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Acute effects of electrical stimulation pulse width and frequency on neuromuscular function

Loïc Espeit[a], Eric Luneau[a], Callum G Brownstein[a], Julien Gondin[b], Guillaume Y Millet[a,c], Vianney Rozand[a], Nicola A Maffiuletti[d], Thomas Lapole[a]

[a] Inter-university Laboratory of Human Movement Biology, University of Lyon, UJM Saint-Etienne, EA 7424, F-42023, Saint-Etienne, France
[b] Institut NeuroMyoGène (INMG), Université Claude Bernard Lyon 1, CNRS UMR-5310, INSERM U-1217, Lyon, France
[c] Institut Universitaire de France (IUF)
[d] Human Performance Lab, Schulthess Clinic, Zurich, Switzerland

INTRODUCTION. Contrary to conventional neuromuscular electrical stimulation (NMES) that mainly activates motor axons, wide-pulse (WP) NMES is thought to also favour the recruitment of sensory axons, potentially resulting in greater neural adjustments. While WP NMES has mainly been used at low stimulation intensities to maximize extra torque, its application at the maximal tolerable intensity – which is known to be more effective for conventional NMES – is rare. Therefore, the aim of the present study was to compare acute neuromuscular changes induced by 20 min of maximal intensity WP and conventional NMES of the knee extensors. We hypothesised that the use of WP NMES would change excitability within the neuromuscular pathway.

METHODS. After a familiarization visit, 17 men (27±6 years) performed three sessions, each consisting of neuromuscular testing before (PRE) and after (POST) a 20-min NMES protocol. The three NMES protocols (randomly presented) consisted in the following pulse width-frequency configurations: 0.2 ms-50 Hz (CONV), 1 ms-50 Hz (WP50), and 1 ms-100 Hz (WP100). Thirty 10-s contractions at maximal tolerable intensity were evoked during each protocol, with 30-s periods of rest in-between. NMES-evoked torque and the associated discomfort were assessed for each protocol. The neuromuscular outcomes were knee extensors maximal voluntary contractions (MVC) torque, voluntary activation (VA), doublets (Db) torque, and vastus lateralis electromyography signals [i.e. M-wave (Mmax), spinal reflex (SR), thoracic motor evoked potential (TMEP) and motor evoked potential (MEP)] evoked using electrical and magnetic stimulations during submaximal knee extensors contractions at the electromyographic level associated with 20% MVC. Intensities were set to evoke SR, TMEP and MEP responses of ~20% Mmax amplitude at PRE.

RESULTS. No significant differences were found in NMES-evoked torque (range: 10-74% MVC; $p=0.24$) and associated discomfort ($p=0.17$) between the three NMES protocols. Decreases in MVC torque at the end of the protocols (-14.1%; $p<0.001$) were not significantly different ($p=0.39$) between NMES protocols. Peripheral alterations were shown by decreased in Db (-6.1%; $p<0.05$) and Mmax (-13.4%; $p<0.01$) amplitudes, though these alterations were not different between protocols ($p=0.33$ and 0.16, respectively). VA was not affected for all protocols ($p>0.32$), suggesting no NMES-induced failure in central drive. Similarly, SR/Mmax, TMEP/Mmax and MEP/Mmax ratios were unaltered for all protocols ($p>0.11$), suggesting unchanged spinal, motoneuronal and cortical excitability, respectively.

CONCLUSION. This study demonstrated that 20 min of NMES applied on the knee extensors at maximal tolerable intensity induced peripheral but not central alterations regardless of pulse width and stimulation frequency. These results contrast with recent findings suggesting neural adjustments when WP NMES is applied on plantar flexors at low stimulation intensity.

Recovery of Neuromuscular Fatigue following a Sprint Interval Training Session.

Lloria-Varella Jaume, Sébastien Morel, Koral Jérôme, Busso Thierry

Introduction

Among the different high intensity interval training methods, the Sprint Interval Training (SIT) is known by its time-efficiency relationship (1). Previous works have shown its potential to improve both, the anaerobic and anaerobic pathways in very short periods of time (2,3). However, such an intense stimulus could generate sufficient stress to disturb the organism from hours to days after the session. Since the way in which the intensity is distributed within a training program is known to be a factor of success of the program itself (4), studying the acute detrimental effects generated by a typical SIT session, could be of importance for future practitioners and coaches aiming to optimize the recovery time between sessions. Moreover, the literature studying the fatiguing effects generated by SIT is sparse. This pilot study aimed to evaluate the SIT-induced fatigue immediately after and the days following the session. In addition, two SIT modalities were compared to determine whether different work:rest ratios could modulate the amount of fatigue generated. We hypothesized that, despite the neuromuscular function will be impaired right after the exercise, fatigue will not last more than 24h. Moreover, we did not expect any differences between SIT modalities in terms of fatigue.

Methods

Eight young and active males (age: 26 ± 5 years; height: 1.78 ± 0.07 m; body mass: 75.1 ± 10.8 kg). Participants performed 2 iso-volume and randomized SIT sessions separated by at least one week. The first modality consisted of 4 x 30-s bouts interspersed by 4 minutes of recovery ($SIT_{30\text{-}4}$) while the second consisted of 8 x 15-s with 2 minutes of recovery ($SIT_{15\text{-}2}$). The neuromuscular function was assessed via an isometric and a dynamic approach. First, the isometric maximal voluntary contraction (IMVC) and twitch responses to electrical stimulation of the knee extensors during the MVC (voluntary activation, VA) and at rest (doublet 100, Db100 and doublet 10, Db10) were measured at different time points: baseline (PRE), one ($POST_1$), two ($POST_2$), 8 minutes ($POST_8$), 24 and 48 hours ($POST_{24h}$ and $POST_{48h}$ respectively) after the last 15 or 30-s cycling bout. Secondly, the power-force-velocity profile was assessed before (PFVP PRE), 10 minutes after the SIT sessions ($PFVP_{POST}$) and at 24h ($PFVP_{24h}$) and 48h ($PFVP_{48h}$) using two different loads. The theoretical maximal force (F_0) velocity (V_0) and maximal power (P_{max})were then calculated using the mathematical model proposed by the literature. The maximal (P_{maxSIT}) and mean ($P_{meanSIT}$) power developed during the cycling bouts and the heart rate (HR) during the session were also measured. Finally, blood lactate was assessed before ($Lactate_{Pre}$) and after 3 minutes the completion of the last bout ($Lactate_{Post3}$).

Results

A significant effect of time was found for both, the isometric and the dynamic approach. Importantly no modality or interaction effects were revealed by the analysis of variance for any of the studied parameters. First, the isometric neuromuscular assessment revealed a significant main time effect where IMVC, Db100 and the ratio between Db10 and Db100 were decreased at $POST_1$, $POST_2$ and $POST_8$ compared to PRE. All these parameters followed a similar evolution being not significantly different from PRE at $POST_{24h}$. No effect of time was found for VA. Secondly, the P_{max} and F_0 were impaired at $PFVP_{POST}$ but not showing any differences with PRE at $PFVP_{24h}$. Interestingly, no time effects were found for V_0 after the sessions. Finally, no differences between modalities were observed for P_{maxSIT} while $P_{meanSIT}$ was significantly higher for the $SIT_{15\text{-}2}$. The average and the maximal HR

during bouts and at rest, were higher for the $SIT_{30\text{-}4}$ and significantly different between modalities. Only a significant time effect was observed between $Lactate_{Pre}$ and $Lactate_{Post3}$.

