

than traditional weight training [3]. Therefore, both training modalities offer important and specific non-gravity dependent stimulus. However, neither the effect of FW on small muscle groups in athletes, nor the comparison of the effects between both training modalities has been studied. Thus, the aim of this study was to analyze the effects of FW on the shoulder muscles' hypertrophy, strength, power and throwing speed in comparison with PN. **Methods:** Eighteen professional handball players were randomly divided into 2 experimental groups, the FW group that performed the training with inertial devices (squat flywheel and conical pulley), and the PN group that performed the training in a pneumatic machine at constant and homogeneous load in both phases of the movement. Both groups carried out 4 sets of 7 maximum concentric repetitions during 6 weeks (12 sessions). Only the dominant arm performed the prescribed training, while the non-dominant arm served as control. The exercises performed were: lateral shoulder raise, internal and external shoulder rotation. **Results:** The variables measured were Subscapularis and Anterior, Middle and Posterior Deltoid muscles thickness, Isoinertial muscle power, throwing speed, and isokinetic rotators cuff strength. Both groups have shown significant increases in all variables ($p < 0.05-0.001$). FW group has demonstrated higher increases ($p < 0.05$) in torque and power at high intensities (60 and 180°/s) and in hypertrophy of the Deltoid muscles in comparison with PN group. No significant differences were observed between trained and non-trained shoulder in PN group. However, FW group has shown significant differences in muscle thickness for the 4 analyzed muscles ($p < 0.05$). **Discussion:** The increments produced in shoulder muscle mass are positively correlated with those demonstrated in larger muscle groups [2]. Indeed, these hypertrophic effects are associated with an enhancement in sports performance and injury prevention [1]. In conclusion, PN and FW enhance strength and power similarly. However, the FW produces greater increases in muscle mass than those produced by a concentric-eccentric resistance-training program without eccentric overload. **References:** [1] Maroto-Izquierdo, S, et al. Skeletal muscle functional and structural adaptations after eccentric overload flywheel resistance training: a systematic review and meta-analysis. *J Sci Med Sport* 20, 2017. [2] Maroto-Izquierdo, S, et al. Functional and Muscle-Size Effects of Flywheel Resistance Training with Eccentric-Overload in Professional Handball Players. *J Hum Kinet* 60, 2017. [3] Frost, DM, et al. Changes in Maximal Strength, Velocity, and Power After 8 Weeks of Training With Pneumatic or Free Weight Resistance. *J Strength Cond Res* 30, 2016. Maroto-Izquierdo is supported by the Ministry of Education of Spain (FPU014/05732). **Mail to:** smaroi@unileon.es.

DIFFERENCES IN PHYSIOLOGICAL VARIABLES BETWEEN EUMENORRHEIC FEMALES AND ORAL CONTRACEPTIVE USERS: IRONFEMME PROJECT

RAEL DELGADO B.,¹ CUPEIRO COTO R.,¹ ROMERO PARRA N.,¹ ALFARO MAGALLANES V.,¹ CASTRO E.,² GARCÍA DE ALCARAZ A.,¹ AND PEINADO LOZANO A.B.¹

¹Universidad Politécnica de Madrid, Spain; and
²Postgraduate Program in Health Promotion, Universidade de Franca, São Paulo, Brazil

Introduction: Hormonal changes induced by the use of oral contraceptive (OC) pills could modify some variables related to performance [1, 2]. Although these pills are widely used by female athletes, there is still unclear the influence of OC pills on performance in this population. Therefore, the aim of this study was to assess differences in some physiological variables between eumenorrheic and OC users athletes. **Methods:** Five oral contraceptive users (age 26 ± 4 years, height 161 ± 7.1 cm, weight 56.68 ± 4.39 kg) and 5 eumenorrheic women (age 33 ± 3 years, height 157 ± 3.9 cm, and weight 53 ± 3 kg), all of them experienced in endurance training, performed an incremental treadmill test protocol during their menstrual phase in order to determine their maximal $\dot{V}O_2$, ventilation (VE), respiratory exchange ratio (RER) and heart rate (HR). T-student test for independent measurements was used to compare $\dot{V}O_2$, VE, RER and HR between groups. Moreover, standardized differences in mean at 95% of confidence interval were employed to analyze the effect size for $\dot{V}O_2$, VE, RER and HR when comparing the groups. **Results:** Regarding maximal $\dot{V}O_2$, eumenorrheic females performed 50.60 ± 1.92 ml·kg⁻¹·min⁻¹ and OC showed 48.60 ± 1.66 ml·kg⁻¹·min⁻¹ ($t_8 = 1.082$; $p = 0.311$; ES: -0.83 ± 1.13). According to maximal VE, eumenorrheic females obtained 107.48 ± 12.32 L·min⁻¹ and OC presented 112.60 ± 15.57 L·min⁻¹ ($t_8 = -0.462$; $p = 0.657$; ES: 0.28 ± 1.34). Considering maximal RER, eumenorrheic females had 1.23 ± 0.04 and OC had 1.13 ± 0.06 ($t_8 = 1.798$; $p = 0.110$; ES: -1.92 ± 1.36). This result showed a large difference between groups. Finally, in accordance with maximal HR, eumenorrheic females reported 186.60 ± 8.53 bpm and OC users exhibited 186.20 ± 8.38 bpm ($t_8 = 1.798$; $p = 0.110$; ES: -0.04 ± 1.17). **Conclusion:** Our results indicate that the use of OC could affect maximal respiratory outcomes measured in incremental effort test, especially regarding maximal RER. However, no effect of exogenous hormones seems to exist over HR. The high effect seen for maximal $\dot{V}O_2$ is in accordance with

previous studies [3], which show a decrease in this variable because of the intake of OC pills. In addition, other studies show a smaller RER in OC users than eumenorrheic females, which means a lower use of glucose in this population [2]. Regarding cardiovascular outcomes, the use of OC pills has no effect over maximal HR, whereas other studies report a higher HR with the OC use [5]. It is important to have these physiological changes into consideration by coaches when training females. Further studies with higher sample size are needed in order to clearly elucidate the physiological differences between eumenorrheic females and OC users in female athletes.

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COULD A COMBINED TRAINING PROGRAMME HELP TO MAINTAIN BASAL METABOLIC RATE IN WOMEN AWAITING BARIATRIC SURGERY?

PICÓ-SIRVENT M.I., ARACIL A., SARABIA-MARÍN J.M., PASTOR D., AND MOYA-RAMÓN M.

Sport Research Center, Miguel Hernández University, Institute of Health and Biomedical Research (ISABIAL-FISABIO Foundation), Spain

Introduction: Bariatric surgery (BS) is the most effective treatment for morbid obesity, one of the most serious and prevalent non-communicable diseases. Preoperative body weight is directly associated with a higher surgical morbidity and mortality. Additionally, it has been shown that basal metabolic rate (BMR) is reduced following BS due to a decrease in fat free mass (FFM). In this line, there is little knowledge about the effects of a training programme combining endurance and resistance training in this population. To our knowledge, there are no studies about analysing the effects of concurrent training on the BMR. Consequently, the aim of this study is to describe the effects of an exercise programme, combining high intensity interval training (HIIT) and resistance training (RT) with progressive workloads on the anthropometric profile, BMR and muscle strength in women awaiting BS. **Methods:** Fourteen candidates for BS (42.6 ± 8.1 years; 41.9 ± 3.8 kg·m⁻²) were distributed in: a) a group that attended to at least the 80% of the sessions of a combined training programme (CTPG; $n = 6$; %FFM = 51.4 ± 2.5 ; BMR = $1,547.9 \pm 401.7$); and b) a control group (CG; $n = 8$; %FFM = 49.5 ± 2.1 ; BMR = $1,774.2 \pm 448.2$). Anthropometric variables, max-

imal isokinetic muscle strength and BMR were assessed before and after a 12-weeks intervention. **Results:** In the CTPG, BMR normalized to FFM (BMR/FFM) remained constant ($g = 0.19$) and daily fat oxidation percentage (%FO) slightly increased ($g = 0.20$), whereas in CG both were decreased ($g = 0.28$ and $g = 0.20$, respectively). Additionally, in the CTPG the effect size (ES) showed small to moderate effects in most of the anthropometric variables, as well as maximal dynamic strength normalized to body weight (MDSBW) for non-dominant quadriceps ($g = 0.29$). In the CG, the ES for the same variables did not reach practical significance.

Discussion: A low BMR is considered an independent predictor of future weight gain, but there is limited knowledge regarding the effects of BS on BMR. In this line, keeping FFM before BS could be a relevant physiological mechanism to improve FO and avoid severe reductions in BMR associated with BS. To get it, performing RT with workloads combined with HIIT seems to be useful to maintain FFM and improve muscle capacity in lower limbs before BS. Our data suggest that a 12-weeks CTP seems to be effective to improve body composition and keep BMR stable in women awaiting BS. However, a larger sample size is needed to confirm these findings. In addition, postsurgical data could be interesting to assess if a CTP provide additional benefits after BS.

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EFFECT OF A POWER-ORIENTED RESISTANCE TRAINING PROGRAM AT MODERATE ALTITUDE ON THE FORCE-VELOCITY RELATIONSHIP IN ELITE JUDOKAS

ALMEIDA F.,¹ BONITCH-GÓNGORA J.,¹ PADIAL P.,¹ MORALES-ARTACHO A.J.,¹ SCHOENFELD B. J.,² DE LA FUENTE B.,³ CALDERÓN C.,³ AND FERICHE B.¹

¹Department of Physical Education and Sport, University of Granada, Spain; ²Department of Health Sciences, CUNY Lehman College, New York University; and ³High Performance Center of Sierra Nevada, CSD, Spain

Introduction: At altitudes greater than 1,500 m, improvements in sprinting or jumping performance have been described (Hamlin et al., 2015). It has been suggested that

the air density reduction and/or an increase in anaerobic metabolism at higher altitudes can influence the metabolic cost, and increase the take-off velocities, the spinal excitability or fast fibre recruitment, which may explain these results [5, 6, 7]. An improvement in explosive movement performance at acute moderate altitude has been observed [1, 3], but a paucity of information about the effect of a resistance training after a training period under altitude conditions exists. Therefore, the aim of this study was to analyze the effect of a muscle power-oriented resistance training period at moderate altitude on lower limb force-velocity. **Method:** Twenty male elite judokas (age: 23.1 ± 3.2 years; body mass: 74.7 ± 7.3 kg; height: 177.1 ± 7.0 cm) performed a 3-week power-oriented resistance training program (3 sessions·week⁻¹) either under normoxia ($n = 10$; N, sea level) or moderate altitude ($n = 12$; H, 2,320 m asl). Before and shortly after the training intervention, height and maximum values of force and velocity were recorded during a 5-load submaximal countermovement jump (CMJ) test to determine maximum theoretical force (F0), velocity (V0), and power (P0) in N conditions by using the Samozino's method. **Results:** H group displayed a moderate effect for F0 ($p = 0.03$ [IC95%: -5.35 to -1.48]; ES = 0.92) and showed moderate to large improvements in the maximum height for all jumps ($\Delta 17.69 \pm 8.18\%$ $p < 0.001$ for all jumps; ES = 0.90 [ranked from 0.66 to 1.22]), while N group only reached practical significance in F0 ($p = 0.079$; [IC95%: -3.14 to 0.21]; ES = 0.52) and small effects in jump height ($\Delta 5.77 \pm 4.16\%$ $p > 0.05$ for all jumps; ES = 0.26 [ranked from -0.05 to 0.40]). Notwithstanding, differences between groups did not reach statistical significance at the end of the training period. **Discussion:** Contrary to what we expected, no changes in P0 were observed in any group. Despite the H group displaying moderate increases in F0 and in maximum height reached during the CMJ, no differences in the immediate effect of the training program were observed between environmental conditions in N condition. Previous studies [2] revealed that the "live low-train high" strategy during RT could have a positive effect on the neuromuscular system's ability to produce higher power. However, the results of this study failed to show that training at moderate altitude confers beneficial effects on aerodynamic resistance [1, 5], neuromuscular [7] and metabolic factors [6] on muscle contraction capacity. Despite the clear tendency to improve the FV relationship towards higher F0 values in H, the effect of 3 weeks of RT conducted at moderate altitude does not seem to produce immediate differences compared to training in N. **References:** [1] Feriche, et al. *PLoS One* 9: e114072, 2014. [2] Feriche, et al. *Proceedings of the ECSS, Essen*. 2017 [3] García-Ramos, et al. *J Strength Cond Res* 32: 475–481, 2018. [4] Hamlin, et al. *Int J Sports Physiol Perform* 10: 881–7, 2015. [5] Levine, et al. *Scand J Med Sci Sports* 18:

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REPETITIONS IN RESERVE AND RATE OF PERCEIVED EXERTION INCREASE THE PREDICTION OF THE LOAD-VELOCITY RELATIONSHIP

BALSALOBRE-FERNÁNDEZ C.,¹ MUÑOZ-LÓPEZ M.,² MARCHANTE D.,² AND JIMENEZ S.L.³

¹Universidad Autónoma de Madrid, Spain; ²PowerExplosive Center, Madrid, Spain; and ³Universidad Europea de Madrid, Spain

Introduction: There is a body of evidence highlighting the relationship that exists between movement velocity and relative load in terms of percentage of the 1-RM 1–4. Recent studies have observed that subjective scales such as the number of repetitions in reserve (RIR) or the rate of perceived exertion (RPE) are also related with relative load 5–8. Thus, the purpose of the present study was to analyze whether RIR and RPE can improve the prediction ability of the load-velocity relationship in experienced powerlifters. **Methods:** Twelve experienced powerlifters took part in this study ($N = 12$; 8 men, 4 women; age = 26.1 ± 3.9 years, relative full-squat 1-RM [kg/kg]: 1.93 ± 0.5). Participants performed an incremental test in the full squat exercise with loads of 50, 60, 70, 80, 90 and 100% of their 1-Repetition maximum. Mean concentric barbell velocity was measured using a linear transducer (Smartcoach Power Encoder, Smartcoach EU, Sweden), and the number of repetitions in reserve (RIR) and the rate of perceived exertion (RPE) were measured after each set. One repetition was performed with each load. First, the association between the studied variables were analyzed using Pearson's product-moment correlation coefficient. Second, single and multiple linear regression were used to create a prediction model of relative load (in terms of %1-RM). The level of significance was set at $p < 0.05$. All calculations were performed using SPSS25 for macOS. **Results:** Average load-velocity relationship: When analyzing the whole dataset from the 12 participants, a moderate relationship between relative load and movement velocity was found by a single linear regression model ($R^2 = 0.766$, SEE = 8.5%, $p < 0.001$). However, when entering the RIR and RPE along with movement velocity as independent variables in a multiple regression model, the dependent variable (i.e., relative load) was better predicted ($R^2 = 0.963$, SEE = 4.8%, $p < 0.001$). Individual load-velocity relationship: When analyzing individual load-velocity profiles from each participant,

high to very high associations were observed in all cases when using movement velocity as the only independent variable ($R^2 = 0.830\text{--}0.996$, $SEE = 1.1\text{--}8.3\%$, $p < 0.001$). However, when incorporating RIR and RPE into the multiple regression model, stronger associations and lower SEE were observed in all cases ($R^2 = 0.958\text{--}0.999$, $SEE = 0.8\text{--}6.1\%$, $p < 0.001$).

Discussion: Results in our study are consistent with the studies that found that both the RIR and RPE can be used to estimate relative load 5–7. However, our investigation adds novel information to the literature, as it has found that incorporating the RIR and RPE to the prediction model of the load-velocity relationship improves the strength of the model and lowers the standard error of estimate in the full squat exercise. These results could have potential practical applications to strength and conditioning coaches who monitor relative load by measuring movement velocity. **Mail to:** carlos.balsalobre@icloud.com.

VELOCITY-BASED VISUAL BIOFEEDBACK ENHANCES BACK SQUAT PERFORMANCE AT DIFFERENT LEVELS OF FATIGUE

STONE J., ARNDTS D., AND ASKOW A.

Texas Christian University

Introduction: In addition to improving strength, resistance training increases maximal power output, which translates to many sport-specific skills [1]. Further, more robust power adaptations are likely if training is performed at higher velocities with consequently greater power outputs [2, 3]. One method to enhance velocity during exercise performance is the use of verbal biofeedback (BF) [4], but verbal BF may not be practical when training teams or groups of athletes. To date, no study has examined the effect of visual BF on acute exercise performance. Therefore, the purpose of the current study was to assess exercise performance during the back squat exercise with and without visual BF. **Methods:** Nine ($n = 9$) resistance-trained men (mean \pm SD; 24.3 ± 5.6 years; 174.1 ± 8.0 cm; 82.5 ± 9.6 kg; $13.5 \pm 6.8\%$ body fat) had their body composition and one-repetition maximum (1RM) back squat (1.85 ± 0.18 1RM to body mass ratio) assessed 72 hours prior to performing single sets of the back squat exercise at 75% 1RM to volitional fatigue with (+BF) and without (–BF) visual BF (separated by ≥ 48 hours), in a randomized order. Kinematic and kinetic data were obtained by an 8-camera motion capture system (120 Hz) and bilateral force platform (1,200 Hz). Reflective markers were placed on each side of a standard Olympic barbell. The reflective

markers on the bar were used to compute mean average (AV) and peak velocity (PV) during the concentric phase. The bilateral (right and left leg) vertical ground reaction force data were summed to define total ground reaction force (GRF) and then multiplied by PV to compute peak barbell power output (PP). Visual BF, in the form of PV within the given set, was provided on a visual display placed directly in front of the subjects. Fatigue was calculated as a 20% (20VL) and 40% (40VL) loss in AV from the first repetition (3). The average of peak GRF (GRFP), PV, PP to 20VL and 40VL were calculated. Paired t-tests were performed to compare differences between conditions; statistical significance was set at $p \leq 0.05$. **Results:** Visual BF resulted in a greater total number of repetitions to 20VL (mean \pm SD; +BF, 8.7 ± 3.6 reps; –BF, 7.1 ± 3.0 reps), though not significant ($p = 0.387$), but not 40VL (+BF, 11.4 ± 4.2 reps; –BF, 11.3 ± 2.7 reps; $p = 0.930$). Additionally, visual BF elicited significantly greater PV to 20VL (+BF, 1.3 ± 0.2 m·s^{–1}; –BF, 1.1 ± 0.2 m·s^{–1}; $p = 0.028$) and 40VL (+BF, 1.2 ± 0.2 m·s^{–1}; –BF, 1.1 ± 0.2 m·s^{–1}; $p = 0.012$), which contributed to enhanced PP at 20VL (+BF, $2,589.4 \pm 293.3$ W; –BF, $2,341.8 \pm 372.6$ W; $p = 0.031$) and 40VL (+BF, $2,492.5 \pm 320.4$ W; –BF, $2,189.9 \pm 350.9$ W; $p = 0.011$), as no differences in GRFP were observed. **Discussion:** Velocity-based visual BF enhanced PV during back squat performance to 20 VL and 40 VL, which resulted in higher PP. These data are the first to suggest that visual BF enhances power output. Future research should examine visual BF during chronic strength training to identify long-term adaptations. **References:** [1] Baker, D. Comparison of upper-body strength and power between professional and college-aged rugby league players. *J Strength Cond Res* 15: 30–35, 2001. [2] Oliver, JM, Jagim, AR, Sanchez, AC, Mardock, MA, Kelly, KA, Meredith, HJ, Smith, GL, Greenwood, M, Parker, JL, Riechman, SE, Fluckey, JD, Crouse, SF, and Kreider, RB. Greater gains in strength and power with intraset rest intervals in hypertrophic training. *J Strength Cond Res* 27: 3116–3131, 2013. [3] Pareja-Blanco, F, Rodríguez-Rosell, D, Sánchez-Medina, L, Sanchis-Moysi, J, Dorado, C, Mora-Custodio, R, Yáñez-García, J, Morales-Alamo, D, Pérez-Suárez, I, and Calbet, J. Effects of velocity loss during resistance training on athletic performance, strength gains and muscle adaptations. *Scand J Med Sci Sports* 27: 724–735, 2017. [4] Argus, CK, Gill, ND, Keogh, JW, and Hopkins, WG. Acute effects of verbal feedback on upper-body performance in elite athletes. *J Strength Cond Res* 25: 3282–3287, 2011. **Mail to:** j.stone@tcu.edu.

