activity. Functional
Near-Infrared Spectroscopy (fNIRS) is a method that measures hemodynamic changes in the brain cerebral cortex based on optical principles.

Objectives: The current study aimed to evaluate the activities of the brain cortex during wrist movement using fNIRS.

Methods: In this study, the activity of the brain motor cortex was investigated during right wrist movement in 10 young right-handed volunteers. Data were collected using a 48-channel fNIRS device with two wavelengths of 855 nm and 765 nm. For this experiment, 20 channels were used and the sampling frequency was set at 10 Hz.

Results: Signal intensity in the motor cortex was significantly higher during movement than in the rest (P ≤ 0.05). The activation map of wrist movements was separated spatially in the motor cortex. The highest activity was recorded in the primary motor cortex (M1). There was a significant difference in the focus of the maximum activation of the brain between the four main directions.

Conclusions: It is possible to differentiate between different directions of movement using near-infrared signals. The presence of directional activation in the cerebral cortex helps confirm the notion that this part of the brain participates in the processing of complex information besides controlling the movement of different parts of the body.