Discussion

Overall, our results show that right after a SIT session, the neuromuscular function is impaired from both, isometric and dynamic standpoints. In addition, and regardless of the work:rest ratio of the modalities and the differences in power and HR, the neuromuscular fatigue did not last more than 24h after a SIT session.

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Mechanisms of muscle pH regulation in sickle cell disease.

Manon Riccetti[1], Benjamin Chatel[2], Léonard Féasson[3], Jérémy Delabre[2], Laurent Messonnier[1]
[1]Laboratoire Interuniversitaire de Biologie de la Motricité, Université Savoie Mont Blanc, Chambéry, France.
[2]CellMade, Le Bourget-du-Lac, France
[3]Laboratoire Interuniversitaire de Biologie de la Motricité, Université de Lyon, Université Jean Monnet, Saint-Etienne, France.

Introduction.

Sickle cell disease (SCD) is a genetic disease that is emerging as a major public health problem with approximately 5 million people affected worldwide (Piel, Steinberg, and Rees 2017). The mode of transmission of the disease is autosomal recessive and according to the genes of the parents, the offspring can be a healthy subject (AA), or a subject carrying the asymptomatic sickle cell trait (AS) or a particularly sick patient (SS) (Piel et al. 2013; Ware et al. 2017). SCD is due to the synthesis of abnormal haemoglobin S (HbS) causing painful vaso-occlusive crises, haemolysis and severe chronic anaemia. These important points disrupt the tissue homeostasis and can lead to necrosis or at remodelling (Ravelojaona et al. 2015). Several elements are involved in the muscle pH regulation. The majority of lactate exchange occurs via the mono-carboxylate transporters (MCT1, MCT2, and MCT4) (Deuticke 1982; Poole and Halestrap 1993) with the help of carbonic anhydrases (CAII and CAIII) and NBC (Na+/bicarbonate co-transporter) in human RBC. Several studies have already showed the physiological differences in the consequences of pathology between the sexes in the skeletal muscle (Cokic et al. 2003). The aim of the present study was to compare the MCT1, MCT2 and MCT4, NHE1 and NBC, and CAII, CAIII, and CAIV between the three genotypes. Specifically, we hypothesis that 1) SS perhaps compensate with more mechanisms, 2) AS have similar number of mechanisms than AA, and 3) differences between men and women are maybe observed.

Method.

Vastus lateralis muscle biopsies of fifty-eight SCD patients were analysed (20 AA, 20 AS and 18 SS). Muscle content of MCT1, MCT2, MCT4, NHE1, NBC, CAII, CAIII and CAIV was studied by Western Blot. ANOVA and Tukeys post-hoc tests were used to compare data of AA, AS, and SS. Significance was accepted when $p \leq 0.05$.

Results.

Muscle content of MCT4 was higher in AS than AA ($p = 0.012$) and that of CAII was higher in AS than AA and SS ($p = 0.008$ and $p = 0.010$). No difference was observed between AA and SS. No significant difference was observed among groups for MCT1, MCT2, NHE1 and NBC. No significant difference was observed between SS men and women.

Discussion.

The present study is the first to evaluate muscle content of proteins involved in pH regulation between AA, AS and SS, and to compare SS men and women. Contrary to our hypothesis, SS do not display higher mechanisms of muscle pH regulation than AA. On the other hand, AS showed higher MCT4 and CAII muscle content than AA. Still contrary to our hypothesis, women did not develop higher muscle pH regulatory mechanisms than men. These results suggest that 1) AS may be subjected to muscle pH challenges and that consequently they developed compensatory mechanisms, 2) the lack of specific adaptation of the studied muscle pH regulatory mechanisms in SS may be a way to protect patients against sicking since the studied mechanisms may favour the release of lactate and H+ from the muscle to the blood, while H+ in blood triggers sickling and 3) women do not seem to have developed specific adaptation.

A comparison of the neuromuscular responses to endurance running and cycling of matched intensity and duration

Brownstein CG[1], Metra M[1], Sabater Pastor F[1], Faricier R[1], Millet GY[1]

[1]Univ Lyon, UJM-Saint-Etienne, Inter-university Laboratory of Human Movement Biology, EA 7424, F-42023, Saint-Etienne, France

Introduction

Running and cycling represent two of the most common forms of endurance exercise. While the neuromuscular consequences of prolonged running and cycling have been well characterised, no study has directly compared these two exercise modalities in regards to their effects on neuromuscular function. Accordingly, the aim of the present study was to compare the effects of endurance running and cycling of matched intensity and duration on neuromuscular function.

Methods

Nine well-trained endurance athletes (age: 35 ± 5 yrs, stature: 180.0 ± 4.8 cm, mass: 72.6 ± 4.1 kg, treadmill VO_{2max}: 59.4 ± 4.2 $ml.min^{-1}.kg^{-1}$, ergometer VO_{2max}: 62.5 ± 3.3 $ml.min^{-1}.kg^{-1}$) performed two sessions consisting of three hours of constant load treadmill running and cycle ergometry at an intensity 5% above the gas exchange threshold (GET). At pre-, mid- and post-exercise, a neuromuscular assessment consisting of maximal voluntary contraction (MVC) knee extensor strength, voluntary activation (VA) and contractile function assessed through high- and low-frequency doublets (Db100 and Db10, respectively), the Db10:100 ratio, and potentiated twitch force ($Q_{tw,pot}$) was performed. In addition, motor evoked potentials (MEPs) and thoracic motor evoked potentials (TMEPs) were assessed using transcranial magnetic and spinal electrical stimulation, respectively, at each time-point. A comparison was subsequently made between the changes in these variables following running and cycling.

Results

Following 3 hrs of running and cycling, MVC and VA was decreased ($P < 0.01$). However, there were no differences between modalities for either variable ($P \geq 0.16$). While Db100 decreased similarly following both running and cycling, Db10 was lower following cycling compared with running ($P = 0.02$). Similarly, the reduction in $Q_{tw,pot}$ was greater following cycling compared with running ($P = 0.02$). No change was found in MEP and TMEP following either modality ($P > 0.05$).

Table 1. Percentage decrease in neuromuscular variables following 3 hrs of matched intensity and duration running and cycling exercise. *P* values display between modality comparisons.