LACTATE EQUIVALENT AND MAXIMAL LACTATE STEADY STATE IN TRAINED RUNNERS. BACK TO THE OLD DAYS?

GARCIA-TABAR I. AND GOROSTIAGA E.M.

Studies, Research and Sports Medicine Center (CEIMD), Government of Navarre, Pamplona, Spain

Introduction: Maximal Lactate Steady State (MLSS) and Lactate Threshold (LT) are fundamental concepts within the sports and exercise sciences, and, theoretically, physiologically-related concepts. Literature concerning their relationship, however, is scarce. As far as the authors are aware, whether the velocity at LT (vLT) obtained during an incremental exercise test predicts the velocity at MLSS (vMLSS) has not been fully explored, and deserves further attention. We hypothesized that vLT, conceptually comprehended as in the old days [4] [e.g., the “Minimum Lactate Equivalent” (LE_{min}) initially described by Berg et al. (1980)] could predict vMLSS more accurate than some other blood lactate-related thresholds (BLRTs) routinely used by many authors and other sport science practitioners.

Methods: Thirteen male endurance-trained (vMLSS 15.0 ± 1.1 km·h⁻¹; $\dot{V}O_{2\max}$ 67.6 ± 4.1 ml·kg⁻¹·min⁻¹) homogeneous (CV: 6–7%) runners conducted a) a submaximal discontinuous incremental running test (SD-IRT) to determine several BLRTs followed by a maximal ramp incremental running test for $\dot{V}O_{2\max}$ determination, and b) several (4–5) constant velocity running tests to determine vMLSS with a precision of 0.20 km·h⁻¹. Determined BLRTs include LE_{min} [1] and LE_{min}-related LE_{min} plus 1 (LE_{min} + 1 mM) and 1.5 mmol·L⁻¹ (LE_{min} + 1.5 mM), along with well-established BLRTs such as traditionally-calculated LT [5], D_{max} [2] and fixed blood lactate concentration thresholds [3]. **Results:** Velocity at LE_{min} (vLE_{min}) was not different from LT ($p = 0.71$; ES: 0.08) and was 27% lower than vMLSS ($p = 0.0001$; ES: 3.54). Velocity at LE_{min} + 1 mM (vLE_{min} + 1 mM) did not differ from vMLSS ($p = 0.47$; ES: 0.09). vLE_{min} was the best predictor of vMLSS ($r = 0.91$; $p < 0.001$; SEE = 0.47), followed by vLE_{min} + 1 mM ($r = 0.86$; $p < 0.001$; SEE = 0.58) and velocity at LE_{min} + 1.5 mM (vLE_{min} + 1.5 mM) ($r = 0.84$; $p < 0.001$; SEE = 0.86). There was no statistical difference between vMLSS and estimated vMLSS using the vLE_{min} prediction formula ($p = 0.99$; ES: 0.001). Mean bias and limits of agreement were 0.00 ± 0.45 km·h⁻¹ and ±0.89 km·h⁻¹. Additionally, vLE_{min}, vLE_{min} + 1 mM and vLE_{min} + 1.5 mM were the best BLRTs predictors of $\dot{V}O_{2\max}$ ($r = 0.72$ – 0.79 ; $p < 0.001$). **Discussion:** The strength of the relationship and prediction accuracy reported in the current study support LE_{min}, an objective submaximal variable, to be one of the best single vMLSS predictors in endurance trained runners. The relevance of LE_{min} as vMLSS

predictor is underpinned by the fact that the other 2 LE_{min}-related thresholds were the second and third BLRTs best correlated with vMLSS. Additionally, LE_{min}, LE_{min} + 1 mM and LE_{min} + 1.5 mM were the best $\dot{V}O_{2\max}$ predictors, whereas average vLE_{min} + 1 mM (15.1 km·h⁻¹) was nearly identical to average vMLSS (15.0 km·h⁻¹). Our study, therefore, advocates factors controlling vLE_{min} to be, at least partly, shared with those controlling vMLSS. **References:** [1] Berg, A, Stippig, J, Keul, J, and Huber, G. [Zur Beurteilung der Leistungsfähigkeit und Belastbarkeit von Patienten mit coronarer Herzkrankheit]. *Dtsch Z Sportmed* 31: 199–205, 1980. [2] Cheng, B, Kuipers, H, Snyder, AC, Keizer, HA, Jeukendrup, A, and Hesselink, M. A new approach for the determination of ventilatory and lactate thresholds. *Int J Sports Med* 13: 518–522, 1992. [3] Garcia-Tabar, I, Izquierdo, M, and Gorostiaga, EM. On-field prediction vs. monitoring of aerobic capacity markers using submaximal lactate and heart rate measures. *Scand J Med Sci Sports* 27: 462–473, 2017. [4] Owles, WH. Alterations in the lactic acid content of the blood as a result of light exercise, and associated changes in the co₂-combining power of the blood and in the alveolar co₂ pressure. *J Physiol* 69: 214–237, 1930. [5] Weltman, A, Snead, D, Seip, R, Schurrer, R, Levine, S, Rutt, R, and Rogol, A. Prediction of lactate threshold and fixed blood lactate concentrations from 3200-m running performance in male runners. *Int J Sports Med* 8: 401–406, 1987. **Mail to:** ibai.garcia.tabar@gmail.com.

THE RELATIONSHIP BETWEEN MAXIMUM STRENGTH AND ACCELERATION PERFORMANCE IN TRACK AND FIELD SPRINT ATHLETES

BRADY C.,¹ COMYNS T.,¹ HARRISON A.,¹ AND FLANAGAN E.²

¹University of Limerick, Ireland; and ²Sport Ireland Institute

Introduction: The determinants of the velocity-time curve of the 100 m are divided into 3 distinct phases, start-acceleration, maximum velocity and deceleration [1]. To achieve a higher maximal velocity, the acceleration from the blocks over the first 10 m followed by the subsequent acceleration has been shown to be directly related to performance [2]. It has been suggested, that performance in the 100 m is associated with athletes having a greater ability to apply a higher resultant ground reaction force during the acceleration phase [3]. Maximum isometric strength tests assess the neuromuscular ability of the lower limbs to produce maximal force during high-load, zero-velocity movements. The purpose of this study was to examine the relationship between peak force (PF) measured during an

isometric mid-thigh pull (IMTP) and isometric squat (ISqT) and acceleration performance in national level sprinters, thus providing the strength and conditioning practitioner with evidence concerning the use of strength training for sprinters.

Methods: Twenty five male ($n = 15$) and female ($n = 10$) sprinters (age 22.6 ± 3.3 years; height 175.1 ± 8.7 cm; mass 71.3 ± 8.2 kg and 100 m personal best 11.34 ± 0.48 seconds) were recruited. Each athlete was assessed for maximal strength, measured by peak force (PF) during the IMTP and ISqT and acceleration from blocks over 30 m, measured with timing gates at 5, 10, 20 and 30 m. Correlations were evaluated using Hopkins' scale [4]. **Results:** Results showed that significantly greater PF was produced during the ISqT compared to the IMTP ($p < 0.001$). There was a significant, strong relationship between PF measured during the IMTP ($1,810 \pm 584$ N) and sprint performance to 5 m (1.22 ± 0.06 seconds; $r = -0.675$, $p < 0.001$), 10 m (1.94 ± 0.08 seconds; $r = -0.671$, $p < 0.001$), 20 m (3.14 ± 0.13 seconds; $r = -0.673$, $p < 0.001$) and 30 m (4.25 ± 0.18 seconds; $r = -0.672$, $p < 0.001$). For the ISqT, a significant, strong relationship was found between PF ($2,142 \pm 626$ N) and 5 m time ($r = -0.643$, $p = 0.001$) and moderate significant relationships with 10 m ($r = -0.526$, $p = 0.007$), 20 m ($r = -0.488$, $p = 0.013$) and 30 m ($r = 0.417$, $p = 0.018$) times.

Discussion: Results from this study suggest that there may be a strong relationship between IMTP PF and overall acceleration performance. Results showed that maximum strength demonstrated during the ISqT having a stronger relationship with the early phase acceleration (0–5 m) compared with subsequent phases, suggesting that maximum strength is most related to the initial first steps from the blocks, where high ground reaction forces are being produced. This information could assist coaches in choosing appropriate tests for use in monitoring, identifying strength and weaknesses and helping with programme design. However, further research is needed to ascertain whether increasing maximal strength results in improved acceleration performance. **References:** [1] Ae, M, Ito, A, and Suzuki, M. The Scientific Research Project at the III World Championships in Athletics: Preliminary reports. The men's 100 metres. *New Studies Athletics* 7: 45–52, 1992. [2] Mero, A, Komi, P, and Gregor, R. Biomechanics of sprint running. *Sports Med* 13: 376–392, 1992. [3] Morin, JB, Bourdin, M, Edouard, P, et al. Mechanical determinants of 100-m sprint running performance. *Eur J Appl Physio* 112: 3921–3930, 2012. [4] Hopkins, W, Marshall, S, Batterham, A, et al. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc* 41: 3–13, 2009. This work is supported by the Irish Research Council and Sport Ireland Institute. **Mail to:** claire.brady@ul.ie.

IS ISCHEMIC PRECONDITIONING MANEUVER OCCLUSION-DEPENDENT TO ENHANCE EXERCISE PERFORMANCE?

MAROCOLO M.,¹ SOUZA H.,¹ ARIEL OLIVEIRA R.,¹ DA MOTA G.,² AND HOHL R.¹

¹Federal University of Juiz de Fora, Brazil; and ²Federal University of Triangulo Mineiro, Brazil

Introduction: In the sporting scenario, some strategies focusing on the pre-competitive moment has been receiving attention [3]. Periodic local blood flow restriction followed by reperfusion, named as ischemic preconditioning (IPC) [2], has already been shown to improve various mode of exercises, although these results are not unanimous [5]. IPC has been applied acutely (i.e., just once before the exercise test), however, the effect of continuous application (i.e., a few days) on exercise performance is still developing in the literature. In addition, little attention has been given to the possible effects of IPC on resistance exercise (RE), being cycling and running the dominant activities in this direction. Thus, the aim of this study was to evaluate the effects of a repeated 5-day IPC, SHAM or control (CON) intervention on RE. **Methods:** Twenty men participated in this study (23.9 ± 4.3 age [y]; 176.9 ± 6.6 height [cm]; 80.1 ± 12.2 weight [kg]; 13.4 ± 5.6 body fat [%]). The experimental procedures were previously approved (n. 993.636) according to the Declaration of Helsinki. We performed a unilateral isometric test and 3 maximal sets of unilateral leg extension after 3 cycles of blood occlusion and reperfusion (IPC, SHAM or CON condition). The IPC session consisted of 3 cycles of 5 minutes of occlusion at 50 mm Hg above systolic blood pressure alternated with 5 minutes of reperfusion at 0 mm Hg of pressure for a total of 30 minutes. The SHAM session was identical to the IPC, except for the pressure used that was 20 mm Hg. In the CON protocol no cuff was applied, while the subject passively remained in the supine position. **Results:** The maximum number of repetitions increased significantly for the IPC (~5–8) and SHAM (~7–8) when compared to their baseline moment and, both IPC and SHAM intervention differs from CON intervention. No differences were found between IPC and SHAM. The isometric force did not differ among the experimental conditions. **Discussion:** The main findings were that both IPC and SHAM significantly increases the number of repetitions compared to the CON group. Salvador et al. [6] proposed that the IPC could be more effective in aerobic conditions. In contrast, a study verified an improvement on performance after a 7-day IPC application before Wingate tests [4]. The evidences supporting the ergogenic effect of IPC are still heterogeneous, and

the variety of IPC intervention protocols may be responsible for these results [5]. In addition, it is believed that the use of strategies with possible ergogenic effects could promote a minor motivational effect on the volunteers, so that the individual could voluntarily be responsible for the improvement on performance [1]. Therefore, we do not discard an increase in number of repetitions due the volunteer's behavioral aspect. In conclusion, a repeated 5-day IPC application did not improve RE performance capable to surpass the SHAM condition.

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VALIDITY AND RELIABILITY OF THE REAR-FOOT ELEVATED SPLIT SQUAT TO DETERMINE UNILATERAL LEG STRENGTH ASYMMETRY

HELME M., EMMONDS S., AND LOW C.

Leeds Beckett University, United Kingdom

Introduction: The purpose of this study was to determine the reliability and analyse the kinetic validity of the rear foot elevated split squat (RFESS) as a field based measure of unilateral leg strength asymmetry. **Methods:** With institutional ethical approval 26 volunteers from Leeds Beckett University were recruited. All subjects were engaged in a structured strength and conditioning program including both bilateral and unilateral exercise. Participants attended a testing facility on 3 occasions, firstly to undergo a familiarisation session, the second and third visits to perform a 5RM RFESS under test and re-test conditions, separated by 72

hours. The participants performed an incremental 5RM test which, concluded when the athlete could not successfully complete 5 repetitions of an assigned load or recorded an RIR-RPE [1] and a concentric vertical velocity of less than $0.25 \text{ min} \cdot \text{s}^{-1}$ for the fifth repetition. Asymmetry was determined using the percentage difference method. Reliability was assessed by a Bland-Altman analysis of bias and Intra-class coefficient (ICC) for level of agreement between tests. Pearson product-moment correlation coefficient (PPMCC) was used between the asymmetries in load and asymmetries in all kinetic and kinematic variables to analyse the validity of the protocol, alpha confidence levels were set at 95% and a magnitude based inference approach to data analysis was applied. **Results:** No proportional bias was observed and ICC = 0.89, typical error was 4.40, indicating high degree of reliability for the percentage asymmetry using external load for the RFESS. When all maximal trials were pooled a likely small positive correlation was found between vertical ground reaction force (vGRF) of the rear foot. A second analysis was performed, dividing the data into trials above or below 5% asymmetry threshold (in either direction). Those trials above a 5% threshold were found to have a most likely large positive correlation between asymmetries in lead foot vGRF when measured in both Newton's and relative to body weight. **Discussion:** The RFESS is a reliable measure of unilateral leg strength asymmetry. The strong reliability of the test would suggest that there are consistent mechanisms present, which determine performance in the RFESS. The analysis suggests that this mechanism may be asymmetries in vGRF of the front leg. However, the test may lack sensitivity below a 5% threshold. Practitioners may be able to use this test protocol to assess leg strength asymmetry, with the understanding that there may be a detection threshold of 5% in determining a valid difference in leg strength asymmetry. **Reference:** [1] Zourdos, MC, Klemp, A, Dolan, C, Quiles, JM, Schau, KA, Jo, E, Helms, E, Esgro, B, Duncan, S, Merino, SG, and Blanco, R. Novel Resistance Training-Specific Rating of Perceived Exertion Scale Measuring Repetitions in Reserve. *J Strength Cond Res* 30: 267–275, 2016. **Mail to:** mark.helme@leedsbeckett.ac.uk.

SINGLE AND COMBINED EFFECTS OF CAPSAICIN AND CAFFEINE SUPPLEMENTATION ON INDOOR ROWING PERFORMANCE

AKCA F. AND ARAS D.

Ankara University Faculty of Sport Sciences, Department of Coaching Education, Division of Movement & Exercise Sciences, Turkey

Introduction: Though the effects of capsaicin on performance rarely studied on human subjects, there is a large evidence

about the positive effects of caffeine on performance. Potential synergistic effects of using caffeine-capsaicin combination is yet to be researched in humans. Therefore, the aim of this study was to compare the acute supplementation effects of capsaicin, caffeine and their combination on rowing ergometer 2,000-m time trial performance. **Methods:** Using a randomized, double-blind Latin square design, 21 male collegiate light-weight rowers (age: 22.1 ± 3.2 years; height: 179.1 ± 7.4 cm; body mass: 69.2 ± 3.3 kg) completed four 2-km time trials on a rowing ergometer. One hour before each trial, participants consumed a capsule containing either $3 \text{ mg} \cdot \text{kg}^{-1}$ caffeine or maltodextrin (placebo). Besides, 45 minutes before each trial, participants consumed 12 mg of purified capsaicin or identical placebo capsules that contain starch. Consequently supplementation trials consisted of 4 conditions: placebo (placebo + placebo), caffeine (caffeine + placebo), capsaicin (capsaicin + placebo) and caffeine + capsaicin. Heart rate (HR), oxygen consumption ($\dot{V}O_2$), carbon dioxide production, minute ventilation (VE), respiratory-exchange ratio (RER), rating of perceived exertion (RPE), gastrointestinal discomfort (GID) and thirst perception (TP) were recorded every 200 meters. Blood lactate (La) was recorded immediately before and after trials. Statistical analyses were performed using software package SPSS (version 20). For all blood and physiological measures 1-way analyses of variance for repeated measures were used to make comparisons between time points and trials. Mean power outputs (MPO) from the 4 trials were analyzed, using the magnitude-based inference approach recommended for studies in exercise [2]. Inference-based approach was also used to compare time to complete each trial. Excel spreadsheet to examine post-only crossover trials, was used to determine the clinical significance of each treatment as based on guidelines outlined by Hopkins (2007). Qualitative inferences are reported as the percentage chance of a positive effect compared with the corresponding trial where a least worthwhile effect on power output of 2% was used as established previously [3]. **Results:** Compared with placebo; supplementation with caffeine, capsaicin and their combination enhanced MPO significantly (3.2, 3, and 3.3%, respectively, $p < 0.01$). Slightly better performance revealed after caffeine-capsaicin combination compared with caffeine or capsaicin alone; however the differences were not significant. **Discussion:** Both caffeine and capsaicin improved rowing performance. The effect of caffeine-capsaicin combination was additive rather than synergistic. The results revealed that capsaicin supplementation is equally effective as caffeine supplementation and can be considered as an alternative nutritional supplement to enhance performance. **References:** [1] Hopkins, WG. A spreadsheet for deriving a confidence interval, mechanistic inference and clinical inference from a p value. *Sportscience* 11: 16–20,

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MINIMUM TRAINING FREQUENCY TO MAINTAIN MAXIMUM SQUAT STRENGTH IN YOUNG MALES

DORADO C., GONZÁLEZ-HENRÍQUEZ J.J., GUERRA-DÍAZ C., QUINTANA-RODRÍGUEZ D., PALLARÉS-FERNÁNDEZ M., ARTEAGA-ORTÍZ R., AND SANCHIS-MOYSI J.

