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Effects of upper- and lower-body muscle fatigue on swimming performance and biomechanics

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Purpose: To compare the effect of muscle fatigue between upper- and lower-limb on velocity and stroke mechanisms in front-crawl.
Methods: Ten swimmers (FINA points = 725 $\pm$ 74) were recruited for the crossover randomized and counterbalanced study design. The participants completed 4 experimental visits over 1 mth with a cadence of 7-day. During visit 1, swimmers completed a 7 $\times$ 200-m incremental protocol until exhaustion in front-crawl to determine velocity at lactate threshold (Dmax). In visits two to four, the experimental conditions were: 1) lower-body fatigue (LBF), 2) upper-body fatigue (UBF), and 3) control condition (CON). Pre- and post-condition, fatigue was measured using the 1RM test in the bench press and leg extension. Immediately after each condition, a 12 $\times$ 100-m at Dmax, and a 400-m maximal effort in front-crawl (5-min passive recovery between) were completed to test performance and biomechanics. Heart rate, lactate, RPE, stroke rate (SR) and stroke length (SL) as index of propelling efficiency were measured at the end of step 4, 8 and 12 of the incremental protocol and in the 1-min after for the maximal bout. The General Estimated Equations (GEE) were used to verify differences and interactions between variables and Bonferroni post-hoc correction was applied to significant variables ($p < 0.05$).
Results: For the 1RM values, there was an interaction between condition x time ($p < 0.001$). It revealed a significant 1RM reduction after both LBF ($p < 0.001$) and UBF ($p < 0.001$) conditions but not different from each other ($p > 0.05$). Regarding technical parameters for the 12 $\times$ 100-m test, significant differences between conditions for SR ($p < 0.001$) and SL ($p < 0.001$) were found. Then, swimmers after LBF ($p < 0.001$) and UBF ($p = 0.002$) presented higher SR and lower SL compared to CON. For the 400-m performance, a condition effect was found ($p < 0.001$). The UBF ($p = 0.002$) and LBF ($p < 0.001$) conditions presented a decreased performance compared to CTRL but not different from each other ($p > 0.05$).
Conclusions: Although the swimmer's propulsion is essentially generated by the arm pull, muscle fatigue induced in the lower limbs reduces the swimming performance and propulsive efficiency as well as that induced in the upper limbs.

Anaerobic power reserve, glycolytic power reserve and maximal aerobic power to prescribe high-intensity interval training: variability in performance and physiological responses

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Purpose: The aim of this study was to compare the inter-subject variability in performance and physiological responses during supramaximal interval training based on anaerobic power reserve, glycolytic power reserve and maximal aerobic power.
Methods: Twelve trained cyclists (VO_{2max}: 58.56 $\pm$ 9.70 ml $\times$ kg^{-1} $\times$ min^{-1}) completed a cardiopulmonary exercise test (CPET), a Wingate anaerobic test and three HIIT sessions until-exhaustion. Initially, both the CPET and Wingate tests were performed to determine the power associated with the VO_{2max} (MAP), the anaerobic peak power output (PPO) and the mean power output of the Wingate (MPO). Then, the Anaerobic power reserve (APR) was calculated as PPO-MAP, while the glycolytic power reserve (GPR) was as MPO-MAP. Subsequently, participants performed in a randomized order and separated by 72 h, three HIIT until-exhaustion sessions with 1 min of work phase and 1 min of active rest, based on APR ($HIIT_{APR}$: MAP + 10% APR), GPR ($HIIT_{GPR}$: MAP + 20% GPR) and MAP ($HIIT_{MAP}$: 120%MAP), respectively. In all HIITs, the rest period was fixed at 45%MAP. Variability in time to exhaustion (TTE), heart rate (HR), oxygen uptake (VO_2) and blood lactate concentration ($[La]^-$) was calculated as coefficient of variation (CV) and as mean of the square root of the squared difference between the individual value and the mean value. Then, values were compared between conditions via repeated-measures analysis of variance with a statistical significance set at $p \leq 0.05$.
Results: CV in TTE was lower in $HIIT_{MAP}$ (21%) rather than in $HIIT_{APR}$ (35%) (effect size [ES] = 0.47), and $HIIT_{GPR}$ (45%)(ES = 0.78). Mean CV in VO_2 was lower in $HIIT_{GPR}$ (6.7%) rather than in $HIIT_{MAP}$ (8.8%)(ES = 0.52) and $HIIT_{APR}$ (9.1%)(ES = 0.47). Mean CV in HR was similar ($\sim$ 4.5%)(ES = 0.16) between conditions. Mean CV in $[La]^-$ was lower in $HIIT_{APR}$ (24.9%) rather than in $HIIT_{GPR}$ (28.1%)(0.36) and $HIIT_{MAP}$ (26.5%)(ES = 0.28). However, for all dependent variables, no significant difference in inter-subject variability was found.
Conclusion: Our findings indicate that HIIT based on APR and GPR does not reduce the inter-subject variability in performance and physiological responses compared to MAP-based prescription. In addition, our results potentially indicate that prescribing HIIT based on MAP could be a better prescription training method than APR and GPR in trained cyclists.