	MVC	**VA**	**Db100**	**Db10**	**Db10:100**	**$Q_{tw,pot}$**
Running	-23.8 ± 18.3	-17.2 ± 13.3	-12.8 ± 27.8	-22.4 ± 19.3	-6.4 ± 20.6	-10.1 ± 25.9
Cycling	-22.2 ±10.3	-9.6 ± 4.3	-13.6 ± 4.5	-30.1 ± 10.7	-19.0 ± 11.9	-27.9 ± 8.9
***P* value**	0.57	0.16	0.64	0.02*	0.15	0.02*

Discussion

The present study found that prolonged running and cycle exercise elicited substantial impairments in knee extensor neuromuscular function. While no difference was found between the reduction in MVC and VA between the modalities, impairments in contractile function were exacerbated following cycling compared with running. Differences in the mechanical and metabolic demands between the modalities might have been responsible for the greater peripheral impairment following cycling, such as time under tension, quadriceps involvement, and lower mechanical efficiency during cycling compared with running.

Fatigue, neuromuscular and cardiorespiratory recovery on COVID19 survivors after ICU stay

Kennouche D[1], Brownstein C[1], Royer N[1], Lapole T[1], Gondin J[3] , Morel J[2] , Millet GY[1,4]

[1] Univ Lyon, UJM Saint-Etienne, Inter-university Laboratory of Human Movement Biology, EA 7424, F-42023, Saint-Etienne, France; [2] Department of Anaesthesiology and Intensive Care Medicine, University Hospital of St-Etienne, 42055 St-Etienne Cedex 02, France.; [3] Institut NeuroMyoGène, UMR CNRS 5310 - INSERM U1217, Université Claude Bernard, Lyon, France; [4]Institut Universitaire de France (IUF)

Key words: COVID19, ICU, fatigue, VO_2max, cardiorespiratory, neuromuscular, MRI.

Introduction

Coronavirus disease 2019 (COVID-19) caused nearly four million of death worldwide, with over 181 million peopled infected. COVID-19 is a new strain of Severe Acute Respiratory Syndrome (SARS) characterized by respiratory symptoms. Approximately 20% of SARS patients develop respiratory failure, which requires mechanical ventilation and even if most patients recover well, patients who have been through intensive care unit (ICU) can experience severe persistent dysfunction several months post ICU stay. Given the breadth of the pandemic, it is important to have objective measurements of cardio-respiratory and neuromuscular state and recovery of these patients. The purpose of this study was to follow-up patients having stayed in ICU due to Covid-19 infection on the the two first months of their discharge and six months after.

Methods

Fifty-four patients (65 ± 10 yr) who had been hospitalized in 6 ICUs of University hospitals and private clinics during 33 days [11-80] and mechanically ventilated during 24 days [4-57] participated in two sets of three visits, with 6 months between sets. The first visit consisted of questionnaires (especially FACIT-F questionnaire to classify patients as fatigued or non-fatigued), blood test, spirometry testing and stress test on ergometric bicycle. The second visit was neuromuscular testing with maximum force and fatigability test (i.e. QIF test). The third visit was an MRI measurement for assessment of quadriceps volume and metabolic fatigue (data not shown).

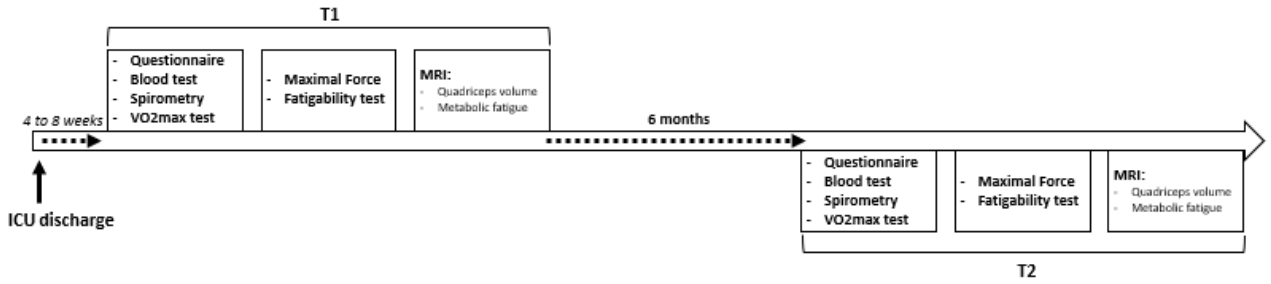

Figure 1. General course of the study

Results

At T1, using FACIT-F questionnaire, 54% of patients were classified as fatigued versus 24% at the 6 months visit. Questionnaires scores and spirometry testing were significantly lower between for the fatigued group ($p<0.05$), maximal power output (P_{max}) reached during stress test on ergometric test was also significantly lower for fatigued group ($p<0.05$). There was no difference between group for neuromuscular parameters. On average, VO_2max, relative to body weight, increased significantly ($p<0.001$) by 15% [22-54] between T1 and T2 (i.e. 17.7 to 20.5 ml/min/kg). The power reached on bicycle during stress test increased significantly by 42% (i.e. 93.5W to 129.5W). The forced vital capacity (FVC), maximum ventilation per minute (MVM) and the forced expiratory volume in one second (FEV) increased also respectively of 9.4, 1.2 and 4.5% to 90.1, 98.8 and 92.5% of matched normal values. Concerning the fatiguability test, both force (+41%) and number of contractions (+42%) increased significantly ($p<0.001$).

Discussion

At T1, there was few objective differences between patients, and only spirometry test and P_{max} allowed to discriminate between patients self-declared fatigued and non-fatigued. At T2, despite an increase on all tested parameters and significantly less self-declared fatigued, COVID survivors still were below normal values. This study will be continued with the same measurements on fatigued and non-fatigued COVID-19 patients without ICU stay, and ICU survivors unrelated to COVID-19 to better understand the implications of COVID-19-induced ICU relative to non-COVID related ICU stays.

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Effects of age on neuromuscular fatigue: comparison between isometric, dynamic and cycling tasks

Giorgio Varesco, Eric Luneau, Guillaume Y Millet, Léonard Féasson, Thomas Lapole & Vianney Rozand

Université de Lyon, UJM-Saint-Etienne, Laboratoire Interuniversitaire de Biologie de la Motricité, EA 7424, F-42023, Saint-Etienne, France.

Introduction

The effects of ageing on neuromuscular fatigue has been extensively studied during local (i.e. single-joint) isometric and dynamic fatiguing tasks. However, the age-related differences have not been directly compared between single-joint isometric and dynamic tasks, nor with locomotor (cycling) tasks with similar duty-cycle and workload. The aim of the present study was to investigate performance fatigability during isometric, dynamic and locomotor fatiguing tasks across age.

Methods

Preliminary data were used for the present abstract. Thirteen healthy young men (<35 yr), four older men (>60 yr) and five very old men (>80 yr) randomly performed three testing sessions: an isometric (ISO) and a dynamic (DYN) quadriceps intermittent fatigue tests on an isokinetic dynamometer and a similar test on a validated cycle (BIKE). The quadriceps intermittent fatigue test consisted of stages of 75 contractions (0.8-s on/0.8-s off; for ISO and DYN) or 120-s cycling at 37.5 rpm (BIKE). Increments were calculated relatively to the participants' body weight using device-specific equations (ISO and DYN: 5% of body weight; BIKE: 0.3 $W.kg^{-1}$). Performance was quantified as test duration and performance fatigability as the loss in maximal isometric force. Voluntary activation (VA%) and contractile function (potentiated twitch amplitude, Tw_{POT}) were evaluated using percutaneous nerve stimulation and the interpolated twitch technique.