Research Institute of Biomedical and Health Sciences (IUIBS), Las Palmas de Gran Canaria University, Spain

Introduction. Heavy resistance training (HRT) using the squat exercise is widely used to improve leg strength and athletic performance [1]. To alternate cycles of training and recovery is important to reduce the risk of maladaptation and injury [2]. The main aim was to examine the effects of including 3, 1 or none HRT sessions during an 8-week detraining period, followed by 2 weeks of retraining, on lean mass, maximum squat strength and athletic performance. **Methods.** Sixty-four healthy physically active males (age 18–32 years) without previous experience in HRT conducted a 4-week velocity-based HRT program (TRA) using the full-squat exercise ($3 \text{ session} \cdot \text{wk}^{-1}$), followed by 8 weeks of detraining (DET) and 2 weeks of retraining (RET). Participants were randomly assigned to 3 different groups depending on the training frequency during DET: 1 session every 15 days (D15); 1 session at 30 days (D30); or no training (control). All training sessions were performed at 70% of 1RM (3 sets, 6 reps, 4 minutes rest) allowing a repetition velocity loss of 20% into each set [3]. Pre-training assessments included dual X-ray absorptiometry, one-repetition maximum (1RM) and the load corresponding to 60% of 1RM (60 load). Post-training assessments, at the end of TRA, DET and RET, also included countermovement jump (CMJ) and 20-m sprint running (time recorded at 10-m and 20-m; T10 and T20, respectively). **Results.** At the end of TRA, D15, D30 and controls increased 1RM (22.3, 21.4 and 10.4%, respectively, $p < 0.05$), 60 load (46.5, 35.6 and 16.8%, respectively, $p < 0.05$) and leg lean mass (3.5, 2.3 and 2.2%, respectively, $p < 0.05$), compared to baseline. After DET, 1RM decreased in D30 and controls (7 and 6.4%, respectively, $p < 0.05$ compared to the end of TRA), whereas remained unchanged in

D15. In D30 and controls, leg lean mass decreased until baseline values after DET, whereas in D15 remained similar to the end of TRA and was greater than in baseline (4.8%, $p < 0.05$). After DET, T10 decreased 6.8, 4.6 and 3.1%, in D15, D30 and controls, respectively (all $p < 0.05$), whereas T20, 60 load and CMJ height remained similar to the end of TRA. After RET, 1RM increased in D30 and controls (5.8 and 8.1%, respectively, both $p < 0.05$) and returned to values similar to the end of TRA, whereas in D15 remained unchanged. After RET, 60 load was 14.9% greater compared to the end of TRA in D15 ($p < 0.05$), whereas in D1 and controls remained unchanged. CMJ height did not change after RET in any group.

Discussion. A main finding is that 1 session of HRT every 15 days allow maintaining the gains in maximum squat strength, muscle power and leg lean mass (muscle mass) obtained after 4-weeks of HRT using the full-squat exercise. Performing only 1 session of HRT every 30 days or no training decrease maximum squat strength and lean mass during the same period of time in healthy physically active males without previous experience in HRT. **References:** [1] Comfort, P, Haigh, A, and Matthews, MJ. Are changes in maximal squat strength during preseason training reflected in changes in sprint performance in rugby league players? *J Strength Cond Res* 26: 772–776, 2012. [2] Soligard, T, Schwelunus, M, Alonso, JM, Bahr, R, Clarsen, B, Dijkstra, HP, et al. How much is too much? (Part 1) International Olympic Committee consensus statement on load in sport and risk of injury. *Br J Sports Med* 50: 1030–1041, 2016. [3] Pareja-Blanco, F, Rodríguez-Rosell, D, Sanchez-Medina, L, Sanchis-Moysi, J, Dorado, C, Mora-Custodio, R, et al. Effects of velocity loss during resistance training on athletic performance, strength gains and muscle adaptations. *Scand J Med Sci Sports* 27: 724–735, 2017.

Mail to: cecilia.dorado@ulpgc.es.

COINGESTION OF CITRULLINE MALATE AND CAPSAICIN IMPROVES EXERCISE PERFORMANCE IN RESISTANCE-TRAINED FEMALES

AKCA F. AND ARAS D.

Ankara University Faculty of Sport Sciences, Department of Coaching Education, Division of Movement & Exercise Sciences, Turkey

Introduction: Citrulline malate supplementation has been shown to increase strength performance, but data for females is limited. Likewise, the data about the effects of capsaicin on humans is very limited, especially for females. There is a recent

investigation that shows the positive effects of capsaicin supplementation on strength performance of males [1]. However, based on physiological differences between genders, these results cannot be extrapolated to females. Therefore, the aim of this study was to compare the acute supplementation effects of capsaicin, citrulline malate and their combination on strength measures of resistance-trained females. **Methods:** Using a randomized, double-blind, crossover design, 17 recreationally trained females (age: 22.4 ± 4.1 years; height: 165.3 ± 7.6 cm; body mass: 54.5 ± 6 kg) performed 4 sets each of bench press and leg press exercises to failure at 70% of previously established one-repetition maximum with 2 minutes rest interval between sets. Forty 5 minutes before each trial, participants consumed citrulline malate (8 g dextrose + 8 g Citrulline malate), 12 mg of purified capsaicin (12 mg capsaicin + 8 g dextrose), placebo (8 g dextrose) or combination of capsaicin (12 mg) and citrulline malate (8 g). Consequently; supplementation trials consisted of 4 conditions: placebo (placebo + placebo), citrulline malate (citrulline + placebo), capsaicin (capsaicin + placebo) and citrulline malate + capsaicin. Immediately after each set, repetitions completed, heart rate and rating of perceived exertion (RPE) were recorded. Blood lactate was collected after each set of exercise, immediately post exercise, and after 3, 5 and at 30 minutes during recovery. **Results:** Repeated-measures analysis of variance indicated that participants completed significantly more repetitions throughout bench press and leg press exercises when consuming citrulline malate vs. placebo ($p = 0.038$, $p = 0.032$, respectively). Similar significant improvements in total repetitions for both bench press and leg press were observed after capsaicin supplementation compared with placebo ($p = 0.027$, $p = 0.03$, respectively). Overall RPE scores were significantly lower during exercise when participants consumed citrulline malate, capsaicin or citrulline malate + capsaicin vs. placebo. The supplement consumed exhibited no significant effects on heart rate at any time point. Blood lactate increased significantly following each set ($p < 0.001$); however, there were no differences between conditions. After consuming citrulline malate and capsaicin together, exercise performance were improved compared with capsaicin and citrulline malate alone. The differences were very close to the significance. **Discussion:** Citrulline malate and capsaicin improved resistance exercise performance in trained females. Coingestion of citrulline malate and capsaicin revealed better performance outcomes and further research needed to determine optimal dosage. **Reference:** [1] Freitas, MC, Cholewa, JM, Freire, VR, Carmo, AB, Botton, J, Bratfich, M, Della, PMB, Gonçalves, CD, Capureto, CE, Lira, F, and Rossi, EF. Acute capsaicin supplementation improves resistance training performance in trained men. *J Strength Cond Res*, 2017.

Mail to: fakca@ankara.edu.tr.

EVOKED FORCE AND FATIGUE BY ELECTROMYOSTIMULATION WITH OR WITHOUT BLOOD FLOW RESTRICTION

RUEDA J., ÁLVAREZ A., HERRERO A.J., BALADRÓN C., SANTOS-LOZANO A., AND MARTÍN-HERNÁNDEZ J.

Department of Health Sciences, European University Miguel de Cervantes, Valladolid, Spain

Introduction: The aim of this study was to compare the acute effects of high-frequency neuromuscular electro-myostimulation (EMS) with or without superimposed blood flow restriction (BFR) on the evoked torque of the knee extensors in consecutive contractions (Q). **Methods:** Twenty healthy physical education students volunteered for the study. (10 men; 10 women; 19 ± 3 years) Following 2 familiarization sessions, subjects underwent 3 testing sessions at least 24 hours apart. In each session, the maximal voluntary isometric contraction (MVIC) of the knee extensors of the dominant leg was assessed by an isokinetic dynamometer following a standardized warm-up. Then, subjects randomly received one of the following interventions: EMS (380 μ s, 75Hz, 1 s ramp up, 3 seconds ON, 1 second ramp down, 20 seconds rest) without BFR (EMS); EMS with BFR (BFR) (250 mm Hg); or EMS with placebo BFR (50 mm Hg PLAC). EMS group received a rectangular biphasic current delivered at 75Hz with a pulse width of 380 μ s and adjusted at an intensity equivalent to 50% of subjects' maximum pain threshold. EMS evoked 5 consecutive contractions of 5 seconds followed by 20 seconds rest periods between them. BFR and PLAC received the same electrical stimulus combined with a severe (BFR, 250 mm Hg) or mild (PLAC, 50 mm Hg) restriction of blood flow. BFR was provided by an inflatable nylon cuff (140 mm wide, 940 mm long). **Results:** The evoked relative peak force was similar independently of the protocol (EMS: $58.7 \pm 22.1\%$; BFR: $63.1 \pm 7.4\%$; Placebo: $60.7 \pm 7.5\%$, $p = 0.570$). Throughout the 5 repetitions, the evoked relative peak force decreased just for the BFR protocol (-11.0 , -19.6 and -28.9% in the third, fourth and fifth repetition respectively, $p < 0.01$, $p < 0.001$ and $p < 0.001$, respectively). **Conclusion:** The combination of EMS and BFR produced an important fatigue in respect to EMS alone. This fact should be kept in mind when designing protocols that combine both training methods, in order to avoid overreaching. **Mail to:** jrueda5609@alumnos.uemc.es.

EFFECT OF HIGH-INTENSITY RESISTANCE CIRCUIT-BASED TRAINING IN HYPOXIA ON MAXIMUM OXYGEN CONSUMPTION

RAMOS CAMPO D.J., RUBIO ARIAS J.A., CHUNG L.H., MARÍN-PAGÁN C., CARLOS-VIVAS J., MARTÍNEZ-NOGUERA F.J., AND ALCARAZ P.E.

Sport Science Faculty, Catholic University of Murcia, UCAM Research Center for High Performance Sport, Murcia, Spain

Introduction: Resistance circuit-based training (RCT) is an effective training method to develop of maximum oxygen consumption ($\dot{V}O_{2max}$) and strength performance [1]. Previous studies applying RCT in hypoxia have reported beneficial responses in anaerobic metabolism and metabolic stress [2]. However, there are no studies which analyse the effect of RCT in hypoxia on aerobic performance. Therefore, the aim of this work was to analyse the effect of 8 weeks of high-intensity resistance circuit-based training (HRC) in hypoxia on $\dot{V}O_{2max}$. **Methods:** Twenty-eight subjects were randomly assigned to hypoxia ($FiO_2 = 15\%$; HRC_{hyp} : $n = 15$; age: 24.6 ± 6.8 years; height: 177.4 ± 5.9 cm; weight: 74.9 ± 11.5 kg) and normoxia ($FiO_2 = 20.9\%$; HRC_{norm} : $n = 13$; age: 23.2 ± 5.2 years; height: 173.4 ± 6.2 cm; weight: 69.4 ± 7.4 kg) groups. Each training session consisted of 2 blocks of 3 exercises (Block 1: bench press, leg extension, and front pull down; and Block 2: deadlift, elbow flexion, and ankle extension). Each exercise was performed at 6RM. Rest periods lasted for 35-seconds between exercises, 3-minutes between sets and 5-minutes between blocks. Participants exercised twice weekly for 8 weeks and before and after the training programme a treadmill running test to determine $\dot{V}O_{2max}$ were performed. **Results:** $\dot{V}O_{2max}$ (HRC_{hyp} pre: 50.9 ± 5.9 ; post: 53.6 ± 5.6 $ml \cdot kg^{-1} \cdot min^{-1}$; $p = 0.008$; HRC_{norm} pre: 55.7 ± 5.0 ; post: 56.3 ± 4.9 $ml \cdot kg^{-1} \cdot min^{-1}$; $p = 0.571$) and time to exhaustion (HR_{Chyp} pre: 942.0 ± 143.2 ; post: 980.7 ± 116.8 seconds; $p = 0.012$; HRC_{norm} pre: $1,008.0 \pm 56.4$; post: $1,005.3 \pm 77.4$ seconds; $p = 0.854$) were significantly increased in HR_{Chyp} but not in the HRC_{norm} . No significant differences between groups were found. **Discussion:** Improvements in $\dot{V}O_{2max}$ are influenced by increases in maximal stroke volume (SV) and maximal cardiac output (CO) and other peripheral factors like increases in capillarisation, activities of metabolic enzymes and improvement in muscle buffering [3]. The main responses of the cardiovascular system to RCT included a significant increase in $\dot{V}O_{2max}$, together with a SV and CO [4]. A meta-analysis [1] showed that RCT improves relative $\dot{V}O_{2max}$, however our results showed $\dot{V}O_{2max}$ values in HRC_{norm} remained unchanged.

Thus, the improvements in $\dot{V}O_2\text{max}$ in the HRC_{hyp} may not be due to RCT but to hypoxia exposure adaptations. Therefore, compared with normoxic conditions, 8 weeks of HRC training under hypoxic conditions efficiently improves aerobic performance. **References:** [1] Muñoz-Martínez, FA, et al. Effectiveness of resistance circuit-based training for maximum oxygen uptake and upper-body one-repetition maximum improvements: a systematic review and meta-analysis. *Sport Med* 48:2553–68, 2017. [2] Ramos-Campo, DJ, et al. Biochemical responses and physical performance during high-intensity resistance circuit training in hypoxia and normoxia. *Eur J Appl Physiol* 117:809–18, 2017. [3] Bassett, DR and Howley, ET. Limiting factors for maximum oxygen uptake and determinants of endurance performance. *Med Sci Sport Exerc* 32:70–84, 2000. [4] Haennel, RG, et al. Effects of hydraulic circuit training following coronary artery bypass surgery. *Med Sci Sport Exerc* 23: 158–65, 1991. **Mail to:** djramos@ucam.edu.

RESPIRATORY AND PERCEIVED EXERTION VARIABLES DURING AN INTERVALLIC ENDURANCE PROTOCOL THROUGH MENSTRUAL CYCLE PHASES

ALFARO-MAGALLANES V.M., CUPEIRO R., BARBA-MORENO L., ROMERO-PARRA N., RAEL B., MAESTRE-CASCALES C., AND PEINADO A.B.

LFE Research Group, Department of Health and Human Performance, Faculty of Physical Activity and Sport Science (INEF), Universidad Politécnica de Madrid, Spain

Introduction: Respiratory variables, rating of perceived exertion (RPE) and perceived readiness (PR) can vary depending on the menstrual cycle phase due to the different sexual hormone environments found through it [1, 2]. Few studies compare more than 2 menstrual cycle phases and even fewer use intense intervallic endurance protocols [1, 2]. Additionally, oestrogen seems to have powerful effects in some exercise variables, although it may reduce muscle endurance capacity [3]. Therefore, the main objective of this study was to compare respiratory variables, RPE and PR measured in 3 phases of the menstrual cycle during an intervallic endurance protocol. **Methods:** Six endurance trained females (33.5 ± 4.2 years; 59.7 ± 8.9 kg; 161.5 ± 8.1 cm; 47.9 ± 4.7 ml·kg⁻¹·min⁻¹) performed a maximal graded test to obtain maximal oxygen consumption ($\dot{V}O_2\text{max}$) and velocity at this level. Subsequently, 3 intervallic running sessions were conducted, consisting the main part on 8 intervals of 3 minutes at 85% of the $\dot{V}O_2\text{max}$ velocity with 90 seconds rest between intervals at each phase of their menstrual cycle (early follicular phase: EFP; late follic-

ular phase: LFP; luteal phase: LP). Ventilation (VE), oxygen uptake ($\dot{V}O_2$), and respiratory exchange ratio (RER) were measured. RPE was measured by Borg 6–20 scale at the end of every interval and PR was measured by Nurmekivi 1–5 scale before each interval. Mixed linear model was conducted to analyse data. **Results:** Hormonal levels were as expected for each menstrual cycle phase. Only PR presented differences for menstrual cycle phase factor (EFP = 4.2 ± 0.3 ; LFP = 3.8 ± 0.3 ; LP = 4.3 ± 0.3 ; $p = 0.002$), not being significant for VE (EFP = 78.7 ± 4.9 ; LFP = 76.7 ± 4.9 ; LP = 76.5 ± 4.9 L·min⁻¹), $\dot{V}O_2$ (EFP = $2,298.1 \pm 146$; LFP = $2,250.5 \pm 146$; LP = $2,128.6 \pm 146$ ml·min⁻¹), RER (EFP = 0.95 ± 0.03 ; LFP = 0.96 ± 0.03 ; LP = 1 ± 0.03) and RPE (EFP = 14.2 ± 0.7 ; LFP = 14.9 ± 0.7 ; LP = 14 ± 0.7). Differences between intervals were observed in $\dot{V}O_2$ ($p = 0.035$), RER ($p = 0.002$), RPE ($p < 0.001$) and PR ($p = 0.002$). No effect was found for intervals and menstrual phase interaction. **Discussion:** Despite the large variations in female sexual hormone levels appeared throughout the tested phases of the menstrual cycle, our preliminary results showed no effect of menstrual cycle phase on respiratory variables and RPE, as well as most of the previous studies [1, 2]. Nevertheless, PR seems to be lower during LFP, matching the highest oestrogen levels during menstrual cycle. This variable may reflect a reduced muscle endurance capacity, which could be produced by high oestrogen levels [3]. Female sexual hormone effects through the menstrual cycle seem controversial and more research with hormone verification is needed to clarify their influence. **References:** [1] Smekal, G, Von Duvillard, SP, Frigo, P, Tegelhofer, T, Pokan, R, Hofmann, P, et al. Menstrual cycle: No effect on exercise cardiorespiratory variables or blood lactate concentration. *Med Sci Sports Exerc* 39:1098–106, 2007. [2] Janse de Jonge, XAK. Effects of the menstrual cycle on exercise performance. *Sports Med* 33:833–51, 2003. [3] Sun, Y, Qin, Z, Wan, JJ, Wang, PY, Yang, YL, Yu, JG, et al. Estrogen weakens muscle endurance via estrogen receptor-p38 MAPK-mediated orosomucoid (ORM) suppression. *Exp Mol Med* 50: e463, 2018. **Mail to:** victor.alfaro10.va@gmail.com.

IMPACT OF SPORTS PERFORMANCE TECHNOLOGY ON STRESS MANAGEMENT IN HEALTHY POPULATION

MAICAS L.

Universidad de Castilla la Mancha, Spain

Introduction: The objective of our study is to evaluate the impact that the use of sports performance technology has on the improvement of stress management and the quality of

recovery in the non-athletic healthy population for integration as effective tools for the promotion of health in environments with high levels of stress and pressure. Almost 75% of healthy people of working age suffer from stress at work, learn to achieve it not only impacting their health, but also their development and professional performance. Performance technology can help improve the dose of physical exercise that has a positive effect on the health of the population with stress.