Breathe in, breathe out for acute post-exercise stress management

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Purpose: Changes in cardiac parasympathetic activity (CPA) can be evaluated by measuring heart rate variability (HRV), with the root mean square of successive differences (RMSSD) being a primary time-domain measure used to estimate vagally mediated changes in HRV. Controlled breathing (CB) during resting has a significant impact on HRV and serves as a strategy to influence CPA. However, the effects of CB on HRV and RMSSD after exercise remain poorly understood. Therefore, the objective of this study was to assess the effects of CB following a submaximal incremental treadmill exercise (SITE) on HRV and RMSSD.
Methods: 9 subjects (7 men; 2 women) performed 2 SITE with a 24-h recovery between sessions. SITE protocol included 3-min warm-up at a fixed slope of 1%, followed by a speed increase of 1 km/h

every 2-min. The exercise ended when the participants reached 95% of their maximal heart rate. 15-min before (PRE) and 15-min after (POST) each SITE, HRV and RMSSD were measured in a quiet and distraction-free room using a heart rate monitor connected to the "Elite HRV" app. During PRE, subjects were instructed to maintain a calm state and breathe freely for 5-min. In POST, two breathing conditions, uncontrolled breathing (UB) and CB following the guidance provided by the "Elite HRV" app, were randomized and performed by each participant. The CB pattern involved 6 breaths per minute with an inhalation/exhalation ratio of 1: 1, consisting of 5 s for inhalation and 5 s for exhalation, for a total of 5-min. Repeated measures mixed models were used to examine the effects of different breathing conditions (UB vs CB) on HRV and RMSSD. Statistical significance was set at $p < 0.008$.

Results: Significant differences ($p < 0.0001$) were observed, indicating lower HRV (49.5 ± 10.1 ms) and RMSSD values (29.8 ± 18.8 ms) in POST UB compared to all other UB (HRV PRE = 59.0 ± 8.8 ms; RMSSD PRE = 53.2 ± 27.4 ms) and CB (HRV PRE = 58.8 ± 7.3 ms; HRV POST = 57.7 ± 11.5 ms; RMSSD PRE = 50.1 ± 19.3 ms; RMSSD POST = 51.9 ± 31.4 ms) time points. On average, UB resulted in a decrease of 8.9 ms and 21.9 ms in HRV and RMSSD, respectively.

Conclusions: The study findings highlight the significance of CB in modulating CPA during stress-inducing conditions, such as exercise. Post-exercise HRV and RMSSD in the UB were markedly lower compared to CB. Consequently, practitioners and athletic trainers can employ slow and CB strategies, either during recovery or as a cool-down strategy after exercise, to enhance CPA and counterbalance excessive activation of the sympathetic branch.