Results

Performance decreased with age for all the tests ($P<0.05$). For the young men, performance was greater for BIKE (10.6±2.4 stages) than ISO (8.6±1.9 stages) and DYN (6.6±1.4 stages, all $P<0.001$). For old and very old men, ISO (old: 6.5±1.7 stages; very old: 4.9±1.1 stages) and BIKE (old: 6.4±1.5 stages; very old: 4.1±0.9 stages) were both significantly higher than DYN (old: 3.5±1.1 stages; very old: 2.2±1.0 stages; all $P<0.05$). No difference was found for the old and very old in ISO *vs.* BIKE (all $P>0.05$). Performance fatigability showed a significant age effect, but not session effect nor session × age interaction. Post-hoc analysis indicated that the loss in maximal force was significantly higher in young men (-29.8±12.6%) than very old men (-19.5±10.4%; $P=0.006$) but not old men (-25.7±10.5%; $P=0.176$) independent of the test. Decrease in Tw_{POT} showed significant age effect, but the post-hoc analysis showed no differences between the young (-44.2±25.0%), old (-32.0±15.1%) and very old (-32.8±13.2%). Finally, difference in VA% was similar across sessions and ages (3.8±7.3%, 2.8±5.3% and 0.8±6.1% for young, old and vey old men, respectively). Those results were probably influenced by the low number of participants included in this preliminary analysis.

Discussion

Those preliminary results suggest different performance and fatigability across ages, with young adults performing better and tolerating a larger amount of fatigability, mainly from peripheral contractile factors. The completed dataset with a sufficient number of participants will elucidate the interaction between age and fatiguing task.

Neuromuscular origin of chronic fatigue among patients with multiple sclerosis.

Royer N[1], Brownstein CG[1], Kennouche D[1], Espeit L[1], Besson T[1], Collet S[1], Pfenninger C[1], Camdessanché JP[2], Millet GY[1]

[1] Univ Lyon, UJM-Saint-Etienne, Inter-university Laboratory of Human Movement Biology, EA 7424, F-42023, Saint-Etienne, France
[2] Department of Neurology, University Hospital of Saint-Etienne, Saint-Etienne, France

Introduction

Multiple sclerosis (MS) is an autoimmune chronic disease targeting myelin of the central nervous system (CNS). Among the manifestations caused by the disease, fatigue is the most common and disabling symptom, being reported by 55% to 78% of MS patients (Lerdal et al., 2007). Causes of the MS-related fatigue remain poorly understood but an impaired neuromuscular function could contribute to this phenomenon. In fact, a higher fatigability in MS patients could lead to a greater reduction in functional capacity and over time, the repetition of the activity of daily living could induce fatigue accumulation (Twomey et al., 2017). This study aims to characterize the causes of chronic fatigue in MS patients using a multifactorial assessment, focusing primarily on neuromuscular function.

Methods

Fourty-four participants with relapsing-remitting multiple sclerosis (RRMS), and 20 healthy controls (HS) will be recruited. MS patients will be assigned in 2 groups (high fatigue [HF] and low fatigue [LF] group) based on the response to fatigue questionnaire (FSS and MFIS). Participants will take part in three visits in the laboratory. The main outcome of this study comes from an incremental fatiguing exercise until exhaustion on a home designed cycling-ergometer. Maximal voluntary contraction (MVC), central (voluntary activation, motor evoked potential [MEP], silent period) and peripheral fatigue (resting twitch, compound muscle action potential [M-Wave]) using transcranial magnetic as well as peripheral nerve stimulation techniques was assessed on quadriceps before, during and after the fatiguing task. The two other visits will allow to assess other potential mechanisms of fatigue (sleep quality, maximal oxygen uptake, heart rate, muscle volume (MRI) and metabolic fatigue (P31 NMR).

Results

Although similar MVC torque loss was displayed at exhaustion for the both groups, MVC torque seemed to decrease to greater extent for the HF group than LF group and HS after the third stage (-14.4%±8.5 vs -9.3%±16.8% & -12.95%±9.2%), and this was associated with a higher RPE for HF (11.5 ± 2.3% vs 9.8 ± 2.4% & 9.3 ± 1.9%). At this stage, the silent period was more prolonged for the HF group (8.1 ± 13.9%) than the two other groups (0.2 ± 8.7% & 0.25 ± 15.9%) and a higher decrease of MEP/M-wave ratio was measured for the HF (-9.6 ± 18.7%) compared to LF (4.2 ± 27.9%).

Discussion

These results provide novel insight into relationship between fatigue and fatigability among patients with MS. HF could have lower resistance during a fatiguing task than LF leading to a higher perceived exertion. Cortico-spinal excitability was also lower for the HF and LF groups. A better understanding of the etiology of chronic fatigue will permit to propose an adapted rehabilitation

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Changes in the energy cost of exercise after 3h of running vs cycling at the

Sabater Pastor F[1], Faricier R, Metra M, Brownstein C, Millet GY

[1]LIBM, Université Jean Monnet, France

Introduction

Previous research has identified changes in the energy cost of exercise after fatiguing prolonged endurance exercise while running and cycling, showing that efficiency decreases after cycling exercise, while the effect of running exercise on economy seems to be dependent on the intensity and duration of the running exercise. However, to date, no study has assessed the effect of different modalities of endurance exercise on energy cost using the same subjects at the same relative intensity. Therefore, the aim of this study was to assess the differences in changes in energy cost of exercise (C_{Ex}) between 3 hours of cycling and running exercise at the same relative intensity (105% of the gas exchange threshold, GET).

Methods

Nine endurance trained men (age: 34.8 ± 6.7 years, height: 180.0 ± 4.8 cm, mass: 72.6 ± 4.1, weekly training duration 11.1 ± 5.4 hours, $\dot{V}O_{2max}$ = 59.4 ± 4.2 ml/kg/min and 62.5 ± 3.3 ml/kg/min for running and cycling, respectively), preparing for triathlon or trail running competitions participated in the study. Each participant completed four visits. The first two visits were used for familiarization with the testing protocols and an incremental test in each exercise modality, from which $\dot{V}O_{2max}$ and the GET were measured. During the 3 h trials, $\dot{V}O_2$ and $\dot{V}CO_2$ were measured using a metabolic cart during three 10-minute periods: the first 10 minutes of the test (START), minutes 80 to 90 (MID) and minutes 170 to 180 (END). C_{Ex} was calculated from $\dot{V}O2$ and the respiratory exchange ratio (RER) and expressed as metabolic power. Ventilation ($\dot{V}_E$) and heart rate (HR) were also assessed. The changes in these variables after running and cycling were compared using an ANOVA.