Methods: An experimental cross-sectional study that included healthy people from a Spanish company ($N = 17$, Age = 30.04 ± 5.58 years, Height = 69.99 ± 14.13 kg and Tall = 168.13 ± 8.92 cm). The physical condition of the worker was evaluated through the measurement of Cardiac Variability through Firstbeat Bodyguard (Firstbeat Technologies Ltd., Jyväskylä, Finland), using RR interval data of beat-to-beat to determine the amount and intensity of Blood pressure (BP), stress and recovery. Once the records were obtained during 48 hours, they were analyzed using the Firstbeat Analysis Server software (version 6.3, Firstbeat Technologies Ltd.). The body composition was also measured through a bioimpedancemeter (Tanita Body Composition Monitor model BC-601) and a CMJ vertical jump to assess the explosive strength of the lower limbs through the MyJump 2 mobile app. The use of technology of sports performance in the workplace allowed us to collect data of correlated interest with health variables such as cardiac response to the environment, body composition and strength in lower limbs. After the initial data collection, individual reports were delivered and 4 practical workshops were designed that included guidelines for Nutrition, Physical Exercise, Stress Management and Recovery Quality Improvement according to the individual profiles of physical condition collected. The intervention period was 6 months. **Results:** Significant improvements in body composition were obtained ($p < 0.05$): Percentage of total fat (% Fat = Pre: 27.08 ± 13.55 Post: 24.84 ± 11.92), the percentage of lean mass (% Muscular Mass = Pre: 46.71 ± 8.2 Post: 48.21 ± 8.6), the percentage of water (% Water = Pre: 53.75 ± 9.6 Post: 55.72 ± 8.4) and the metabolic age (AgeMet = Pre: $28, 44 \pm 15.05$ Post: 26.33 ± 13.73). The variables related to the explosive force in lower limbs (Fexplosiva) did not show any significant change. In terms of stress management, there are improvements in the percentage of the total hours of the day that people spend reacting to stress (% Stress Pre = 48.72 ± 11.57 Post = 45.94 ± 15.7) ($p = 0.34$) showing significant improvements in the time they spend recovering (% recovery = Pre: $25.94\% \pm 10.6\%$; Post: $25.44\% \pm 15.4\%$). **Discussion:** The use of sports performance technology that is susceptible due to its ease and the type of data it provides if applied in non-sport environments of healthy people could provide valid measurement tools on physical condition in order to offer useful feed-

back to professionals to design more efficient wellness programs. Including future physical intervention programs adapted to the physical condition profile in the intervention could have a greater impact on the cardiac response to stress, as well as improving the quality of recovery. **Mail to:** info@luismaicas.com.

THE INTERDAY RELIABILITY AND USEFULNESS OF REACTIVE STRENGTH INDEX DERIVED FROM A MAXIMAL HOPPING TEST

COMYNS T.,¹ HARPER D.,² FLEMING S.,¹ AND FITZGERALD E.¹

¹University of Limerick, Ireland; and ²York St John University, United Kingdom

Introduction: Reactive strength index (RSI) has been described as an individual's ability to change quickly from an eccentric to a concentric contraction [1]. RSI has been used in the practical strength and conditioning setting and exercise science literature as a means of quantifying fast stretch-shortening cycle performance [2]. Self-regulated maximum vertical hopping tests have been used to derive RSI [3, 4]. The maximal 5 hopping test (5max), proposed by Lloyd et al. (3), involves participants performing a countermovement jump followed by 4 maximal hops where contact time is minimised and height maximised. RSI is calculated for each of the 4 hops and the average is then obtained. While Lloyd et al. [3] reported acceptable ICC values for interday RSI reliability (0.90), the coefficient of variation (CV%) for this group of male youth athletes was high (11–21%). Limited research exists on the interday reliability and usefulness (ability to detect the smallest worthwhile change) of this RSI test for an adult population. The purpose of this study was to examine the interday reliability and usefulness of RSI derived from the 5max test for an amateur female adult field sport cohort. **Methods:** Ethical approval was obtained from the institutional committee and all procedures were in accordance with the Declaration of Helsinki (2008). Fifteen female participants (age: 21.1 ± 0.9 years; height: 1.7 ± 0.7 m; body mass: 62.0 ± 5.1 kg) were recruited and completed 2 trials of the 5max test with 60 seconds rest after a warm-up protocol on 2 testing sessions separated by a minimum of 48 hours. A 5max test familiarisation session preceded the 2 testing sessions. For all trials the subjects were instructed to minimise ground contact time and maximise jump height. The best trial from each testing day was used for the reliability and usefulness analysis, which was completed using a Microsoft Excel spreadsheet [5]. Acceptable reliability was determined at an ICC ≥ 0.80 and a CV $\leq 10\%$ [6]. Usefulness

was determined by comparing the typical error (TE) to the smallest worthwhile change (SWC) [7]. **Results:** The mean \pm SD for RSI was 1.21 ± 0.48 for day 1 and 1.17 ± 0.46 for day 2. The reported ICC for RSI was 0.97 (95% CI: 0.92–0.99) and the CV was 8.3%. The SWC for RSI was 0.09 and the TE was 0.08 which results in a usefulness rating of “good” for this test [7]. **Discussion:** Results from this study suggest that the 5max test is a reliable test to assess RSI for female players. The test is also useful in detecting if a meaningful change in RSI performance has occurred. Strength and conditioning coaches should consider using 5max test as a field based test to assess female players fast stretch-shortening cycle capabilities. Further research is needed to examine the relationship between RSI derived from the 5max test and other physical qualities important for successful field sport performance, such as acceleration and change of direction capabilities. **References:** [1] Young, WB. Laboratory strength assessment of athletes. *New Stud Athl* 10: 89–96, 1995. [2] Flanagan, EP and Comyns, TM. The use of contact time and the reactive strength index to optimize fast stretch-shortening cycle training. *Strength Cond J* 30: 32–8, 2008. [3] Lloyd, RS, Oliver, JL, Hughes, MG, and Williams, CA. Reliability and validity of field-based measures of leg stiffness and reactive strength index in youths. *J Sports Sci* 27: 1565–73, 2009. [4] Harper, D, Hobbs, S, and Moore, J. The 10 to 5 repeated jump test. A new test for evaluating reactive strength. In: British Association of Sports and Exercises Sciences Student Conference, Chester. 2011 (Vol. 1, No. 1). [5] Hopkins, WG. Spreadsheets for analysis of validity and reliability. *Sports Science* 19: 36–42, 2015. [6] Hopkins, WG. Measures of reliability in sports medicine and science. *Sports Med* 30:1–15, 2000. [8] Hopkins, WG. How to interpret changes in an athletic performance test. *Sports Science* 8: 1–7, 2004. **Mail to:** tom.comyns@ul.ie.

TEST RETEST RELIABILITY OF SPECIFIC ABILITIES TEST IN YOUTH RHYTHMIC GYMNASTICS

REY E., FERNÁNDEZ-VILLARINO M.A., GONZÁLEZ S., AND PÉREZ-FERREIRÓS A.

University of Vigo, Spain

Introduction: The aim of this study was to determine the test-retest reliability of Specific Abilities Tests (SAT) in Youth Rhythmic Gymnastics [3]. **Methods:** Thirty-four rhythmic gymnasts took part in the research. The subjects were between the age of 10 and 20 year old (13.7 ± 2.7 years). Rhythmic gymnasts performed the SAT on 2 occasions, separated by 7 days. Rel-

ative reliability was assessed by intraclass correlation coefficient (ICC) and absolute reliability was assessed using the typical error (TE), expressed as coefficient of variation (CV%) [4]. An ICC ≥ 0.7 indicated satisfactory, ≥ 0.75 good, and ≥ 0.9 excellent reliability [1]. According to previous reliability studies, a CV of less than 5% was set as the criterion for reliability [2]. **Results:** The pairwise analysis revealed no significant differences between the 2 trials for all variables of the SAT. Seven (coordination, flexibility, jump test, speed, abdominal strength, musicality, and agility) of the 14 variables of the SAT showed very good reliability between sessions (ICC ≥ 0.9 ; CV $< 5\%$). **Discussion:** The results of this study demonstrate that some variables of the SAT are both a reliable and useful to test specific abilities rhythmic gymnastics. **References:** [1] Atkinson, G and Nevill, AM. Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. *Sports Med* 26: 217–38, 1998. [2] Buchheit, M, Lefebvre, B, Laursen, PB, and Ahmaidi, S. Reliability, usefulness, and validity of the 30-15 Intermittent Ice Test in young elite ice hockey players. *J Strength Cond Res* 25: 1457–1464, 2011. [3] Gateva, M. Investigation of the strength abilities of rhythmic gymnasts. *Federation Sports Pedagogues Republic Macedonia* 41: 248, 2013. [4] Hopkins, WG. Measures of reliability in sports medicine and science. *Sports Med* 30: 1–15, 2000. **Mail to:** zequirey@uvigo.es.

THE FIRST PULL IN OLYMPIC WEIGHTLIFTING: BIOMECHANICAL CONSIDERATIONS AND PRACTICAL APPLICATIONS IN STRENGTH TRAINING FOR SPORTS

SQUILLANTE A.

A.T. Still University

Introduction: Olympic-style weightlifting exercises have found their place in the training of high school and collegiate athletes. A better understanding of the nature of these explosive movements can provide more insights on the use of Olympic-style weightlifting exercises and their derivatives in strength training for sport. **Method:** Vertical ground reaction force (GRF), peak vertical bar velocity (PVBV), average joint angular displacement and average joint angular velocity measured among a pool of 5 experienced lifters. These data were used to compare the mechanics of the pull in Olympic weightlifting with the descriptive data on jumping mechanics available in the literature. **Results:** During the transition between first pull and second pull in the snatch, clean and jerk knees bend under load of approximately $16.2 \pm 6.64^\circ$ while the angle at hips progressively

increases from 89.5 ± 2.47 degrees of flexion (knee joint at approximately $134 \pm 7.59^\circ$) to 58 ± 2.47 degrees of flexion (knee joint at approximately $117.8 \pm 6.62^\circ$). The transition between first pull and second pull only lasts for approximately 0.148 ± 0.015 seconds and it initiates the fast, concentric, muscle action of the lower extremities that results in a sudden increase in vertical bar velocity. **Discussion:** As knees are extending during the liftoff, vertical GRF peaks right before hamstrings and glutes undergo a time of vigorous eccentric contraction while their proximal insertion stays still to preserve the angle at the hip joint. Elastic energy is stored and promptly utilized from the power position to increase PVBV. This dampening mechanics closely resemble the amortization phase in jumping mechanics as confirmed by the significant similarities between the power position in Olympic weightlifting and the take-off position in a standing countermovement jump. From the power position, a higher degree of angular velocity at the hip joint ($460.7 \pm 27^\circ \cdot s^{-1}$) compared to the knee joint ($390 \pm 49.4^\circ \cdot s^{-1}$) suggests a higher contribution of hamstrings and glutes over quadriceps, as a consequence of the stretch-shortening cycle taking place during the second knee bent. **Conclusion:** The plyometric nature of Olympic weightlifting is, therefore, inherent to the active transition from first to second pull whereas movements initiated at the power position only rely on the ability to create a high level of starting strength without taking full advantage of the physiological stretch-shortening cycle involved in athletic-like activities. **References:** [1] Kipp, K, Redden, J, Sabick, M, and Harris, C. Kinematic and kinetic synergies of the lower extremities during the pull in Olympic weightlifting. *J Appl Biomech* 28: 271–278, 2012. [2] Moolyk, AN, Carey, JP, and Chiu, LZ. Characteristics of lower extremity work during the impact phase of jumping and weightlifting. *J Strength Cond Res* 27: 3225–3232, 2013. **Mail to:** anto.squillante@gmail.com.

THE EFFECTS OF A FASCIA MANIPULATION DEVICE ON METABOLISM, CONNECTIVE TISSUE REMODELING, AND IRISIN IN MIDDLE AGED WOMEN

JAMESON B.,^{1,2} BLACK A.,¹ AND WILSON J.²

¹Ashley Diana Black International Holdings, LLC, Houston, TX; and ²The Applied Science and Performance Institute, Tampa, FL

Introduction: Research suggests that mechanical manipulation of fascia provides a non-invasive method to treat cellulite. However, the metabolic impact of these techniques remains to be investigated. The purpose of this study purpose was to

investigate the metabolism, connective tissue remodeling and safety impact of mechanically manipulating fascia with a fascia treatment device (FasciaBlaster, Ashley Diana Black International Holdings, LLC; Houston, TX). **Methods:** Thirty-three women volunteered to participate in the self use condition (Fascia Manipulation [FM]) of the study (40 ± 6 years, height: 165.51 ± 2.66 , weight: 76.67 ± 14.79 kg) and 10 female subjects served as the control (CON; age: 43 ± 2 years, height: 165.10 ± 4.02 cm, mass: 73.80 ± 23.45 kg). **Results:** Metabolism (REE), irisin, and Carboxyterminal Propeptide of Type I Procollagen (PICP) were examined in 4 weeks intervals. REE was greater at week12 compared to baseline (BL) ($1,724 \pm 43$ vs. $1,556 \pm 70$ kcal·d⁻¹; $p < 0.05$). Carboxyterminal Propeptide of Type I Procollagen (PICP) was higher at week 4 compared to BL (1.20 ± 0.06 vs. 0.98 ± 0.04 a.u.; $p < 0.05$) serum irisin levels at week 4 were significantly higher than BL (1.48 ± 0.08 vs. 0.96 ± 0.09 a.u.; $p < 0.001$), week 8 (1.48 ± 0.08 vs. 0.93 ± 0.09 a.u.; $p < 0.001$) and week 12 (1.48 ± 0.08 vs. 1.14 ± 0.07 a.u.; $p < 0.05$). **Discussion:** These data indicate that mechanical manipulation of fascia, specifically through use of the FasciaBlaster, can increase metabolism. The mechanism is likely tied to elevated irisin and or an increase in connective tissue remodeling. **Mail to:** tbartjameson@gmail.com.

POST-EXERCISE ISCHEMIA ACCELERATES PERFORMANCE RECOVERY OF CYCLISTS

MAROCOLO M.,¹ ARIEL OLIVEIRA R.,¹ SOUZA H.,¹ AND DA MOTA G.²

¹Federal University of Juiz de Fora, Brazil; and ²Federal University of Triangulo Mineiro, Brazil

Introduction: Brief moments of blood flow occlusion followed by reperfusion cause hyperemia [1], and this may raises delivery of glucose and oxygen supply to muscles favouring glycogen, ATP and PCr re-synthesis [2] post-exercise. Beyond this, the maneuver inhibited reactive oxygen species (ROS) [3] and creatine kinase (CK) [4] production. Thus, this study assessed the effect of ischemia post-exercise (IPE) on recovery and physiological variables in trained cyclists. **Methods:** In a randomized, single-blind model, 28 trained cyclists (27.1 ± 1.4 years) performed a maximal incremental test (MIT) in cycle ergometer. Outcome measures of creatine kinase (CK), muscle soreness and perceived recovery status, were taken before MIT and measures of heart rate, perceived exertion and power output were taken during MIT and repeated post 24-hours later. Immediately after MIT, the cyclists performed 1 of the 4 intervention: those who underwent 2×5 -minutes

occlusion/5-minutes reperfusion (IPE or SHAM, 2 × 5) or 5 × 2-minutes occlusion/2-minutes reperfusion (IPE or SHAM, 5 × 2). The IPE (50 mm Hg above systolic blood pressure) or SHAM (20 mm Hg) were applied unilaterally alternating the thighs. After 24-hours, the cyclists performed a second MIT. **Results:** Post 24-hours, all groups increased CK compared baseline ($p < 0.05$) (IPE 2 × 5 = 33 ± 18; IPE 5 × 2 = 38 ± 26; SHAM 2 × 5 = 62 ± 49; SHAM 5 × 2 = 15 ± 8 (U/L). The IPE groups were more tired at 24-hours post ($p < 0.05$) (IPE 2 × 5, baseline: 8.3 ± 1.1 and post 7.3 ± 1.1; IPE 5 × 2, baseline: 8.1 ± 3.0 and post: 7.1 ± 2.8 scores), but maintained their performance ($p > 0.05$). However, both SHAM groups had decreased performance post 24-hours compared to baseline ($p < 0.05$) (SHAM 2 × 5 = -38 ± 29.7 seconds; SHAM 5 × 2 = -15 ± 15.9 seconds). There were no significant differences for heart rate, power output and perceived exertion post 24-hours compared baseline for any interventions ($p > 0.05$), and were not found differences for any measures post 24-hours between interventions ($p > 0.05$). **Discussion:** The main finding in this study is that IPE accelerates recovery of performance 24-hours after a MIT, indicating a feasible tool to use following exercise sessions or multi-stage competitions. In this study, the CK increment was lower than previous study [5]. Probably is due to the low volume (average 14 minutes), and the minimal eccentric contribution from the MIT. Higher CK values are found in 90 minutes [6]. The perceived recovery status showed that both IPE groups were more tired at post 24-hours compared to baseline, but their MIT performance were similar to baseline. The discomfort of IPE application may have influenced the cyclists' responses. A possible explanation for faster performance recovery is that increase blood flow caused by IPE could raises delivery of glucose and oxygen supply to muscles favouring glycogen, ATP and PCr re-synthesis, and inhibition ROS production. In conclusion, IPE promoted faster recovery of performance 24-h post-exercise in trained cyclists. **References:** [1] Libonati, JR, Howell, AK, Incanno, NM, Pettee, KK, and Glassberg, HL. Brief muscle hypoperfusion/hyperemia: an ergogenic aid? *J Strength Cond Res* 15:362–6, 2001. [2] Bangsbo, J and Hellsten, Y. Muscle blood flow and oxygen uptake in recovery from exercise. *Acta Physiol Scand* 162:305–12, 1998. [3] Jin, C, Wu, J, Watanabe, M, Okada, T, and Iesaki, T. Mitochondrial K⁺ channels are involved in ischemic postconditioning in rat hearts. *J Physiol Sci JPS* 62: 325–32, 2012. [4] Zhang, L, Ma, J, and Liu, H. Protective effect of ischemic postconditioning against ischemia reperfusion-induced myocardium oxidative injury in IR rats. *Mol Basel Switz* 17: 3805–17, 2012. [5] Franz, A, Behringer, M, Harmsen, JF, Mayer, C, Krauspe, R, Zilkens, C, et al. Ischemic Preconditioning Blunts Muscle Damage Responses Induced by Eccentric Exercise. *Med Sci Sports Exerc*, 2017. [6] Greer,

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INFLUENCE OF SEX HORMONES ON MUSCLE FUNCTION AND JUMP PERFORMANCE IN ORAL CONTRACEPTIVE USERS: IRONFEMME PROJECT

ROMERO-PARRA N., PEINADO A., ALFARO-MAGALLANES V.F., RAEI B., KARABÁS S., NAVARRO-GARCÍA J.M., AND CUPEIRO R.