The VO2 slow component in different exercise intensities and domains: association with markers of metabolic instability and muscle fatigue

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Purpose: The appearance of the slow component of VO_2 ($\dot{V}O_{2sc}$) in the heavy and severe exercise domains is explained by a combination of metabolic instability (measured with NIRS and hematochemical markers) and muscle activation (measured by EMG). To the best of our knowledge, no studies investigated how these parameters are associated with the $\dot{V}O_{2sc}$ in two different intensities of the moderate, heavy, and severe domains. Moreover, no studies have tested exercise intensities based on physiological thresholds: gas exchange threshold (GET), respiratory compensation point (RCP) and maximum oxygen uptake (VO_{2max}).

Methods: Eleven active men performed 6 × 9 min constant work cycling trials at 33% and 66% of the moderate (> VO_2rest/ < GET; M1, M2), heavy (> GET/ < RCP; H1, H2) and severe (> RCP/ < VO_{2max}; S1, S2) domain. During each session, VO_2, hematic markers (i.e. [La^-], pH, HCO_3^-), as well as local muscle O_2 extraction (deoxyhemoglobin, [HHb]) and muscle activity (EMG) of the vastus lateralis were measured. We tested the hypothesis that the VO_{2sc} is intensity and domain-dependent and can be predicted by metabolic instability and muscle activation. More specifically, within the domains: (i) no presence of VO_{2sc} in the moderate; (ii) VO_{2sc} being larger with increasing intensity within the heavy domain with the only contribution of metabolic instability (iii) VO_{2sc} being larger with increasing intensity in the severe domain with both contribution of metabolic instability and muscle recruitment.

Results: The slope of [HHb] and RMS between minutes 3 and 9 were calculated and the relationship with $\dot{V}O_{2sc}$ evaluated by simple and multiple linear regressions. The post-hoc analysis comparisons between the six different intensities of [HHb] and RMS with $\dot{V}O_2$ beyond the third minute of exercise showed that [HHb] kept increasing significantly in all the intensities within severe and heavy, but not within the moderate domain. RMS increased significantly over time only in the S2. Moreover, beyond the third minute of exercise, VO_{2sc} was significantly correlated with the slope of [HHb] ($r = 0.56$, $p < 0.001$) and RMS ($r = 0.58$, $p < 0.001$) and both were significant predictors of the $\dot{V}O_{2sc}$ ($r = 0.68$; SSE 0.94% ml•min^{-2}, $p < 0.001$).

Conclusions: We confirmed the contribution (i.e., 68%) of both metabolic instability and muscle activation to the dynamic of the VO_{2sc} across different exercise intensities. However, the insurgence of the O_{2sc} in the heavy domain stem especially from metabolic instability, while in the severe domain it stem also from muscle activation.

The VO_2 slow component in different exercise intensities and domains: association with markers of metabolic instability and muscle fatigue

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Physical education to enhance health related-fitness in adolescents: a mediation analysis from the regional observatory of motor development and health prevention in apulia

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Purpose: The Regional Observatory of Motor Development and Health Prevention is a regional project involving secondary schools of first and second grade in Apulia aimed at (a) assessing the levels of physical efficiency and health status of children and young adolescents, and (b) defining national recommendations and guidelines for the practice of physical activity and healthy habits. Previous studies have showed that physical self-perception (PSP) and enjoyment are key factors to promote greater adherence to physical activity (PA), and PA is strictly linked to better physical fitness and inversely related to body mass index (BMI). In the light of these evidence, the present study aims to assess the mediation role of PSP and enjoyment in enhancing PA and physical fitness according to BMI values.

Methods: The sample (N = 180, age = 11–13 years; M = 90, Nw = 30, Ow = 30, Ob = 30; F = 90, Nw = 30, Ow = 30, Ob = 30) was recruited by the school that joined the Regional Observatory of Motor Development project with a simple randomization. The total sample was divided according to gender (male and female) and BMI group (normal weight, overweight, and obese). Physical efficiency was assessed with standing long jump (SLJ), Medicine Ball Throw (MBT), 10 × 5 shuttle run (10 × 5), One Mile Run Walking Test (MRWt), while three validated questionnaires were used for the evaluation of levels of physical activity, enjoyment and PSP. The assessment took place during curricular physical education lessons and was conducted by a team of Experts in Motor and Sports Sciences, and in Preventive and Adapted Motor Activities. The results of