Results

There was a time*modality interaction in C_{Ex} ($p = 0.012$) and RER ($p = 0.016$). C_{Ex} increased significantly at END cycling compared to START (1054 ± 86 vs 1002 ± 100 W, $p < 0.001$), but not at END running (1049 ± 109 vs 1042 ± 108 W). While there were no differences in RER at START, cycling RER was significantly lower than running RER at END (0.83 ± 0.02 vs 0.085 ± 0.03, $p = 0.036$). There was an effect of time for $\dot{V}_E$ and HR, which increased at END compared to START ($p < 0.05$).

Discussion

The present study found that prolonged cycling exercise led to an increased C_{Ex}, while prolonged running did not lead to any significant changes in C_{Ex}. Cycling had a greater effect than running on RER, which indicates a greater lipid utilization in cycling. This may be caused by a greater use of glycogen during cycling compared to running, which may lead to greater oxygen requirements to oxidize lipids requiring greater work of the ventilatory muscles, therefore increasing C_{Ex}. Alternatively, biomechanical differences between running and cycling could explain the differences in C_{Ex}, since subjects may be able to modify their running pattern to accommodate for fatiguing muscles, but not their cycling pattern, since the cyclist is attached to the bike by the pedals and saddle. Therefore, during cycling it may be more difficult to change the movement pattern to decrease the workload of the increasingly fatiguing muscles, thereby decreasing efficiency.

Effect of time on leg muscle activity and running biomechanics: interest for assessment of running footwear

Marie-Caroline PLAY[1], Antoine RAVEL[1], Guillaume Y. MILLET[1], Jérémy ROSSI[1]

[1]*Univ Lyon, UJM-Saint-Etienne, Inter-university Laboratory of Human Movement Biology, EA 7424, F-42023, Saint-Etienne*

Introduction

The increase of running practice leads to a great interest in research about running biomechanics. Most of the time, literature studies performed their analysis after a variable long warm-up (i.e between 3 and 10 minutes). Moreover, changes in footwear conditions throughout a session result in kinematics (4, 5) and muscular adjustments (6) within the first minutes of running. Concerning soft tissue vibrations, no study has focused on this mechanism yet. Thus, the aim of this study was i) to investigate whether there is a systematic change over the time course in biomechanics, electromyography and vibration data while running at self-preferred speed, ii) to determine the potential influence of shoe condition on it. We hypothesized that changes occurred during the first minutes before reaching a steady state.

Methods

After 10 minutes of warm-up and treadmill familiarization, 45 physically adults (17 females and 28 females) assessed 3 shoes conditions with different cushioning (soft (40 Asker C), intermediate (55 Asker C) and hard (65 Asker C)) during 8 minutes each at self-preferred speed. Ground reaction forces, kinematics, electromyography and vibrations of lower leg muscles were recorded from the start till the end of the trial, every two minutes. Several variables such as loading rate, impact peak, contact and flight times, hip, knee, ankle and foot angles, muscular intensities (i.e. RMS during stance phase) and vibration amplitudes were calculated. Each variable of interest was averaged over ten steps for all subjects. Effects of *time* and *footwear* condition on variables were examined using Friedman analysis and post-hoc tests with Dunn's correction.

Results

Flight time and step frequency significantly decreased by 8% and 3% respectively with a steady state reached at 6 minutes. No significant difference in ground reaction forces and vibrations occurred between the first and eight minutes. The greatest kinematics changes happened only in the frontal plane with a significant increase in foot inversion angle. Finally, gastrocnemius activity decreased significantly by 12% within the two first minutes. No significant *time x footwear condition* interactions occurred.

Discussion

Temporal evolutions of flight and contact time agree with previous works (3, 5). However, the significant decrease of step frequency is not enough to have an effect on ground reaction forces (7). More flexed knee contact angles result in lower vibrations (8). Here, the absence of time effect on kinematics in sagittal plane could explain the stagnation of vibration over time. Finally, the significant decrease of muscular activity is lower but in line with the literature, explaining a better efficiency of neuromuscular system over time (6). Since no significant *time x footwear condition* interactions occur, runners apparently use similar strategies regardless of which footwear condition. Thus, future running protocols for testing shoes should include a habituation time of at least 6 minutes prior to reliable data collection.

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Cost of running, biomechanics and neuromuscular characteristics of elite vs experienced male and female trail runners

Thibault Besson[1], Frederic Sabater Pastor[1], Giorgio Varesco[1], Marilyne Berthet[1], Djahid Kennouche[1], Pierre-Eddy Dandrieux[1], Jeremy Rossi[1], Guillaume Y Millet[1,2].

[1]Univ Lyon, UJM-Saint-Etienne, Inter-university Laboratory of Human Movement Biology, EA 7424, F-42023, Saint-Etienne, FRANCE

[2]Institut Universitaire de France (IUF)

Introduction
Over the last 20 years, trail running (TR) has gone from a niche practice to a major outdoor activity. The increased participation in TR races in both males and females and the emergence of official international races increased the level of the world best trail runners. The specificities of TR make the analyses of the determinants of performance very complex. The aim of the present study was to compare, for both males and females, cost of running (Cr), neuromuscular function and biomechanical characteristics of elite trail runners to their lower level counterparts.

Methods
Twenty elite (10 females; ELITE) and 21 experienced (10 females; EXP) trail runners participated in the study. Cr and running biomechanics were measured at 10 and 14 km/h on flat and at 10 km/h with 10% uphill incline. Participants also had to perform maximal isometric voluntary contraction of knee and hip extensors and knee flexors and maximal 7-s sprints on a cycle ergometer to assess the power-torque-velocity profile (PTVP).

Results
Compared to EXP, ELITE had a lower (i.e. better) Cr in the three running conditions (all $p < 0.005$), and for similar maximal lower limb power ($p = 0.059$), they displayed a more relative torque (+11%, $p < 0.01$) and less speed oriented (V_0; -12%, $p < 0.01$) PTVP. Females displayed shorter contact times ($p < 0.01$) compared to males but no sex differences were observed in Cr (all $p > 0.05$).Whereas males and females exhibited a similar slope of PTVP ($p = 0.692$), males exhibited greater relative torque (T_0REL; +8%, $p < 0.01$) and velocity capacities (V_0; +11%, $p < 0.01$) compared to females.

Discussion
The present study showed that top world class trail runners have a better cost of running and different neuromuscular characteristics (greater lower limb extensor strength but less velocity capacities) compared to their lower level counterparts. Male and female trail runners differed in term of running biomechanics but showed similar PTVP. Although those data do not comprehensively assess all factors of TR performance, it shows for the first time level- and sex-specificities of trail runners.