LFE Research Group, Department of Health and Human Performance, Faculty of Physical Activity and Sport Science (INEF), Universidad Politécnica de Madrid, Spain

Introduction: Oral contraceptives (OC) are widely used by female athletes even if there is some controversy in the literature regarding their influence on different sport performance variables [1, 2]. Decreases in performance of counter movement jump (CMJ) has been related with muscle damage and loss of muscle function after strength training, but few studies have investigated these effects after an intense strength training in women. Therefore, the purpose of this study was to examine whether lower-limb muscle function and damage are affected by hormonal fluctuation within an OC cycle in female athletes. **Methods:** Seven oral contraceptive users (age 30 ± 4 years, height 164 ± 5.2 cm, body mass 60 ± 6.3 kg) experienced in resistance training, performed a 1RM test to determine their maximal back squat load. After load estimation, they completed an eccentric-based resistance protocol consisting of 10 sets × 10 reps of back squat in order to elicit muscle damage [3]. Both 1RM estimation and the eccentric-based protocol were performed twice, in hormonal and non-hormonal phases of an OC cycle (being hormonal phase the period in which participants were taking the OC, and non-hormonal phase the week when participants were not taking the OC or taking the inactive pills). Participants also performed CMJ before (pre-trial), and 0, 24 and 48 hours after eccentric protocol (post-trial). Jump height was measured by using My-Jump App. [4] Mixed linear model was conducted to analyze repeated measures. **Results:** Mean 1RM load was 63.7 and 62.1 kg for hormonal and non-hormonal phases while jump height was 19.9 ± 3.1 and 19.8 ± 3.8 cm for the mentioned phases. No significant effect of phase for 1RM and CMJ

performance was found ($p = 0.840$, $p = 0.639$, respectively). Jump height values were significantly affected by moment ($p < 0.001$), being 0, 24 and 48 hours post-trial values significantly lower in comparison to pre-trials. Mean jump height values for pre-trial and 0, 24 and 48 hours post-trial measures were 21.6 ± 2.9 , 18.5 ± 3.1 , 19.3 ± 3.5 and 20.1 ± 3.7 cm, respectively. No significant interaction between phase and moment was observed ($p = 0.101$). **Discussion:** An eccentric-based resistance protocol consisting of 10 sets of 10 back squats affects muscle function in trained women as CMJ post-trial values were significantly lower than pre-trial measures. Nevertheless, muscle function does not seem to be influenced by hormonal fluctuation as no differences among hormonal phases were observed. Further studies are needed to confirm these preliminary findings with a larger sample and different hormonal profiles. **References:** [1] Rechichi, C and Dawson, B. Effect of oral contraceptive cycle phase on performance in team sport players. *J Sci Med Sport* 12: 190–195, 2009. [2] Anderson, LJ, Baker, LL, and Schroeder, ET. Blunted Myoglobin and Quadriceps Soreness After Electrical Stimulation During the Luteal Phase or Oral Contraception. *Res Q Exerc Sport* 88: 197–202, 2017. [3] MacdonaldGZ, Button, DC, Drinkwater, EJ, and Behm, DG. Foam Rolling as a Recovery Tool after an Intense Bout of Physical Activity. *Med Sci Sports Exerc* 46: 131–142, 2014. [4] Gallardo-Fuentes, F, Gallardo-Fuentes, J, Ramírez-Campillo, R, et al. Intersession and Intrasession Reliability and Validity of the My Jump App for Measuring Different Jump Actions in Trained Male and Female Athletes. *J Strength Cond Res* 30: 2049–2056, 2016. The Iron-FEMME Study is funded by the Ministerio de Economía, Industria y Competitividad, Convocatoria de Ayudas I + D 2016, Programa Estatal de Investigación Científica y Técnica y de Innovación 2013-2016 (Grant code DEP2016-75387-P). **Mail to:** n.romero@upm.es.

WICKET RUN METHOD AND MAXIMAL RUNNING SPEED RELATIONSHIP

GONZÁLEZ-FRUTOS P., MORENCOS E., AND ARIAS-TOMÉ A.

¹Universidad Francisco de Vitoria, Spain; and ²Universidad Autónoma de Madrid, Spain

Introduction: Previous studies have analyzed the relationship between maximal running speed, step frequency (SF) and step length (SL), with different results [1, 2, 3]. The aim of our study was to analyze the correlation between the

natural maximal speed test and the results of optimal SL and SF wicket run in maximal speed test. **Methods:** A total of 51 athletes (18 university students of sport sciences, 18 athletes U-16 and 19 athletes U-14) performed different flying 20 m sprints at maximal-effort: flat and wicket runs at different distances (1.50–2.30 m). Speed, SL and SF were calculated by high speed video analysis and photocell split times. The acceleration phase speed (15 m previous to the flying 20 m) was controlled at the last 5 m. The difference between the first and second part of the flying 20 m was calculated with a halfway time. The fastest wicket run was selected to compare with the flat sprint. **Results:** The flying 20 m flat speed had the highest correlation with the flying 20 m wicket run speed ($r = 0.953$; $p < 0.001$). The higher correlations occurred with acceleration phase speed in flat ($r = 0.947$; $p < 0.001$) and wicket run conditions ($r = 0.929$; $p < 0.001$). In addition, the flying 20 m speed has a higher correlation with the SF in flat and wicket run conditions ($r = 0.756$; $p < 0.001$) than with the SL in flat ($r = 0.622$; $p < 0.001$) and wicket run conditions ($r = 0.367$; $p < 0.01$). On the other hand, the flying 20 m speed has a higher correlation with the speed increase in that phase, both flat ($r = 0.435$; $p < 0.001$) and wicket run conditions ($r = 0.548$; $p < 0.000$). The analysis of each group showed similar results, except in some cases where no significant correlation was found (athletes U-14 and U-16: wicket run SL; university students: SL and speed increase in maximal speed phase). **Discussion:** The fact that the SF has a greater correlation with the maximal speed than the SL, like some athletes of the study of Salo et al. (2011), could reinforce the idea of training with SL lower or similar to the optimal to increase this parameter (SF). It seems interesting the use of at least 20 m for the maximal speed phase to train the speed increase within this phase. Increase the maximal speed with wicket runs could be a good strategy to develop the natural maximal speed that also increases athlete's motivation. It is important to pay attention to the acceleration phase, so coaches should encourage their athletes to perform this first part with the maximum intensity possible. In conclusion, the use of wicket run method allows controlling some variables related to the natural maximal speed. **References:** [1] Mackala and Mero. A kinematic analysis of 3 best 100 m performances ever. *J Hum Kinet* 36: 149–160, 2013. [2] Hunter, JP, Marshall, RN, and McNair, PJ. Interaction of step length and step rate during sprint running. *Med Sci Sports Exerc* 36: 261–271, 2004. [3] Salo, AI, Bezodis, IN, Batterham, AM, and Kerwin, DG. Elite sprinting: are athletes individually step frequency or step length reliant? *Med Sci Sports Exerc* 43: 1055–1062, 2011. **Mail to:** p.gfrutos.prof@ufv.es.

SKELETAL MUSCLE ACTIVATION IN LOWER LIMB DISTAL DISTRICT DURING SINGLE STANCE POSTUROGRAPHY IN EYES OPEN AND EYES CLOSED SENSORY CONDITIONS

VILLANI C.,¹ CREMONESI I.,¹ MANZONI F.,² AND D'ANTONA G.¹

¹Sport Medicine Centre Voghera, University of Pavia, Pavia, Italy; and ²Department of Public Health, Experimental and Forensic Medicine, University of Pavia, Italy

Introduction: We analyzed in healthy subjects selected skeletal muscle activation in 2 different sensory conditions, eyes open and eyes closed, during one-foot static posturography. **Methods:** Fourteen healthy females (mean age 27 years, range: 25–34 years) were evaluated in different sensory conditions (eyes open, EO; eyes closed, EC) during a stability test for postural control (Delos Postural System) performed in single stance on the ground, without arms counterbalance. Each leg performed a first trial with EO and a second trial with EC, in an alternate sequence for the left and the right limb. The subject stood with the weight-bearing knee bent to 170° and the non weight-bearing knee flexed to 45°. To detect muscle activation, surface electromyography (sEMG) was obtained from the following muscles: tibialis anterior, peroneus longus, gastrocnemius medialis, gastrocnemius lateralis. Average rectified value (ARV) was recorded. For simplicity, the measurements were obtained only on the dominant limb. **Results:** EO: a reduction of the sagittal plane oscillations (y_{EO}) correlated with increased activation of the long peroneus ($r = -0.63$) whereas a reduction of the frontal plane oscillations (x_{EO}) correlated with increased activation of the medial gastrocnemius muscle ($r = -0.54$); EC: an increase of the oscillations on the frontal plane correlated with the activation of the long peroneus ($r = 0.55$). **Conclusions:** Results show that in EO the activation of long peroneus and the medial gastrocnemius muscle is associated with better postural control, while in EC, despite the activation of long peroneus, oscillations increase indicating a worsening of postural control. **Reference:** [1] Riva, D, Mamo, C, Fani, M, Saccavino, P, Rocca, F. Momente', M, and Fratta, M. Single Stance Stability and Proprioceptive Control in Older Adults Living at Home: Gender and Ages differences. *J Aging Res* 2013, 2013. **Mail to:** cristianovillani01@gmail.com.

BLOCK PRACTICE ENCOURAGES MOTOR LEARNING OF DYNAMIC BALANCE SKILL IN HEALTHY YOUNG ADULTS

ALADRO-GONZALVO A.,¹ LUCHA-LÓPEZ M.,² TRICAS-MORENO J., AND ESPARZA-YÁNEZ D.³

¹Faculty of Nursing, Pontifical Catholic University of Ecuador; ²Physiotherapy Research Unit, Division of Psychiatry and Nursing, University of Zaragoza; and ³Physiotherapy School, Universidad de las Américas

Introduction: The scheme of learning complex skills during practice affects motor performance [1, 3], however, not much is known about the most efficient way to learn fundamental untrained motor skills. Locomotor skills such as walking, running, sitting and getting up, involve temporarily optimal and precise dynamic movements of body weight displacement in frontal and sagittal planes [2, 4]. Purpose of this study was to determine if practice scheme modifies motor learning of a dynamic balance skill in healthy young subjects. **Methods:** After sample power analysis, 63 university students (20.63 ± 2.58 years) without balance disorders and previous training, participated in the study. They were randomly assigned to 1 of 3 practice schedules (block "B," random "R" or increasing "I"). Learning task was to move body weight laterally on a platform of force according to visual feedback provided on a computer. Eighteen trials were carried out during acquisition, and again 24 hours later, during evaluation of retention of the skill. Force-load was manipulated between trials ranging from 35 to 15% of body weight, in order to get contextual interference effect [6]. Outcome measures were execution errors and time of execution (s) during acquisition and retention of the skill. Experimental study, in accordance with Declaration of Helsinki, was approved by Institutional Review Board (Universidad de las Américas, Ecuador), and participants gave informed consent. **Results:** Wilcoxon test found that all 3 practice schemes retained the learning, and that motor performance with B practice even improved in retention (time of execution: median differences = -24 seconds, $Z = -3.555$, $p = 0.000$; execution errors: median differences = -36, $Z = -2.728$; $p = 0.006$). Kruskal-Wallis H of execution errors between practice schedules was significant ($p < 0.05$). Mann-Whitney U post hoc procedure found that I schedule increased execution errors during acquisition and retention comparing with B ($p < 0.017$), while between B and R there were no differences in motor performance. **Discussion:** Results did not support better effect of I scheme during retention [5], and partially according with results of Jiménez-Díaz et al. (2016) meta-analysis, that found differences between practice schemes only in acquisition. During learning process with B practice, motor system linked the

execution time with the precision of the movement, because both improved in retention. In summary, young and healthy subjects learned to control the body weight during a dynamic balancing task in few trials, optimizing the execution time and decreasing errors when continuous trials of the skill were performed without early modification of force-load parameters. These results may be useful for coaches, physical therapists and physical educators to create better learning environments for dynamic balance skills.

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COMPARISON OF $\dot{V}O_2$ MAX OBTAINED BY DIRECT AND TWO INDIRECT TESTS IN YOUNG ADULTS AT MODERATE ALTITUDE: AN OBSERVATIONAL STUDY

SÁNCHEZ I.,¹ TRIANA H.,¹ GUTIÉRREZ A.,¹ RODRÍGUEZ J.,² AND RODRÍGUEZ L.²

¹Universidad Santo Tomás, Grupo GICAEDS, Línea de fisiología muscular y entrenamiento deportivo; and ²Centro de Formación en Actividad Física y Cultura SENA, Grupo de Investigación en Actividad Física y Deporte

Introduction. Hypobaric hypoxia causes a significant reduction in $\dot{V}O_2$ max at above 1,500 meters, which may affect the performance during indirect tests used for the estimation of $\dot{V}O_2$ max. This study aimed to compare the values of $\dot{V}O_2$ max obtained by Cooper's 12-minute run test (CRT), 20-meter multi stage shuttle run test (SRT) and a direct $\dot{V}O_2$ max estimation. **Methods.** Fifteen university students (9 male and 6 female) were recruited by simple random sampling from the University of Santo Tomás, Bogotá (mean age 20.3 ± 2.0 years; mean body weight 66.2 ± 10.0 kg; mean body mass index 22.9 ± 2.5 kg). $\dot{V}O_2$ max of each participant was determined at moderate altitude of 2,600 meters by the direct proce-

dure (Metamax 3B spirometric device) and 2 indirect methods (CRT and SRT). **Results.** The mean value of direct $\dot{V}O_2$ max (ergo spirometry) was 50.1 ± 8.5 ml·kg⁻¹·min⁻¹ among female, and 60.8 ± 10.3 ml·kg⁻¹·min⁻¹ in male. The mean value of CRT in female was 37.8 ± 14.2 ml·kg⁻¹·min⁻¹, and 42.4 ± 9.0 ml·kg⁻¹·min⁻¹ in male. Finally, SRT mean values were 51.8 ± 4.4 ml·kg⁻¹·min⁻¹ in female, and 51.4 ± 4.0 ml·kg⁻¹·min⁻¹ in male. Statistically significant differences on $\dot{V}O_2$ max values between direct test and CRT were observed in male ($p < 0.01$) but not for SRT values ($p > 0.05$). No significant differences were found among female. No correlation was found on $\dot{V}O_2$ max values when obtained by direct and 2 indirect field tests (female CRT $r = 0.00$ $p = 1.0$, SRT $r = 0.15$ $p = 0.77$; male CRT $r = 0.18$ $p = 0.62$, SRT $r = 0.31$ $p = 0.41$). **Discussion:** Our results suggested that SRT predicted $\dot{V}O_2$ max values in both male and female at moderate altitudes. Conversely, CRT did not predict $\dot{V}O_2$ max in men but not in women. Further research using larger sample sizes is warranted. **References:** [1] Bandyopadhyay, A. Validity of 20 meter multi-stage shuttle run test for estimation of maximum oxygen uptake in female university students. *Indian J Physiol Pharmacol* 57: 77–83, 2014. [2] Bandyopadhyay, A. Validity of Cooper's 12-minute run test for estimation of maximum oxygen uptake in male university students. *Bio Sport* 32: 59–63, 2014. [3] Bandyopadhyay, A. Validity of Cooper's 12-min run test for estimation of maximum oxygen uptake in female university students. *Indian J Physiol Pharmacol* 58: 184–6, 2015. **Mail to:** isabel.sanchez@usantotomas.edu.co.

ACCELERATION IMPACTS DURING RUNNING ARE AFFECTED BY THE TYPE OF SURFACE

DE ANTONIO J., CALVO J., NAVANDAR A., AND FERRO A.

Universidad Politécnica de Madrid, Spain

Introduction: Despite all the benefits of running studies have shown that high acceleration peaks on ground impact and repetitions of these impacts contributed as potential risk factors. This study analysed the differences in the acceleration variables on impact while running on different surfaces. **Methods:** Thirty adults (8 males; 22 females); age 22.6 ± 2.43 years, trained runners. A multisensor-wireless-inertial-measurement-unit, Wimu (Real Track, Almería, Spain) which 2 3-axis-accelerometers (1,000 Hz) was placed on the sacrum, parallel to the lumbar spine. Participants performed one trial 120 meters running on 3 different surfaces: tartan (40 m), grass (40 m) and concrete (40 m) at 3.3 min·s⁻¹ running-speed, which was controlled with a GPS (Garmin-Fore-Runner 630, Kansas, USA). The values of the resultant

accelerations (a_x , a_y , a_z) were obtained. The mean and peak total accelerations in the impacts (MI and PI) (in g) and the total number of impacts (NI) were calculate and compared across the 3 surfaces using a linear mixed model (fixed effect: surface, random effect: participant). Standardized differences (SD) between surfaces were also determined, with the threshold values for small, medium and large being 0.2, 0.6 and 1.2 [1]. **Results:** The MI, PI and NI of each surface were for tartan, grass and concrete, respectively, MI: 1.3 ± 0.1 g, 1.31 ± 0.1 g and 1.35 ± 0.1 g.; PI: 3.68 ± 0.45 g, 3.76 ± 0.48 g and 3.9 ± 0.55 g; NI: 74.03 ± 12.51 , 76.83 ± 9.85 and 69.97 ± 10.39 . Concrete surfaces showed greater MI, SD with tartan: 0.42 (0.21, 0.64); with grass: 0.27 (0.05, 0.48) and PI, SD with tartan: 0.43 (0.33, 0.54); with grass: 0.36 (0.25, 0.46) while a greater NI were observed for tartan and grass as compared to concrete, SD with tartan: -0.36 (-0.68 , -0.05); with grass: -0.66 (-0.97 , -0.35). Trivial differences were observed between tartan and grass. **Discussion:** The findings implies that a runner would be subject to greater biomechanical loads while running on concrete as compared to tartan or grass, a finding similar to previous research [2]. The number of impacts on concrete was also lower as compared to tartan and grass, possibly indicating that the running technique could be different on such a surface to withstand the greater loads. Given the increasing popularity of running, runners must be trained to withstand the different loads on different surfaces. **Conclusion:** Running on tartan and grass could be more suitable during training periods due it produced less peak accelerations on the impacts while running on concrete could be reserved for the competitions where this surface is usually imposed by the organizers of this events. **References:** [1] Cohen, J. Statistical power analysis. *Curr Dir Psychol Sci* 1:98–101, 1992. [2] Tessutti, V, Ribeiro, AP, Trombini-Souza, F, and Sacco ICN. *J Sports Sci* 30:1545–1550, 2012. FINANCIAL SUPPORT: Ministry of Economy and Competitiveness (MINECO). National Plan R&D&I. Ref. project: DEP2012-38785. **Mail to:** amelia.ferro@upm.es.

RESISTANCE TRAINING VELOCITY BASED ON ARTERIAL STIFFNESS IN HEALTHY SUBJECTS

RODRÍGUEZ-PÉREZ M.A., LORENTE-CAMACHO D., GARCÍA-MATEO P., AND ALCARAZ-IBÁÑEZ M.

University of Almería, Spain

Introduction: Strength training has been proved as a useful exercise modality for health improvement. However, previous research investigating the effects of resistance training

on an indicator of cardiovascular health such as arterial stiffness has reported mixed findings [1, 2]. Velocity-based resistance training (VBRT) has been proposed as a preferable alternative to traditional methods in terms of quantification of load during training. This study aims to compare the acute effects of 2 VBRT protocols on arterial stiffness [3]. **Method:** Sixteen healthy and physically active subjects (age 21.8 ± 2.3 years, height 1.74 ± 0.7 m, body weight 77.8 ± 8.9 kg) were aleatory assigned to 2 groups. The same relative load (75% 1RM), number of exercise sets [3] and inter-set rest duration (3 minutes) were used in both. The protocols differed in the number of repetitions performed in each set in relation to the expected maximum. Thus, the protocol performed by group 1 involved a maximal effort (to failure) and a maximum loss of velocity of 60%. In turn, the protocol performed by group 2 involved only half of the maximum number of expected repetitions for set, specifically, by allowing a maximum loss of velocity of 20%. Pulse-wave velocity (PWV) was measured after and 10 minutes before VRBT using Mobil-O-Graph (I.E.M., Stolberg, Germany). **Results:** After VRBT, increased values were found in group 1 (5.03 vs. $5.33 \text{ min} \cdot \text{s}^{-1}$) whereas decreased values were found in group 2 (5.26 vs. $4.86 \text{ min} \cdot \text{s}^{-1}$). Effect size of difference in PWV between groups was ($d = 1.571$), therefore large according to the cut-off points proposed for recreationally trained individuals [5]. **Conclusion:** Compared to resistance training protocols aimed to reach the maximum number of executable repetitions, those involving only half by allowing moderate velocity loss may induce positive acute effects in arterial stiffness. **References:** [1] Ashor, AW, Lara, J, Siervo, M, Celis-Morales, C, and Mathers, JC. Effects of exercise modalities on arterial stiffness and wave reflection: A systematic review and meta-analysis of randomized controlled trials. *PLoS One* 9, 2014. [2] Kingsley, JD and Figueroa, A. Acute and training effects of resistance exercise on heart rate variability. *Clin Physiol Funct Imaging* 36: 179–187, 2016. [3] González-Badillo, JJ, Yañez-García, JM, Mora-Custodio, R, and Rodríguez-Rosell, D. Velocity loss as a variable for monitoring resistance exercise. *Int J Sports Med* 38, 2017. [4] Pareja-Blanco, F, Rodríguez-Rosell, D, Sánchez-Medina, L, Sanchis-Moys, J, Dorado, C, Mora-Custodio, R, Yañez-García, D, Morales-Alamo, M, Pérez-Suarez, CL, Calbet, JA, and González-Badillo, JJ. Effects of velocity loss during resistance training on athletic performance, strength gains and muscle adaptations. *Scand J Med Sci Sports*, 2016. [5] Rhea, MR. Determining the magnitude of treatment effects in strength training research through the use of the effect size. *J Strength Cond Res* 18: 918–920, 2014. **Mail to:** manolo.rodriguez@ual.es.

BLOOD FLOW RESTRICTION DURING REST INTERVALS OF HEAVY LOAD RESISTANCE TRAINING INFLUENCES MUSCLE FATIGUE

MARTÍN-HERNÁNDEZ J.,¹ BALADRÓN C.,¹
SANTIAGO-PESCADOR S.,¹ CAMBRA-GAÍNZA A.,¹
HERRERO A.J.,² LUCIA A.,³ AND
SANTOS-LOZANO A.¹

¹*i+HeALTH Research Group, European University Miguel de Cervantes, Valladolid, Spain;* ²*GIDFYS Research Group, European University Miguel de Cervantes, Valladolid, Spain;* and ³*Faculty of Sport Sciences, Universidad Europea de Madrid, Spain*

Introduction: Training intensity plays a major role in determining acute and long-term adaptations to resistance training. Mechanical stress has been considered to be the keystone of muscle hypertrophy, although metabolic stress and metabolite accumulation are currently considered to cooperate in the post-exercise hypertrophic response [1]. This is somehow illustrated by blood flow restriction (BFR) training (BFRT). This method involves lifting light loads (<40% 1RM) while blood flow to/from the muscle is partially reduced by a compressive cuff placed proximally. BFRT has proved to result in anabolic signaling and protein synthesis, with metabolic stress and accumulation underlying this response [1]. BFR has been combined with moderate-to-high (i.e., 60 and 80% 1RM) training intensities during contraction –not during rest– and has shown to produce no additive effect on muscle strength or hypertrophy in the long-term [2], possibly due to the fact that intense muscle contractions per se result in some degree of acute hypoxia [3]. Rest intervals between sets of resistance training have an influence on overall training load and are intended to manage metabolic stress and fatigue. Therefore, the purpose of this study was to get insight into how BFR applied only during rest intervals of heavy-load resistance training (HLRT) could affect volitional fatigue as a proxy of metabolic stress.

Methods: Twenty physically active males were randomly divided into a) HLRT group ($n = 11$) and b) BFR (during rest intervals) group ($n = 9$). BFR was applied by means of a 140 mm wide and 940 mm long compressive cuff inflated to 250 mm Hg. Muscle fatigue was measured as the number of repetitions performed to muscular failure in 3 consecutive sets of HLRT at 80% 1RM with intersets rest intervals of 4 minutes. Participants underwent each condition twice in order to ensure the repeatability of the measurements. **Results:** The reduction in the number of repetitions was significantly greater for BFR compared to HLRT in the second (5.8 ± 1.5 vs. 8 ± 1.7 repetitions, respectively; $p < 0.05$) and third exercise sets (3.2 ± 2 vs. 6.8 ± 1.3 repetitions; $p < 0.001$). No Session

effect was found, indicating that the number of repetitions performed in each set by each group was consistent across the 2 testing days. **Discussion:** The reduction in the number of repetitions in the BFR group may be interpreted as muscle fatigue [4]. Although our methodological design does not allow to get insight on metabolite accumulation, previous work has shown BFR during rest intervals of work-matched HLRT to increase lactate production [5]. It should also be noted that the total time under tension and mechanical work performed in BFR was lower than that of HLRT. These results indicate that BFR during rest intervals of HLRT affect the acute response to exercise. Long-term implications remain unexplored.

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TRAINING LEADING TO FAILURE AND NOT TO FAILURE ON PHYSICAL PERFORMANCE IN YOUNG BASKETBALL PLAYERS

VAZ R.,¹ AREDE J.,² AND LEITE N.²

¹*Department of Sport Sciences, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal;* and ²*Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, University of Trás-os-Montes and Alto Douro, Portugal*

Introduction: Gains in strength can be achieved both by using repetitions until failure or not to failure [1]. However, there is a lack of information on which effects training to failure and not to failure, have on other physical performance variables. The aim of this study was to assess changes in maximal force, maximal power output, jumping, sprinting and change of direction using repetition to failure and repetitions not to failure in young female basketball players. **Methods:** Fourteen regional level basketball players (age = 15.8 ± 1.4 years;

height = 168.4 ± 4.5 cm; body mass = 60.2 ± 6.0 kg; basketball experience = 4.0 ± 2.8 years; strength training experience = 1.5 ± 1.1 year). The participants were randomly assigned into 2 experimental groups: repetitions to failure group (RF, $n = 7$) and repetitions in reserve group (RIR, $n = 7$). All subjects done their normal 4 sessions per week of basketball training along with a 8-week general strength training program, 2 times per week. Both groups done the same training program but, the RMG did sets of 10 repetitions maximum and the RIRG did sets of 7 with 3 repetitions in reserve (RPE 7). To control the repetitions in reserve we used the resistance exercise-specific rating of perceived exertion scale from Zourdos [2]. Before and after intervention, back squat and bench press 1RM and maximal power output, jumping height (CMJ, SJ and Abalakov jump), 20 m sprint and change of direction (T-test and V-cut test) were assessed. In order to assess the practical meaning of the results, data were analyzed using the magnitude-based inference approach. **Results:** Within-group analysis showed that RIR group had large to very large effects on bench press power output (ES: 1.80 ± 0.39) moderate to large effects on CMJ (ES: 1.54 ± 0.53), SJ (ES: 1.19 ± 0.51), abalakov jump (1.78 ± 0.69), back squat 1RM (1.02 ± 0.26), back squat power output (0.94 ± 0.28) and small to large effects on bench press power output (ES: 1.13 ± 0.60). RF group showed trivial to large effects on abalakov jump (ES: 0.72 ± 0.54) and T-test (0.78 ± 0.65) and trivial to moderate effects on CMJ (0.42 ± 0.30), SJ (0.36 ± 0.32), 20 m (0.25 ± 0.42), back squat 1RM (0.65 ± 0.12) and back squat power output (0.50 ± 0.58). In between-groups analysis, RIR group showed small to large effects on back squat and bench press power output (ES: 0.91 ± 0.57 ; ES: 1.05 ± 0.73 , respectively) and small to moderate effects on CMJ (ES: 0.64 ± 0.52) when compared with RF group. **Discussion:** To develop power, sets should stop sufficiently short of volitional failure [3]. An RPE of 7 seems to be beneficial to improve explosive capabilities like power production and jumping. In conclusion, coaches should consider repetitions in reserve when programming strength training. **References:** [1] Davies, T, Orr, R, Halaki, M, and Hackett, D. Effect of Training Leading to Repetition Failure on Muscular Strength: A Systematic Review and Meta-Analysis. *Sports Med* 46: 487–502, 2015. [2] Zourdos, MC, Klemp, A, Dolan, C, Quiles, JM, Schau, KA, Jo, E, Helms, E, Esgro, B, Duncan, S, Garcia Merino, S, and Blanco, R. Novel resistance training-Specific rating of perceived exertion scale measuring repetitions in reserve. *J Strength Cond Res* 30: 267–275, 2016. [3] Haff, GG and Nimphius S. Training principles for power. *Strength Cond J* 34: 2–12, 2012. **Mail to:** rafaelvaz6950@gmail.com.

ASSOCIATION BETWEEN NEUROMUSCULAR ASYMMETRIES AND PHYSICAL PERFORMANCE IN YOUTH SPORTS TEAM ATHLETES

FORT-VANMEERHAEGHE A.,¹ AGUILERA-CASTELLS J.,¹ DE BLAS-FOIX X.,¹ BUSCÀ-SAFONT B.,¹ AND MONTALVO A.M.²

¹FPCEE and FCS Blanquerna, Universitat Ramon Llull, Barcelona, Spain; and ²Nicole Wertheim College of Nursing and Health Sciences, Florida International University, Miami, FL

Introduction: Nowadays, there is a lack of consensus about the real association between inter-limb neuromuscular asymmetry and physical performance in youth athletes [1, 2]. The aim of the present study was to identify the relationship between unilateral jump asymmetries and sprinting, jumping and change of direction. **Methods:** A total of 80 youth elite team-sport players (32 males, 48 females) were included in this study: age (15.94 ± 1.11 years), body mass (69.72 ± 11.63 kg), height (1.79 ± 0.19 m), and sport experience (5.82 ± 2.93 years). Linear sprinting, vertical and horizontal unilateral jumping, and change of direction were assessed with the 30 m sprint, single leg countermovement jump (SLCMJ), one leg hop test (OLHT), and v-cut test, respectively. In addition, to the assessment of inter-limb neuromuscular imbalances, vertical and horizontal jump asymmetry index (%ASI) were calculated from SLCMJ and OLHT, respectively. The relationship between neuromuscular asymmetries and physical performance was analyzed using Pearson coefficient correlation. **Results:** Pearson's correlations showed significant relationships between vertical jump asymmetries from the SLCMJ and 30-m sprint time ($r = 0.258$; $p < 0.01$). Significant negative correlations were also found between vertical jump asymmetries and SLCMJ in the non-dominant leg ($r = -0.255$; $p < 0.05$) and horizontal jump asymmetries and OLHT in the non-dominant leg ($r = -0.441$; $p < 0.05$). No correlations were observed between asymmetries and change of direction performance. Vertical jump asymmetries (11.3 ± 8.32) were larger than horizontal jump asymmetries (5.01 ± 6.22). **Conclusions:** The main finding of this study was that higher vertical jump asymmetries were associated with slower sprint times. Moreover, higher asymmetries are associated with diminished jump performance in the non-dominant leg (weaker) and appear to be direction-specific. In accordance with other authors [1, 3], and compared with the OLHT, the SLCMJ is likely the most sensitive task for detecting asymmetries between legs. Strength and conditioning coaches can use this information as physiological norm values to guide neuromuscular performance

programs in youth sports team players. **References:** [1] Bishop, C, Read, P, McCubbine, J, and Turner, A. Vertical and Horizontal Asymmetries are Related to Slower Sprinting and Jump Performance in Elite Youth Female Soccer Players. *J Strength Cond Res* 1, 2018. [2] Maloney, SJ, Richards, J, Nixon, DGD, Harvey, LJ, and Fletcher, IM. Do stiffness and asymmetries predict change of direction performance? *J Sports Sci* 35: 547–56, 2017. [3] Fort-Vanmeerhaeghe, A, Montalvo, AM, Sitjà-Rabert, M, Kiefer, AW, and Myer, GD. Neuromuscular asymmetries in the lower limbs of elite female youth basketball players and the application of the skillful limb model of comparison. *Phys Ther Sport* 16, 2015. **Mail to:** azaharafv@blanquerna.url.edu.

EFFECT OF WHOLE-BODY ELECTROMYOSTIMULATION ON CK, LACTATE, HR AND RPE DURING A SINGLE STRENGTH SESIÓN

RECAREY RODRÍGUEZ A.E., BURGOS POSTIGO S., TOBÍA DEL BUSTO D., CLEMENTE SUÁREZ V., AND FERNÁNDEZ ELÍAS V.E.

Physical Activity and Sports, Universidad Europea de Madrid, Madrid, Spain

Introduction: We evaluated the acute effect of whole-body electromyostimulation (WB-EMS) during and after dynamic maximum strength exercise on blood creatin kinase and lactate concentrations, heart rate and its variability, and rate of perceived exertion. **Methods:** Twenty healthy, physically active participants (10 men and 10 women) with strength training experience of 3–5 d·wk⁻¹ during, at least, the last 2 years, enrolled in the study. They first performed a familiarization trial with the WB-EMS device and a 1RM test based on mean propulsive velocity analysis for bench press and full-squat to establish their exercise load (90% 1RM). Then, subjects performed 3 maximal strength sessions, in a randomized way, consisting of 5 sets of 5 repetitions with 3 minutes of rest between sets of bench press and full-squat using different protocols: WB-EMS with continuous stimulus (85 Hz, 250/350 μs; Cont-EMS), WB-EMS with stimulus coordinate with the movement concentric phase (85 Hz, 250/350 μs, 1 second strain to 2 seconds rest; Coord-EMS) and a session without WB-EMS (No-EMS). **Results:** During the strength sessions, HR was similar in all set in both bench press (116 ± 20 b·min⁻¹) and full squat exercises (132 ± 14 b·min⁻¹). Also, RPE reported was similar in all sessions, being significantly greater in the last 2 sets (1-fold over 10; $p < 0.05$). After exercise, CK significantly increased in the 3 trials (19 ± 13, 15 ± 14 and 30 ± 23% for Cont-EMS, Coord-EMS and No-EMS

respectively; $p < 0.05$) being significantly greater only when comparing No-EMS with Cont-EMS (148.5 ± 145.0 vs. 99.0 ± 71.7 IU/L; $p < 0.05$). Lactate significantly increased in the 3 trials (1.7 ± 1.0 to 2.7 ± 1.7 mmol·L⁻¹ for Cont-EMS; 2.0 ± 0.9 to 2.9 ± 1.8 mmol·L⁻¹ for Coord-EMS; 1.7 ± 0.8 to 2.7 ± 1.1 mmol·L⁻¹ for No-EMS; all $p < 0.05$), with no differences between trials. Further, HR variability (Square root of the mean value of all sum of squared differences of all R-Rs following intervals [RMSSD]; Low Frequency band [LF]; High Frequency band [HF]) did not change after trials. **Discussion:** According to these data, for healthy, physically active and with strength training experience subjects, the use of WB-EMS devices, with continuous or coordinate with the muscle contraction stimulus protocol, did not have a greater effect on the internal load of a maximum strength training session and thus, it may be an effective and secure training method. **References:** [1] Jee, YS. *J Exerc Rehabil* 14: 49–57, 2018. [2] Herrero, AJ, et al. *Rev Andal Med Dep* 8: 155–162, 2015. [3] Kemmler, W, et al. *J Strength Cond Res* 24:1880–7, 2010. This study was partially supported by Myofx. Authors declare no conflict of interest. **Mail to:** anel1115.recarey@gmail.com.

THE EFFECT OF PLAYING STATUS ON ADAPTATIONS TO STRENGTH AND CONDITIONING INTERVENTION AND DETRAINING IN YOUTH BASKETBALL

AREDE J.,¹ VAZ R.,¹ AND LEITE N.²

¹Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, University of Trás-os-Montes and Alto Douro, Portugal; and ²Department of Sport Sciences, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal

Introduction: Physical performance changes during a competitive period according to playing status (starters vs. non-starters) [1]. However, the impact of transition period and strength and conditioning training response during competitive period stills remain unclear. The aim of this study was to assess changes in high-intensity actions, neuromuscular and aerobic performance after transition and training period, according to the playing status. **Methods:** Thirteen under-16 regional level basketball players (age = 15.2 ± 0.7 years; height = 174.1 ± 8.9 cm; body mass = 66.1 ± 12.1 kg) participated in this study. Participants were grouped in starters ($n = 5$) and non-starters ($n = 8$), according to time played in the previous season (minutes played = 1,160 > 446; $d = 0.88$ –2.56). All subjects accomplished an 8-week transition period (absence of supervised training), 3-week preparatory period consisted of neuromuscular training program (4 sessions/w; 24 sets/session) and 12 weeks on-

field applied strength in basketball-specific skills training program (SBASK) (2 sessions/w, 12 sets/sessions). Prior and after transition and training period, aerobic fitness (YO-YO IR1), jumping ability (SJ, CMJ and Abalakov jump), reactive strength (30 cm drop jump), agility (V-cut and T-tests) and sprinting (0–10, 10–20 and 0–20m split times) were assessed. Also, lower limb asymmetry index (ASI) was calculated. Specifically-designed spreadsheets were used to analyze within- and between-group changes using magnitude-based inferences. **Results:** Within-group analysis showed moderate improvements in RSI in both groups (d: 0.74–0.91) and moderate to large negative changes occurred in T-test, 10–20 m split time in starters, after transition period (d: 0.89–1.26). Moderate to large improvements occurred in ASI, agility tests and 10–20 m split time for both groups, but also for 0–20 m split time in starters after training period (d: 0.64–1.58). In contrast, large decrements were observed for RSI (d: 1.35). Between-group analysis showed better results in T-test and 10–20 m split time in non-starters after transition period (d: 2.03–2.61). Large improvements in V-Cut, 0–10 m and 0–20 m split times for starter players after training period (d: 1.01–1.51). **Discussion:** SBASK elicits relevant effects in injury risk factor (i.e., ASI) and high-intensity actions, particularly in starters. Transition period affects negatively starters, however seems to be beneficial for explosive capabilities (i.e., RSI). In conclusion, playing status should be considered as confound variable in training design. **References:** [1] Gonzalez, AM, Hoffman, JR, Rogowski, JP, Burgos, W, Manalo, E, Weise, K, et al. Performance changes in NBA basketball players vary in starters vs. nonstarters over a competitive season. *J Strength Cond Res* 27: 611–615, 2013. Financial support: This work was supported by a grant from the Foundation for Science and Technology (SFRH/BD/122259/2016) and by Project Symbiotic technology for societal efficiency gains: Deus ex Machina (DEM) (NORTE-01-0145-FEDER-000026). **Mail to:** jorge_arede@hotmail.com.

STRENGTH AND CONDITIONING TRAINING IN PHYSICAL EDUCATION CLASSES AND COMPARISON OF GAINS IN BOTH GENDERS

CARVALHO C.,¹ SÁ P.,¹ DUARTE A.M.,¹ DIAS I.,¹ CARVALHO A.,¹ VILAÇA-ALVES J.,² AND VIEIRA L.

¹University Institute of Maia—(ISMAI), Portugal; and

²University of Trás-os-Montes and Alto Douro (UTAD), Portugal

Introduction: The increase in sedentarism in adolescents, associated to the reduced time of Physical Activity per-

formed at schools and the almost inexistence of specific training for the development of the strength during Physical Education (PE) classes could affect negatively the physical and psychological health of students. Thus, in the present study we intend to apply a training program aimed at developing the strength and conditioning of students during PE classes and compare the gains between both genders.