Seasonal changes in sprinting horizontal force-production : cohort versus individual analysis

Prince C[1], Edouard P[2], Samozino P[1]

[1]University of Savoie Mont Blanc, Laboratoire Interuniversitaire de Biologie de la Motricité (EA7424), Chambéry, France
[2]University of Lyon, UJM-Saint-Etienne, Inter-university Laboratory of Human Movement Science (LIBM EA 7424), Saint-Étienne, France

Introduction

A close relationship exists between hamstring muscles function and horizontal force production during the accelaration phase of sprint (Morin et al., 2015). Over an athletic season, exposure to sprint varies and so does the occurrence of hamstring muscles injuries (Roe et al., 2018). However, seasonal variation of horizontal force production are not yet known. As such, monitoring its seasonal variation and complementing a cohort-level with an individual-level analysis would also provide additional insights necessary to customize training as well as enhance injury prevention strategies. To conclude, the aim of this study is to compare the seasonal variations of horizontal force production during sprinting, at a cohort and individual levels, while assuming that part of the variations at the individual-level will not be reported at the cohort-level.

Method

A longitudinal monitoring of 12 sprinters was carried out during one athletic season. The sprinting horizontal force production capacity at low (F0) and high (V0) speeds was computed from running velocity data. These measurements were recorded at five different times : outside the competition and training (OFF) periods, during general (PPG) and specific (PPS) physical preparation, at the start (C1) and at the end (C2) of the competition period. A repeated-measures analysis of variance (ANOVA) was performed to assess seasonal changes in F0 and V0 at a cohort-level. A reproducibility analysis estimated the Minimum Detectable Change (MDC) for F0 and V0. To perform the analysis at an individual level, the difference between the maximum and minimum value of F0 and V0 recorded during the year and for each subject was compared to the MDC of F0 and V0.

Results

The results of the ANOVA showed that the time of the season had no effect on F0 and V0 values. The reproducibility analysis showed MDC of 0.94 $N.kg^{-1}$ and 0.24$m.s^{-1}$ for F0 and V0, respectively. The individual analysis reported variations in F0 and V0 beyond the MDC for 33.3% and 83.3% of the athletes, respectively.

Discussion

This study showed that an analysis at the individual level can highlight « true » seasonal variations in horizontal force production which are concealed at a cohort-level. In conclusion, individual analysis seems promising to identify athletes' seasonal variations and to optimize their training and injury prevention strategies.

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Does foot posture and morphological deformation influence ankle plantar flexion performance and kinetics during vertical drop jump?

Tourillon R[1,2], Six A[2], Fourchet F[1,2], Morin J-B[1]

[1]UJM-Saint-Etienne Interuniversity Laboratory of Human Movement Biology, EA 7424, University of Lyon, Saint-Étienne, France

[2]Motion Analysis Lab, Physiotherapy Department, La Tour Hospital, Swiss Olympic Medical Center, Meyrin, Switzerland

Introduction

The human foot is composed of passive elastic and active components that allow it to support body weight and generate forward propulsion [1]. Recent studies showed that foot flexibility in 1 dimension influenced propulsion mechanics during jumping and running: individuals with a stiffer medial longitudinal arch displayed greater ground reaction force (GRF) impulse and vertical stiffness [2,3]. The aim of this pilot study was to explore the potential influence of foot posture and foot morphological deformation in 1, 2 and 3 dimensions on ankle plantar flexion performance and kinetic parameters during vertical drop jumps (VDJ).

Methods

39 healthy active volunteers (28.9±5.4 years, 172.8±8.7 cm, 68.6±13.0 kg) were evaluated during a single session. Foot posture was assessed in standing position according to the Foot-Posture Index-6 test whereas foot morphological deformations in 3 dimensions were assessed using the Arch Height Index Measurement System. Ankle plantar flexion performance in different contractions mode was assessed using a Biodex System 4 Pro dynamometer. Kinetic variables during eccentric and concentric VDJ subphases were analysed using ForceDecks FD4000 Dual Force Platforms. Statistical analysis was based on a between-group difference using independent samples t-tests ($p<0.05$) and magnitude of difference using effect size following foot posture approach 1, 2 and 3-dimensions analysis of deformation.

Results

Regarding 1 dimension foot deformation significantly greater concentric impulse ($p<0.05$; ES=0.75) and eccentric impulse ($p=0.004$; ES=0.98) was found in the stiffer arch group (0.24±0.05 BW.s; 0.24±0.07 BW.s) compared to the flexible arch group (0.21±0.03 BW.s; 0.18±0.04 BW.s). Regarding 2-dimensions foot deformation no significant differences were found for kinetic variables. Regarding 3-dimensions foot deformation significantly greater eccentric impulse ($p<0.05$; ES=0.71) was found in the stiffer group (0.22 0.04 BW.s) compared to the flexible group (0.19±0.04 BW.s). No significant differences were found between groups in 1, 2 and 3-dimensional or foot posture analysis regarding ankle plantar flexion performance.

Discussion

The main result of this study was that foot posture is not associated with kinetics and isokinetic performance which is in line with a previous study showing that arch height is not correlated with vertical jump performance [4]. The second result was that individuals with stiffer foot have greater GRF impulse in the eccentric and concentric phase of the VDJ. However, this kinetic difference did not result in a better jump height suggesting that both passive and active structures of the foot are used differently between athletes to achieve similar jump performance. Finally, we found no difference in ankle plantarflexion performance between groups. From a clinical perspective, these results suggested that foot posture and foot deformation morphology should be associated with more dynamic evaluations (e.g. foot strength) to deepen the exploration of the potential role of the foot in sport performance.

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Influence of knee strength and inter-limb asymmetry on deceleration performance in professional soccer players

Qingshan Zhang[1], Christophe Hautier[1]

[1] Université de Lyon, UCBL1, Laboratoire Interuniversitaire de Biologie de la Motricité - EA 7424, UFR STAPS, 27-29 boulevard du 11 novembre 1918, 69622, Villeurbanne Cedex, France.

Introduction

The previous study has demonstrated that the higher eccentric force of the quadriceps and concentric force of the hamstring contributes to better deceleration performance[1]. Still, the association between the parameter of knee muscles' force-velocity-power profiles and the deceleration performance was not explored. Although, the inter-limb asymmetry based on unilateral jumping was related to the injury risk and physical performance of the soccer player[2]. In this regard, the main objective of the present study aimed to examine inter-limb unilateral jumping and force-velocity profile asymmetries and their association with deceleration performance in soccer players.

Methods

Twenty professional soccer players (14 females and 8 males) performed unilateral drop jumping (30cm box height) and isokinetic test at different angular velocities (60°.s^{-1}, 180°.s^{-1}), and maximal linear deceleration test after 20m sprint. The jump power (JP) during the unilateral drop jumping test was calculated from the flight time method, and reactive strength index (RSI) was quantified using the equation flight time/ground contact time. The force-velocity-power profiles was calculated by fitting a linear regression through the force and velocity data from 60°.s^{-1} and 180°.s^{-1} which were extrapolated to determine the maximal force (F0), maximal velocity(V0) and maximal power (P_{max}). Furthermore, inter-limb asymmetries were quantified as a percentage difference between limbs. Also, the kinetic parameter of deceleration including horizontal braking force (HBF) and horizontal braking power (HBP) was calculated in the basic of velocity-time curve.

Results

Pearson's correlation coefficients revealed that the JP and RSI in both legs were significantly related to HBF and HBP ($0.47 < r < 0.72$). Moreover, a significant correlation was found between the V0 of knee flexion in the right leg and HBF ($0.48 < r < 0.62$). In contrast, no correlation was found between all the inter-limb asymmetric indexes and deceleration performance.

Discussion

The current study found that jumping power and RSI during unilateral drop jumping related to the HF and HP. It could be caused by the critical role of the jump power as the indicator of the knee muscular capacity could contribute the higher power output to the decelerate following the higher braking force and power. In addition, the higher V0 of knee flexion may assist the athlete to rapidly contract the knee flexor to maintain the knee and hip dynamic stability to better control the body position for decelerating. The lack of association between the inter-limb asymmetric indexes and deceleration performance does not support the evidence that the higher inter-limb asymmetries affect physical performance.

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The Antepulsio® System, a new 3D interactive digital tool for human anatomy learning

Gallot M[1], Di Rienzo F[1], Binay Marion[1], Collet C[1] & Hoyek N[1]

[1] Université de Lyon, Université Claude Bernard, Lyon 1. Inter-university Laboratory of Human Motor Performance (LIBM - EA 7424), Villeurbanne Cedex, France

Introduction

Learning human anatomy is often perceived as difficult by students due to the amount of information and time required for memorization, and the understanding of spatial relationships among anatomical structures. Recent advances in technology allowed to develop digital tools using 3D technology. Students preferred digital on traditional tools and enhanced their learning thanks to 3D viewing. However most existent tools lack interactivity. To overcome this concern, we designed Antepulsio®, a 3D interactive application promoting better anatomical viewing by integrating technological advances. This application contains 4 types of exercises: Muscle understanding, Motion analysis, Motion reproduction and Evaluation.

Methods

We assessed Antepulsio® by comparing three groups to test whether it is likely to favor anatomy learning during three training sessions spread over a week. The active group (n=17, age:17.76 ± 0.56 years) interacted with Antepulsio®, the passive group (n=18, age:17.89 ± 0.83 years) watched videos of Antepulsio® while the control group (n=15, age:18.07 ± 0.80 years) performed a neutral activity unrelated to anatomy. We previously collected different associated variables (2D/3D spatial abilities, laterality judgement and working memory abilities) from all groups to set up our three homogeneous groups and to explore interactions with students individual differences. We assessed students' anatomy levels during pre-test, post-test, and two retention tests (8 and 12 weeks after the post-test) as well as the time they spent for learning anatomy during the experimental week. We computed how the anatomy grades evolved in each group according to the pre-test, post-test and the two retention tests as well as the different associated variables.

Results

When the time spent on learning increased, anatomy grades were better for the passive group students at post-test whereas for the first retention test, anatomy grades were better for the control group students. On the other hand, students from the active group with higher visuospatial working memory performed better during the first retention test.

Discussion

The selective benefits of Antepulsio® are discussed regarding: i) the duration of training; ii) the necessary period of familiarization with the tool[1]; iii) and the temporary excessive load as described in the ability as enhancer hypothesis[2,3].

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Characterization of stress sensitivity and determination of coping techniques

Schlatter S[1], Guillot A[1], Debarnot U[2]

[1] Univ. Lyon, UCBL-Lyon 1, Laboratoire Interuniversitaire de Biologie de la Motricité, EA 7424, F-69622 Villeurbanne, France
[2] Institut Universitaire de France

Introduction

Stress occurs when a situation is perceived as stressful and is characterized by a psycho-physiological response. Acute stress has usually a negative impact on cognitive abilities and manual dexterity, while chronic stress leads to the development of serious mental and physical diseases. Based on these deleterious effects, studies dedicated to offer a better understanding of stress are needed. Our studies aim at offering a better characterization of stress and its impacts (n°1,2,3,4,5) and identifying the most relevant technique to decrease the deleterious stress effects (n°2,3,4,5). While relaxing breathing (RESPI), cardiac biofeedback (BFB), and brain stimulation (TDCS) have shown some beneficial effects, the cumulative impact of these methods remained unexplored.

Methods

First, we determined the effects of stress on motor imagery, before characterizing in greater details the period of anticipatory stress. Then, we explored the preventive beneficial effects of specific techniques on laboratory and through ecological settings (with anesthetists). Finally, we explored how personality may interact with both anticipatory stress and cardiac biofeedback.

S1 (n=30, STRESS *vs* CTRL): participants were exposed to a stress or a ctrl condition then they performed explicit and implicit motor imagery. **S2** (n=44, ANTICIPATION + BFB, ANTICIPATION + VIDEO, CTRL+ BFB): participants were exposed to an anticipatory stress or a ctrl, then they were exposed to 15 min of cardiac biofeedback or a video. **S3** (n=80, BFB, TDCS, BFB + TDCS, CTRL): participants were exposed to a 15 min intervention (BFB, TDCS, BFB + TDCS, CTRL) during the anticipation of a stressful event, the impact of following stress response was assed. **S4** (n=33, BFB, RESPI, CTRL): anesthesiologists were exposed to a 5 min intervention (BFB, RESPI, CTRL) during the anticipation of a critical care, the impact of following stress response and performance were assed. **S5** (n=147, BFB, RESPI, CTRL): anesthesiologists were exposed to a 5 min intervention (BFB, RESPI, CTRL) during the anticipation and their personality was assessed.

Results

We showed that explicit motor imagery is stress-resistant.
We designed a new tool for studying anticipatory stress. We demonstrated that cardiac biofeedback effectiveness on psychophysiological stress markers was potentiated by cerebral stimulation over the left prefrontal cortex. Personality interacted with anticipatory stress.

Discussion

Due to its resistance to stress, explicit motor imagery might relevantly be used during a stressful event such as a sportive competition. Practicing cardiac biofeedback paired with transcranial stimulation appears the best option to reduce psychophysiological stress. These techniques offer interesting applications for the treatment of stress related disorders. Personality is a critical factor for determining stress sensitivity and designing stress management intervention.

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Effects of motor imagery combined with transcranial direct current stimulation on motor sequence learning task in healthy young and older adults

Angèle Métais[1], Camille O. Muller[1,2], Caroline Breuil[1], Nawale Boublay[3], Franck Di Rienzo[1], Aymeric Guillot[1,] Christian Collet[1], Pierre Krolak-Salmon[3] & Arnaud Saimpont[1]

[1]Laboratoire Interuniversitaire de Biologie de la Motricité, Université de Lyon, Villeurbanne, France
[2] Centre EuroMov, Digital Health in Motion, Université de Montpellier, IMT Mines Alès Montpellier France
[3]Centre de Recherche Clinique VCF, Hospices Civils de Lyon, Lyon, France

Introduction. Motor imagery (MI) training and anodal transcranial direct current stimulation (a-tDCS) are methods that have already showed – independently – improving the acquisition stage of a finger tapping task (FTT) in young and older adults. Interestingly, cumulative effects of these methods during a single MI training of a FFT was found in young adults[1]. So far, the impact of MI and the additional effect of a-tDCS of the acquisition of FFT has never been compared between young and older adults.