Methods: The study was carried out with 124 students in the 12th grade at Rocha Peixoto School (Póvoa Varzim, Portugal), divided into 2 groups: a control group ($n = 31$) and an experimental group ($n = 92$). The evaluation was performed with the following tests: push-ups 30", curl-ups 30", MB throws of 2 kg, sextuple jumps, horizontal jumps and 30 m sprint. The training program consisted of calf raises, lunges, half squats, bench press, butterfly, vertical rowing, burpees, swings with kettlebell, abdominal and lower back extension (2 sets of 15 repetitions at about 60% 1 RM for 30" action and 30" rest). This was carried out twice a week and lasted 9 weeks. **Results:** The results showed that students, both in the experimental and in the control groups showed improvements from the first to the second evaluation moment in all the tests. However, the differences were only statistically significant in the experimental group. The control group only improved significantly in the sit-ups and the horizontal jumps. When comparing the average of the gains between both groups, there were significant differences in favor of the experimental group in: the push-up, MB throws and sextuple. We found higher values for males in all tests of the assessments process. However, the gains between the first and second moments of evaluation were significant for all students. It should be noted that the gains obtained, benefiting the boys, only registered significance in the abdominal and horizontal impulsion. The results obtained can be explained by the fact that the circuit training allows a suitable changes for both genders [1], this is because each student will always perform the maximum number of repetitions, regardless of being boys or girls, when they perform the strength and conditioning training adequately. **Conclusion:** The results obtained in this study show that PE classes can contribute to the improvement of the muscular strength of students, in both sexes. It should be noted that PE classes, with a focus on the organization and application of a strength program, induce superior gains. Therefore, the importance of the implementation of strength training in a school context in PE classes must be emphasized. **Reference:** [1] Faigenbaum. Resistance training for children and adolescents: Are there health outcomes? *Am J Life Med* 1: 190–200, 2007. **Mail to:** ccarvalho@ismai.pt.

LIMITED RELATIONSHIP BETWEEN VERTICAL FORCE ASYMMETRIES AND HORIZONTAL CHANGE OF DIRECTION ASYMMETRIES IN SOCCER PLAYERS

JANIKOV T., ZAHALKA F., AND TUFANO J.

Charles University in Prague, Czech Republic

Introduction: Vertical jumping and running with rapid changes of direction are key components in many sports. Asymmetries in lower limb force production ability could have negative impact on performance, and it is common to examine this asymmetry via vertical jump tests, but it should be determined if unilateral asymmetries during a bilateral task correlate to functional asymmetries during running tasks. Therefore, the purpose of this study was to determine the relationship between vertical jump force asymmetries and horizontal change of direction asymmetries. **Methods:** Seventeen elite male soccer players (19.06 ± 0.98 years; 179.5 ± 7.62 cm; 71.98 ± 6.55 kg) participated in 2 testing sessions separated by about 2 weeks: one laboratory and one field session. The laboratory testing included 3 maximal bilateral countermovement jumps with arm swing (CMJA) and 3 with the hands on the hips (CMJ). Vertical jump peak force (N) for each leg was recorded using 2 independent and synchronized force plates (Kistler, Switzerland) sampling at 1,000 Hz. The field testing included the 505 agility test with 2 trials performed to each side, measured using timing gates (Brower Timing Systems, USA). Subjects performed a standardized warm up before each testing session. Only the highest of the 3 jumps for each side and quicker of the 2 runs for each side were analyzed. All variables were expressed as the absolute difference between the right and left legs, which was then used for analysis. Spearman correlation coefficients (r) were calculated to determine the relationship between vertical jump asymmetries (force) and 505 change of direction asymmetries (time). Wilcoxon Signed Rank test was calculated to assess asymmetry of limbs for significant difference ($\alpha = 0.05$). **Results:** Right to left asymmetries were not present during the 505 agility test ($p = 0.423$), CMJA ($p = 0.421$) or CMJ ($p = 0.897$). The relationship between 505-time asymmetry and vertical jump peak force asymmetry was weak for both the CMJA ($r = 0.27$) and CMJ ($r = -0.24$). **Discussion:** To our knowledge no previous study has explored the relationships between magnitude and directions of horizontal and vertical asymmetries in lower limbs. Our results show that the strength of the investigated relationships is weak, their opposite directions indicate that CMJA may better correspond to the 505 agility test asymmetry than CMJ. On the other hand, the magnitude of asymmetry itself was not statistically significant in our research

sample. Considering this, future research investigating related topics should incorporate subjects that have significant lower limb asymmetries. Also, using the single legged CMJA instead of bilateral vertical jumps could result in a stronger relationship with the 505 agility test asymmetries due to the unilateral nature of both tests. Future research may additionally consider to investigate a rate of force development asymmetry in relationship to a horizontal change of direction asymmetry. **Mail to:** james.j.tufano@gmail.com.

CHANGE OF DIRECTION AND MENTAL TRAINING IMPACT ON AGILITY SUBCOMPONENTS IN YOUNG ELITE SOCCER PLAYERS

JABRI M.,^{1,2} NASRI H.,² GUELMAMI N.,² AND BOUASSIDA A.²

¹Faculté des sciences de Bizerte, Université Carthage, Tunis, Tunisia; and ²Research Unit, Sportive Performance and Physical Rehabilitation, High Institute of Sports and Physical Education, Kef, University of Jendouba, Jendouba, Tunisia

Introduction: As modern soccer is perceived as a nonlinear dynamic activity, it is important to apply complex motor skills with young players since an early age [4]. In this perspective, several studies suggest that a combined training modality involving reactive agility training according to the discipline-specific requirements and mental/imagery training may improve performance [3, 5]. Thus, the aim of the current study is to investigate the impact of this combined training on the physical and cognitive subcomponents of reactive agility among young soccer players (U14). **Methods:** Fifteen elite soccer players (13.3 ± 0.5 years/ 170.0 ± 0.1 cm/ 57.3 ± 8.0 kg) completed a 2 months specific intensive training program comprising 10 to 12 sessions per week. It was divided into field physical sessions and mental-imagery training indoors: (a) the main components of agility (reaction time and acceleration, coordination, anticipation, and plyometric exercises) with an alternation between preplanned and reactive COD circuits; (b) daily mental-imagery training starting by abdominal breathing exercises and relaxation techniques followed by concentration tasks then the 3 types of imagery (kinesthetic, external and internal imagery) alternatively. The following tests were administered before and after the training period: 5, 10 and 20 m maximal sprints, 5 Jump test (5JT), Coordination under time pressure (CUTP), Illinois agility test, The 45° Change-of-Direction and Acceleration Test (CODAT45°), Slalom Sprint and Dribble Test (SSDT), Concentration grid exercise 1 minute, Ottawa Mental Skills Assessment Tool 3 (OMSAT-3) and The

Sport Imagery Questionnaire for Children (SIQ-C). **Results:** All physical parameters except 10 m increase significantly at the end of the training program. The CODAT45° ($p < 0.01$), sprint speed ($p < 0.01$), CUTP ($p < 0.01$), reactive power ($p < 0.05$) and acceleration ($p < 0.05$) are relevantly enhanced. The significantly improved agility subcomponents were highly correlated. No significant impact was seen on global scores of the 3 mental assessments. Only 2 skills (commitment and competition planning) showed significant improvements ($p < 0.05$).

Discussion: The physical responses show a significant improvement in some of the abilities faster than other ones. The specific gains suggest that the training procedure has limited transfer from one performance ability to another. However, positive mental ability and imagery skills effects seem to be latent; as it occurs after extensive practice and application [1]. These findings confirm the before/after discriminating power of agility training reported in this study. It presents agility as a main parameter in talent detection and the guidance of young players to the top level [2]. The results also suggest that the progress in the agility tasks is a long lasting response from motor memory. **References:** [1] Cumming, J, Hall, C, and Shambrook, C. The influence of an imagery workshop on athletes' use of imagery. *Athletic Insight* 6: 52–73, 2004. [2] Reilly, T and Doran, D. Fitness assessment. *Science Soccer* 21–46, 2003. [3] Sheppard, JM and Young, WB. Agility literature review: classifications, training and testing. *J Sports Sci* 24: 919–32, 2006. [4] Williams, AM, Davids, K, and Williams, JG. Visual Perception and Action in Sport. London: Routledge; 1999. [5] Young, WB, James, R, and Montgomery, I. Is muscle power related to running speed with changes of direction? *J Sports Med Physical Fitness* 43: 282–288, 2002. **Mail to:** shandoman@yahoo.fr.

THE RELATIONSHIP BETWEEN LUMBOPELVIC MOTOR CONTROL AND INJURY INCIDENCE IN CROSSFIT ATHLETES

ORTEGÓN PIÑERO A., SOLANA-TRAMUNT M., MORALES J., NIETO A., NISHISHINYA B., AND CABREJAS C.

Department of Sports Sciences, Ramon Llull University, FPCEE Blanquerna, Spain

Introduction: Lumbopelvic motor control (LPMC) plays a critical role in stabilizing the spinal system [1] and is related to the incidence of injuries [2–4]. It can help to prevent fatigue and increase the stability of the spine during potentially high-risk exercises [6]. Injuries have been commonly reported among CrossFit athletes, particularly afflictions related to the low back

[5]. However, there have been no studies assessing LPMC and the prevalence of injuries among CrossFit athletes. The purpose of this study was to relate injury epidemiology and LPMC performance among CrossFit athletes. **Methods:** Seventy-two CrossFit athletes (mean age: 33 ± 8 years) voluntary participated. A Pressure Biofeedback Unit (PBU) was used to assess the maximal mm Hg deviation LPMC in 4 common tests: The Active Straight Leg Raising (ASLR), the Bent Knee Fall Out (BKFO), the Knee Lift Abdominal Test (KLAT) and the PRONE test (PRONE). A structured questionnaire was developed to determine the incidence of injuries and the characteristics of each subject's training session and their experience with CrossFit practice. Descriptive and chi-squared analyses were performed using SPSS software, version 22.0 (IBM Corporation, NY, USA). A p -value of 0.05 was assumed to indicate statistical significance. **Results:** The CrossFit athletes had, on average, 1.7 ± 1.1 years of experience with the practice and worked out for, on average, 5.9 ± 4.1 hours per week. The frequency analysis revealed that 66.7% of the participants were non-competitors; 91.7% included a warm-up period in their sessions; 52.8% included a cool-down period at the end of their session; 59.7% referred to being injured during CrossFit practice; 34.7% reported low back pain within the last 3 months. The participants exhibited the following LPMC performance: KLAT 20.4 ± 23.9 ; ASLR -1.9 ± 6.4 ; BKFO right side 5.3 ± 11.0 ; BKFO left side 7.1 ± 11.9 ; PRONE test -20.3 ± 12.8 . The chi-squared results revealed no association between LPMC performance level and participating in competitions ($\chi^2(2) = 0.45, p = 0.79$); including a warm-up period during sessions ($\chi^2(2) = 1.70, p = 0.42$); including a cool-down period during sessions ($\chi^2(2) = 3.23, p = 0.19$); having a previous injury ($\chi^2(2) = 3.29, p = 0.19$); having low back pain within the last 3 months ($\chi^2(2) = 2.54, p = 0.28$).

Discussion: Contrary to our hypothesis, there were no association among performance on the LPMC tests and any of the variables related to injury incidence (e.g., participating in competitions, a high reported incidence of injury, or a high reported incidence of low back pain). These results are inconsistent with those reported by previous studies [7], which found a significant association between the number hours of practice and injury incidence. In conclusion, a poorer performance in LPMC tests does not yield additional information about the incidence of injury among CrossFit athletes. Additional research is necessary to assess the link between these tests and the technical abilities of CrossFit athletes. **References:** [1] Borghuis, J and Hof, AL. The Importance of Sensory-Motor Control in Providing Core Stability. Implications for Measurement and Training. *Sport Med* 38: 893–916, 2008. [2] Roussel, N, Nijs, J, Truijen, S, Verweken, L, Mottram, S, and Stassijns, G. Altered breathing patterns during lumbopelvic motor control tests in chronic

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MAXIMUM STRENGTH IN OLDER WOMEN: A COMPARISON BETWEEN FOLK DANCES AND WALKING

MAIALEN A.,¹ MIRIAN ARANZAZU G.,¹ LEIRE S.,¹ BENGOCHEA A.,² LASCURAIN I.,¹ AMAIA M.,¹ AND ORTIZ T.¹

¹University of the Basque Country (UPV/EHU), Spain; and ²Université Libre de Bruxelles, Belgium

Introduction: Older women tend to be at greater risk of disability and morbidity than men. A decrease in muscle strength can further impair balance and mobility, leading to a decline in functional capacity [1]. Identifying the exercise interventions that can improve the strength of older women is important to counteract this age related decline. Dance-based studies involving older adults have been published suggesting it is a promising intervention, but evidence is conflicting regarding the effect of dance on muscle strength. Furthermore, effects may differ between different dance types [2]. Folk dances in the Basque Country are well accepted by the older population but its benefits are unknown. The aim of this study was to compare the strength between participants of a folk dancing group (FDG) and others whose habitual physical activity was walking (PAG). **Methods:** A cross-sectional study was performed. Healthy women ($n = 22$; age = 64.04 ± 4.4) participating in 90 minutes (twice a week) Folk dancing (FDG) and women ($n = 22$; age = 64.8 ± 3.7) whose main physical activity was

walking (PAG) were compared. Both groups underwent an assessment session including isometric knee extension strength (MIF_KG) and 5 repetition Sit-to-stand Test (STS). **Results:** FDG participants demonstrated greater strength (8% in MIF_Kg and in 10% STS) but differences did not reach statistical significance (MIF_Kg, $p = 0.2$; STS, $p = 0.059$). **Discussion:** Folk dances (FD) do not seem to improve maximum isometric strength (MIE). However, one possible explanation is that the MIE assessment method used may not be appropriate to assess the type of strength or muscles involved in FD. STS was almost significantly better in FDG. STS is a test of dynamic strength and power [3], more likely developed during dancing than walking. Power is also a better marker for detecting decline in muscle function in older people than MIE. Good strength values shown by all subjects may indicate a ceiling effect in STS for the older people without disability. Other assessment methods that include the measurement of power may be used in future studies to describe strength improvements in dance-based interventions. **References:** [1] Brady, AO and Straight, CR. Muscle capacity and physical function in older women: What are the impacts of resistance training? *J Sport Health Sci* 3: 179–188, 2014. [2] Keogh, JW, Kilding, A, Pidgeon, P, Ashley, L, and Gillis, D. Physical benefits of dancing for healthy older adults: a review. *J Aging Phys Act* 17: 479–500, 2009. [3] Lindemann, U, Claus, H, Stuber, M, Augat, P, Mucche, R, Nikolaus, T, and Becker, C. Measuring power during the sit-to-stand transfer. *Eur J Appl Physiol* 89: 466–70, 2003. **Mail to:** maialen.araolaza@ehu.eus.

MATCH PHYSICAL PERFORMANCE OF ELITE FEMALE SOCCER PLAYERS DURING NATIONAL COMPETITION: ACCELERATION AND DECELERATION PROFILE

ROMERO-MORALED A B.,¹ GIRALDEZ V.,² MORENCOS E.,³ AND SUÁREZ-ARRONES L.⁴

¹Camilo José Cela University, Spain; ²School of Sports Science, European University of Madrid, Madrid, Spain; ³Exercise and Sport Sciences, Education and Humanities Faculty, Francisco de Vitoria University, Spain; and ⁴Department of Sports and Computing, Sport Faculty, Pablo de Olavide University of Sevilla, Sevilla, Spain

Introduction: To develop specific training programs is necessary a comprehensive understanding of the physiological and biomechanical external demands of competition [1]. Research in female soccer has been focused on analyzing kinematics demands, especially in the distance covered for

different speed thresholds [2, 3]. However, quantification of mechanical activities through the number of accelerations and decelerations for player-position, provides more specific information to adequate management of neuromuscular workload. Therefore, the purpose of this study was to describe and compare the position-specific activity profiles of female soccer players with special emphasis on accelerations and decelerations. **Methods:** A total of 106 individual match observations (16 elite-competitive national matches) during 2017–2018 season were analyzed using Global Positioning Systems (GPS) devices (SPI Elite, GPSports, Australia). Twenty players were included (26.5 ± 5.7 years, 164.4 ± 5.3 cm and 58.6 ± 5.6 kg) and categorized into 5 positions: Central Backs (CB $n = 4$), Wide Backs (WB $n = 4$), Central Midfielders (CM $n = 6$), Wide Midfielders (WM $n = 4$) and Forwards (FW $n = 2$). **Results:** Total number of relative moderate accelerations ($AC1 < 1 \text{ m}\cdot\text{s}^{-2}$, $n\cdot\text{min}^{-1}$) and decelerations ($DC1 > -1 \text{ m}\cdot\text{s}^{-2}$, $n\cdot\text{min}^{-1}$) were 1.26 ± 0.36 and 0.62 ± 0.18 , respectively, and the number of relative high accelerations ($AC2 > 1 \text{ m}\cdot\text{s}^{-2}$, $n\cdot\text{min}^{-1}$) and decelerations ($DC2 < -1 \text{ m}\cdot\text{s}^{-2}$, $n\cdot\text{min}^{-1}$) were 0.40 ± 0.15 and 0.22 ± 0.08 , respectively. Small to very large differences in $AC1$ ($n\cdot\text{min}^{-1}$) were observed for CM (ES: 0.48–1.88) compared with all positions. Wide Midfielders performed more $AC2$ ($n\cdot\text{min}^{-1}$) compared to CB (small, ES: 0.58) and CM (small, ES: 0.54). Central Backs had moderate fewer $DC1$ ($n\cdot\text{min}^{-1}$) (ES: 0.60–0.83). The relative distance ($\text{m}\cdot\text{min}^{-1}$) covered in average for all positions was 95.53 ± 9.99 , being CM who covered the highest distance (small to very large, ES: 0.49–1.98) and CB the lowest (large to very large, ES: 1.40–1.98). High speed distance average ($>15 \text{ km}\cdot\text{h}^{-1}$) was $7.44 \pm 2.84 \text{ m}\cdot\text{min}^{-1}$. ES for high-speed distance was moderate for WB compared to CB (ES: 0.84). **Discussion:** There are differences in kinematic demands, including accelerations and decelerations between player positions, which is relevant information when monitoring training and match loads and designing specific training exercises. **References:** [1] Vanrenterghem, J, Nedergaard, NJ, Robinson, MA, and Drust, B. Training Load Monitoring in Team Sports: A Novel Framework Separating Physiological and Biomechanical Load-Adaptation Pathways. *Sport Med* 47: 2135–42, 2017. [2] Datson, N, Hulton, A, Andersson, H, Lewis, T, Weston, M, Drust, B, et al. Applied physiology of female soccer: an update. *Sport Med* 44: 1225–40, 2014. [3] Vescovi, JD and Favero, TG. Motion Characteristics of Women's College Soccer Matches: Female Athletes in Motion (FAIM) Study. *Int J Sports Physiol Perform* 9(3, SI): 405–14, 2014. **Mail to:** bromero@ucjc.edu.

EFFECT OF PHOTOBIMODULATION ON MUSCULAR RECOVERY IN RUNNERS

ROS-CASTELLO P. AND LLANA BELLOCH S.