Methods. A total of 32 young (16 women; 21.9 ± 1.9 years) and 31 older (16 women; 71.5 ± 4.9 years) right-handed adults were separated into two groups. One received a real a-tDCS (*Stim* group, current intensity = 1.5mA, current density = 0.06mA/cm^2, over the right primary motor cortex) while the other received a sham stimulation (*Sham* group), concurrent with MI. During MI, subjects mentally repeated an 8-element FTT with their left hand during 15 blocks of 30s. Before (pre-test) and after (post-test) MI training, they repeated the sequence, physically then mentally, as fast and accurately as possible for 8 blocks of 12s. Performance was analyzed using the number of correct presses. We also explored the temporal congruence between executed and imagined presses. We calculated an index, the number of presses performed mentally divided by the number of correct presses performed physically. The closer the index is to 1, the better the temporal congruence.

Results. The result showed that both groups improved their physical performance after a single MI session with no significant differences between the *Stim* and *Sham* groups. Compared to the young, the older subjects performed the sequence slower, both physically and mentally. Interestingly, after a single MI session, the temporal congruence decreased (pre-acquisition 0.97 ± 0.18; post-acquisition: 0.88 ± 0.25) but was better for older (1.03± 0.32) than young adults (0.83±0.25).

Conclusion. In line with previous studies, we showed that MI has a positive effect on the fast learning of a FTT [2]. We confirmed that older adults were slower than the younger ones to imagine and execute the task [3]. Despite the complexity of task, we showed that older adults have a better temporal congruence than young adults. This suggest that if motor performance was positively influenced by MI training is not directly relied on the MI abilities, which present a great interest for rehabilitations protocol. Finally, a-tDCS did not enhance the beneficial effects of MI, which adds the inconsistency of results founds in tDCS studies.

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Preliminary results of the Physical Activity and Carotid Atherosclerotic Plaque hemorrhage (PACAPh) project

Mura M[1], Khenniche L[1,2], Weiss-Gayet M[3], Josset L[1], Millon A[1,2], Pialoux V[1,4]

[1]Laboratoire Interuniversitaire de Biologie de la Motricité, ATPA Team, Lyon
[2]Service de chirurgie vasculaire et endovasculaire, Hospices Civils de Lyon, Lyon
[3]Institut NeuroMyoGène, Stem cell environment and skeletal muscle homeostasis team, Lyon
[4]Institut Universitaire de France

Introduction

Atherosclerotic disease is a vascular disorder characterised by a deposit of fat and infiltration of circulating monocytes (MC). Carotid plaque can remain silent until it promotes major ischemic events possibly leading to death. The Instable plaques contain leaky neovessels that bleed into intraplaque haemorrhage as well as large content of blood infiltrated pro-inflammatory MC.[1] In recent cross-sectional studies, our team demonstrated that atherosclerotic patients practicing moderate physical activity (PA) have less intraplaque hemorrhage[2] and less pro-inflammatory circulating MC[3] than non-active ones. The objective of this study is to determine the effect of an individualized home-based PA intervention on carotid atherosclerotic plaque instability factors, through the evaluation of intraplaque haemorrhage, MC phenotype and blood coagulation measurements.

Methods

The PACAPh study is a longitudinal, interventional, monocentric, randomized, controlled study. 80 asymptomatic patients will be recruited with carotid stenosis >50%, without indication of surgery or intercurrent inflammatory diseases. Patients will be randomized 1:1 either in the control or in the PA group. The control group will follow its usual care. Patients of the PA group will receive a connected wristlet for daily steps count, and a PA instructor will call them twice a month to set new daily steps goal. The final objective will be to increase by 30% the daily step count. In both groups, tests will be done before and after the 6months intervention. Fitness will be evaluated by quadriceps maximal isometric strength, 6minutes walking test coupled with VO2 measurements. MC subsets will be assessed by flux cytometry and blood coagulation by thromboelastography. Intraplaque hemorrhage will be assessed by gadolinium injected MRI.

Results

31 patients were included (16 men, 73±8y/o). To date, 10 patients completed the entire protocol. Thus, only descriptive statistics will be presented here. PA group increases daily steps by 29% whereas control group decreases by 32%. PA group decreases less its quadriceps strength than control group (-20% vs. -28%). MRI pictures are not yet analyzed. Percentage of classical pro-inflammatory MC are increased after the 6 months in the control group while rate of MC subsets is not modified in PA group.

Discussion

Fitness results suggest that the PA intervention increases the active behavior of patients while limiting the strength decreases. PA intervention might also limit the shift anti- to pro-inflammatory phenotype of MC and the reduced time of coagulation initiation observed in the control group. To confirm these results, the analysis of the 6month results of a majority of our patients is upcomming and more patients needs to be included.

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Interactions between pre-treatment exercise and combined immuno-chemotherapy on tumour in a pre-clinical cancer model and in cancer patients

Gouez M[1], Fervers B[2], Pialoux V[1]

[1]Department of Cancer Prevention and Environment, Léon Bérard Cancer Center, Lyon, France.
[2] Inter-University Laboratory of Human Movement Biology EA7424, University Claude Bernard Lyon 1, University of Lyon, Lyon, France.

Introduction

Current evidence suggests that post-diagnostic physical activity improves survival outcomes for at least 11 cancer types, including lung cancer(1) although the biological mechanisms behind the potential antitumor effects of regular PA are still poorly understood. Furthermore, acute exercise, immediately prior to immunochemotherapy injection has not been assessed so far. To date, emergent preclinical cancer studies report that exercise among other effects, may affect the tumor microenvironment through immune and metabolic modulation and consequently may contribute to limiting tumor growth(2–5). In brief, acute exercise can increase immune cells infiltration in tumor, namely NK cells and cytotoxic T cells. This has been associated with a better cancer prognosis. In addition, it has been suggested that acute exercise may enhance tumor perfusion thereby potentially enhancing drug delivery during and shortly after exercise(3). Finally, physical fitness has been associated with reduced inflammatory profiles; and exercise in cancer patients may help cancer treatment by reducing the circulating levels of multiple inflammatory markers.
The aim of this project is therefore to validate the hypothesis that exercise performed before immunochemotherapy injection would potentiate this treatment and limit tumour growth.

Methods

This project is composed of a clinical study (ERICA) in metastatic non-small cells lung cancer patients and a preclinical study in mice model of colorectal cancer (MC38 murine tumor model) to decipher the interaction mechanisms between exercise et immunochemotherapy. The ERICA study focuses on the circulating immune regulation and the clinical outcomes while the preclinical study explores the tumor immune infiltration and the perfusion tumor microenvironment, both in response to acute exercise just before immunochemotherapy.

Conclusion

To our knowledge, these clinical and preclinical studies should i) help to understand the potential beneficial interactions between acute exercise and anti-tumour treatments and ii) validate the feasibility of such therapeutically approach in cancer patients.

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