University of Valencia, Spain

Introduction: Photobiomodulation, also known as Low-Level Light Therapy (LLLT) [1, 2], is a relatively new technique that is being used recently to stimulate recovery in sport and physical exercise settings [3, 4]. A wide variety of studies have tested the effectiveness of this new technique with very different methods and results. Our aim is to test the effectiveness of a new tight's prototype with LEDs that administers different photobiomodulation treatments on 10 runners. **Methods:** An experimental design was made in which all the 10 participants (healthy males, minimum of 5 years as runners, 28.58 ± 3.51 year old, height 1.754 ± 0.053 meters, weight 72.88 ± 6.93 kilograms) received 5 different treatments (4 photobiomodulation + 1 placebo) in a randomized order. For assessing the effectiveness of the treatment the countermovement jump test (CMJ) was used (best of 3 jumps). The treatment protocol started with a first CMJ test, then the participant received 20 minutes of treatment and after the treatment run for 40 minutes at a speed below anaerobic threshold. After the run another CMJ test and 20 minutes of treatment and another CMJ test. Then the participant rested for 24 hours and then was assessed with another CMJ test. All participants all participants engaged in this study voluntarily complying with the Declaration of Helsinki, and with the agreement of the University of Valencia Ethic's Committee. The data of the variables studied (flying time, kinetic height, kinematic height, power, take off velocity, force and mechanic impulse) was analyzed with a mixed model MANOVA. **Results:** Multivariate comparisons showed a significant effect of the measure's moment on dependent variables ($F_{21,28} = 10.86$; $p < 0.001$). However, significant effect was not found by the type of treatment applied on the dependent variables ($p > 0.05$). Interaction effect between the type of treatment and the measure's moment on the dependent variables was neither observed. Univariate comparisons showed that the measure's moment effect was on all dependent variables: flying time ($F_{3,135} = 67.69$; $p < 0.001$), kinetic height ($F_{3,135} = 13.37$; $p < 0.001$), kinematic height ($F_{3,135} = 71.65$; $p < 0.001$), power ($F_{3,135} = 132.54$; $p < 0.001$), take off velocity ($F_{3,135} = 58.02$; $p < 0.001$), force ($F_{3,135} = 20.59$; $p < 0.001$) and mechanic impulse ($F_{3,135} = 12.22$; $p < 0.001$). **Discussion:** Our results contradict other studies that have been made [5, 6]. Even though, other authors did not find significant effect of photobiomodulation treatments like us [7, 8]. Probably analyzing

blood metabolic markers we could have found different results, and that was one of the present study's limitations.

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PULSE-OXIMETRY IS A VALID TOOL FOR DETERMINING ARTERIAL OCCLUSION PRESSURE

SANTIAGO-PESCADOR S.,¹ SANTOS-LOZANO A.,¹ BALADRÓN C.,¹ ARRARÁS A.,¹ DÍAZ-MARTÍNEZ G.,¹ LUCÍA A.,² AND MARTÍN-HERNÁNDEZ J.¹

¹*i+HeALTH Research Group, European University Miguel de Cervantes, Valladolid, Spain; and* ²*Faculty of Sport Sciences, Universidad Europea de Madrid, Spain*

Introduction: According to general periodization principles, programming a blood flow restriction training (BFRT) session requires adjustment of every single variable potentially influencing the acute and the subsequent long-term response to repeated interventions. Specifically, the externally applied pressure provided by compressive cuffs mediates the actual reduc-

tion of blood flow, which in turn is known to influence the acute physiologic response to exercise [1], the rate of perceived exertion [2] and eventually, cardiovascular safety. Recent and past evidence indicate that the actual reduction of blood flow is primarily dependent not only on tourniquet width and pressure [3], but also on limb perimeter [4]. Therefore, the pressure needed to completely occlude blood flow in an individual is unique for a given tourniquet. This pressure is usually referred to as arterial occlusion pressure (AOP) and its magnitude (i.e., %AOP) is currently being used as an estimate of the reduction of deep blood flow. AOP can be directly measured through Doppler ultrasound (DU) or otherwise estimated through regression equations, limited to certain tourniquet widths [4]. The purpose of this study was to determine whether a commercially available pulse-oximeter (POx) is sensitive enough to determine AOP as compared to DU. **Methods:** Thirty-eight participants volunteered for the study. AOP was calculated as previously described by Loenneke and colleagues [4]. Briefly, following 10 minutes of supine rest a 9 cm wide pressure cuff was placed around the most proximal end of the right arm. Pressure was progressively inflated with 30 mm Hg increments until pulse was no longer detected. Cut-off points were simultaneously assessed by DU in the radial artery and POx in the third finger and were registered as 30 mm Hg-sensitivity AOP. Pressure cuff was progressively deflated with –10 mm Hg decrements until pulse reappearance. These values were registered as 10mm Hg-sensitivity AOP for each device. **Results:** No significant differences were found between the AOP defined by the POx or DU (149 ± 17 mm Hg vs. 150 ± 16 mm Hg, $p = 0.160$). Agreement analysis to assess the sensitivity, the specificity and the area under the Receiver Operating Characteristic (ROC) curve for the POx using the DU as reference showed values of 95, 86 and 0.97% (95% CI: 0.93–1.00), respectively, to determine AOP. Also, the Bland & Altman analysis revealed a BIAS between methods of -1.43 ± 6.47 (95% CI: -14.10 to 11.25) without heterogeneity ($R^2 = 0.018$; $p = 0.403$). **Discussion:** POx and DU showed high levels of agreement, with no significant differences between values of AOP calculated by either method. However, POx tended to slightly underestimate AOP, presumably due to a lower sensitivity of a low-cost photoplethysmography as compared to a professional DU unit (15€ vs. 25,000€). In summary, our results show that the POx could be a viable alternative to DU as well as to the use of regression equations to calculate AOP irrespectively of the tourniquet characteristics. **References:** [1] Loenneke, JP, Kim, D, Fahs, CA, Thiebaud, RS, Abe, T, Larson, RD, Bembem, DA, and Bembem, MG. Effects of exercise with and without different degrees of blood flow restriction on torque and muscle activation. *Muscle Nerve* 51: 713–21, 2015. [2] Loenneke, JP, Kim, D, Fahs, CA, Thiebaud, RS, Abe, T, Larson, RD, Bembem, DA, and Bembem, MG. The effects

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IMPACT OF WHOLE-BODY ELECTROMYOSTIMULATION ON PHYSICAL PERFORMANCE IN A SINGLE STRENGTH TRAINING SESIÓN

TOBÍA DEL BUSTO D., FERNÁNDEZ ELÍAS V.E., RECAREY RODRÍGUEZ A.E., CLEMENTE SUÁREZ V., FERNÁNDEZ A., AND BURGOS POSTIGO S.

Physical Activity and Sports, Universidad Europea de Madrid, Madrid, Spain

Introduction: We evaluated the acute effect of whole-body electromyostimulation (WB-EMS) after dynamic maximum strength exercise on jumping performance (Squat jump, countermovement jump and Abalakov jump tests), handgrip maximal isometric strength, and punching frequency motor skill for 5 seconds.

Methods: Twenty healthy, physically active participants (10 men and 10 women) with strength training experience of 3–5 d·wk⁻¹ during, at least, the last 2 years, enrolled in the study. They first performed a familiarization trial with the WB-EMS device and a 1RM test based on mean propulsive velocity analysis for bench press and full-squat to establish their exercise load (90%1RM). Then, subjects performed 3 maximal strength sessions, in a randomized way, consisting of 5 sets of 5 repetitions with 3 minutes of rest between sets of bench press and full-squat using different protocols: WB-EMS with continuous stimulus (85 Hz, 250/350 μs; Cont-EMS), WB-EMS with stimulus coordinate with the movement concentric phase (85 Hz, 250/350 μs, 1 second strain to 2 seconds rest; Coord-EMS) and a session without WB-EMS (No-EMS). **Results:** Squat jump and countermovement jump tests did not show significant changes after exercise in any of the trials (mean 0.01 ± 0.03 m for both SQJ and CMJ). Abalakov jump test was similar after Cont-EMS (0.43 ± 0.10 to 0.44 ± 0.10 m) and No-EMS (0.43 ± 0.08 to 0.44 ± 0.09 m) and showed a significant increased only after Coord-EMS (0.43 ± 0.08 to 0.45 ± 0.10 m; $p < 0.05$) with no significant differences between trials. Handgrip isometric strength was similar after Cont-EMS (39.3 ± 11.0 to 39.6 ± 10.7 Kg) and Coord-EMS (40.0 ±

11.2 to 40.3 ± 11.0 Kg) and significantly increased after No-EMS trial (38.4 ± 10.4 to 40.3 ± 10.6 Kg; $p < 0.05$) with no significant differences between trials. Finally, punching frequency motor skill for 5 seconds did not show significant changes after any of the maximum strength training sessions (mean -0.43 ± 4.01 punches). **Discussion:** According to these data, for healthy, physically active and with strength training experience subjects, the use of WB-EMS devices, with continuous or coordinate with the muscle contraction stimulus protocol has a similar impact than a regular training on physical performance on jumping ability, maximal isometric strength, and motor skill ability. This study was partially supported by Myofx. Authors declare no conflict of interests. **References:** [1] Filipovic, A, et al. *J Sports Sci Med* 15: 639–648, 2016. [2] Herrero, AJ, et al. *Rev Andal Med Dep* 8: 155–162, 2015. [3] Kemmler, W, et al. *J Strength Cond Res* 24: 1880–7, 2010. **Mail to:** davidtobiadelbusto@gmail.com.

HIGH-INTENSITY INTERVAL TRAINING: MONITORING AND EFFECT BETWEEN GENDERS

BENTO A. AND LOUREIRO V.

Instituto Politécnico de Beja, Portugal

Introduction: Specialized literature provides compelling evidence attesting the efficiency of HIIT. However, it is important to identify gender-specific differences to provide suitable intensity levels, in order to maximize results and minimize the likelihood of injuries. This study aims to assess HIIT effect at the body mass and cardiorespiratory level as well as its volitional intensity, prescribed according to a progressive maximal effort test. **Methods:** Eleven women (35.4 ± 8.3 years) and 9 men (36.6 ± 8.0 years), all HIIT practitioners, underwent a 3 times a week exercise plan, for 4 weeks, comprised of 4 series of 7 holistic calisthenic exercises (4 × 7 × 30" with 15" pause among them), with 45" pause. **Results:** Concerning volitional intensity, only women followed the protocol with significant statistical differences if compared with men ($p = 0.017$). These results are corroborated by the percentage increase in average heart rate, which was 87.6 ± 2.7 for female and 83.4 ± 3.0 % maxHR for male subjects ($p = 0.004$). Only women improved their aerobic aptitude capacity, increasing 2.51 ± 1.99 ml·kg⁻¹·min⁻¹ ($p = 0.002$) their relative $\dot{V}O_{2\max}$, and 150.0 ± 146.6 ml·min⁻¹ ($z = -2,491$ $p = 0.005$) absolute $\dot{V}O_{2\max}$. Medium weight loss was 0.485 ± 1.19 kg, close to significance ($p = 0.084$). However, only males showed a statistically significant drop in weight (-0.70 ± 0.89 kg; $p = 0.046$). **Conclusion:** The effect of HIIT was different between genders. These findings show a polarized difference concerning

the 2 main variables of this study: women improve their aerobic capacity while men lose more weight. They also present differences in their volitional intensity, given that only women were able to follow the protocol with the expected intensities. **Mail to:** andre.bento@IPBeja.pt.

EFFECTS OF DIFFERENT SET STRUCTURES ON RPE, VELOCITY AND POWER DECREMENT DURING A BACK SQUAT EXERCISE

Jukić I.,¹ Young M.,² and Tufano J.J.³

¹Faculty of Kinesiology, University of Zagreb/Athletic Lab, Sport Performance Training Centre, Cary, North Carolina;

²Athletic Lab, Sport Performance Training Centre, Cary, North Carolina; and ³Department of Physiology and Biochemistry, Faculty of Physical Education and Sport, Charles University, Prague, Czech Republic

Introduction: Traditionally, repetitions in each set are performed in sequence with no rest between repetitions and therefore has been defined as traditional set structure (TS). When using this structure, concentric velocity decreases as the number of repetitions increases because of muscular fatigue. In addition, power output and velocity likely decrease when TS are extensively used without sufficient replenishment of ATP and PCr. One potential strategy to overcome this problem is to implement rest redistribution (RR) protocols which consist of more frequent rest periods compared to TS. However, it remains unclear whether higher frequency rest redistribution protocols (HFRR) could yield even more benefits. The purpose of this study was to compare the influence of TS, RR and HFRR set structures on RPE, velocity and power decrement during a high volume back squat session where the total time, number of repetitions, and load were equal across structure protocols. **Methods:** Twenty-six strength-trained males (age 28 ± 5.44 , body mass 84.6 ± 10.5 kg, 1RM-to-body-mass ratio 1.82 ± 0.33) reported to the lab 4 times to perform 1RM testing and 3 experimental sessions with their respective protocols. Each protocol was performed with 70% of participants' predetermined 1RM. TS consisted of 3 sets of 10 with 240 seconds rest, RR consisted of 5 sets of 6 with 120 seconds of rest, while HFRR employed 10 sets of 3 repetitions with 60 seconds of rest. This ensured equivalent volume, intensity and total training time across protocols. The order of each protocol was randomized. Velocity and power measures were recorded with PUSH band (PUSH Inc., Toronto, Canada) while CR-10 scale was used to evaluate RPE scores. Effect sizes (d) were calculated to examine the magnitude of difference in velocity and power decrement across the 30 reps between protocols. Effect sizes were also calculated between the protocols to reveal differences in RPE

scores. Only moderate ($0.5-0.79$) and large (<0.8) effect sizes are reported. **Results:** Moderate differences ($d = 0.59$) between HFRR and RR in velocity decrement were observed as well as large differences between HFRR and TS ($d = 0.8$). In addition, moderate effects were observed between HFRR and RR ($d = 0.56$) and between HFRR and TS ($d = 0.59$). Regarding RPE, there were large ($d = 0.88$) effects between HFRR and RR with very large effects ($d = 1.99$) between HFRR and TS. Large effects ($d = 0.93$) were also observed between TS and RR. **Discussion:** With the higher RPE scores and decreases in velocity and power observed in TS and RR, HFRR appears to be a more appropriate protocol when the goal is to maximize velocity and power and reduce RPE scores of an athlete. Coaches should be aware of potential velocity/power decrement and higher RPE scores associated not only with TS, but to a lesser extent with RR. Therefore, shorter but more frequent rest periods should be utilized to ensure maximum training adaptations while keeping total training time the same. **References:** [1] Haff, GG, Hobbs, RT, Haff, EE, Sands, WA, Pierce, KC, and Stone, MH. Cluster training: A novel method for introducing training program variation. *Strength Cond J* 30: 67-76, 2008. [2] Tufano, JJ, Brown, LE, and Haff, GG. Theoretical and practical aspects of different cluster set structures: a systematic review. *J Strength Cond Res* 31: 848-867, 2017. **Mail to:** ivan.jukic@athleticlab.com.

EFFECTS OF LOW-VOLUME AND HIGH-SPEED STRENGTH TRAINING ON PHYSICAL PERFORMANCE IN HIGH-LEVEL 800 METERS ATHLETES

BACHERO-MENA B.,¹ PAREJA-BLANCO F.,² LEÓN-PRADOS J.A.,² AND GONZÁLEZ-BADILLO J.J.²

¹Departamento de Educación Física y Deporte, Universidad de Sevilla, Spain; and ²Universidad Pablo de Olavide, Spain

Introduction: Traditionally, athletes involved in endurance running events have performed little strength training to improve performance. However, the demonstrated benefits of strength training in long and middle endurance performance have led to a growing interest in assessing muscle strength in middle and long-distance athletes [1, 2, 3]. The aim of this study, therefore, was to analyze the effects of a 14-week high-speed strength training program on physical performance and hormonal response in high-level 800 m athletes. **Methods:** Thirteen male athletes (800 m personal best: 1:43-1:58 min:s) were divided into 2 groups: one group ($n = 6$) followed a 14-week high-speed strength training (STG), whereas a control group ($n = 7$) followed a strength-endurance training (CG). Two tests (T1 and T2) including sprint, 800 m running, strength exercises, and blood hormones samples were carried

out. The strength-training program of STG consisted in full squats (SQ), jump squat (JS), countermovement jump (CMJ), resisted sprints, and step phase of triple jump, with a frequency of 2 sessions per week. The relative intensity of the squat exercise progressively increased from 45 to 55% 1RM. Training volume was always low (2–3 sets and 4–6 repetitions per set) and each repetition was performed at maximal intended velocity. **Results:** Both groups significantly improved performance in 800 m ($p < 0.01$), however, STG showed an additional improvement in 200 m ($p < 0.05$), countermovement jump ($p < 0.01$), and squat-strength ($p < 0.05$), whereas CG did not reach significant improvements in any of the strength variables analyzed. Concerning hormones, only STG showed a significant ($p < 0.05$) decrease in IGF-1 from T1 to T2. In addition, CG showed a likely increase in cortisol from T1 to T2. **Discussion:** In conclusion, a high-speed and low volume strength-training program performed during 14 weeks resulted in meaningful gains in running and strength-related variables, accompanied by little or no changes in the hormonal response. These results suggest the positive effects that a strength training program with these characteristics could have in 800 m performance, especially in 800 m races where the result is decided in the final sprint, which reflects the importance of strength levels in middle-distance athletes. **References:** [1] Aagaard, P and Andersen, JL. Effects of strength training on endurance capacity in top level endurance athletes. *Scand J Med Sci Sports* 20: 39–47, 2010. [2] Beattie, K, Kenny, IC, Lyons, M, and Carson, BP. The Effect of Strength Training on Performance in Endurance Athletes. *Sports Med* 44: 845–865, 2014. [3] Taipale, RS, Mikkola, J, Salo, T, Hokka, L, Vesterinen, V, Kraemer, WJ, Nummela, A, and Häkkinen, K. Mixed maximal and explosive strength training in recreational endurance runners. *J Strength Cond Res* 28: 689–699, 2014. **Mail to:** beatriz.bachero@hotmail.com.

ANALYSIS OF THE FREQUENCY OF CONSUMPTION OF NUTRITIONAL SUPPLEMENTS IN INTERNATIONAL ATHLETES OF DIFFERENT SPORTS

ORELLANA-RICO E.,¹ SÁNCHEZ-OLIVER A.J.,² JODRA P.,¹ MATA-ORDÓÑEZ F.,³ LÓPEZ-SAMANES A.,⁴ AND DOMÍNGUEZ R.⁴

¹Universidad Alfonso X el Sabio, Madrid, Spain;

²Universidad Pablo Olavide, Sevilla, España y Universidad de Sevilla, Sevilla, Spain; ³NutriScience, Córdoba, Spain; and

⁴Universidad Francisco de Vitoria, Madrid, Spain

Introduction: Nutritional supplements (NS) are normally used by elite and non-elite participants of different sports modalities [1]. In order to categorize the NS, the Australian Institute of

Sport (AIS) [2] has made a classification of the supplements (sports food, medical supplementation and ergogenic aids) based on the level of scientific evidence (A, B, C and D). The aim of this study was to analyze the frequency of NS consumption in elite athletes from different sports disciplines such as powerlifting, bodybuilding, fencing and squash. **Methods:** Forty-four international athletes from different sports: powerlifting ($n = 10$), bodybuilding ($n = 11$), fencing ($n = 12$) and squash ($n = 11$) completed a validated NS intake questionnaire [3]. To analyze the differences in NS consumption, an ANOVA was performed on the variable of total number of NS consumed, as well as number of SN consumed belonging to the categories and level of evidence of the AIS. After checking homoscedasticity, using a Levene statistic, Bonferroni post-hoc was applied. The level of statistical significance was set at $p < 0.05$. **Results:** Statistical differences were found in the number of NS consumed ($p < 0.001$), powerlifters vs. fencers (14.5 + 9.7 vs. 4.3 + 2.5, $p = 0.007$) and bodybuilders (19.7 + 6.3 NS) having greater consumption with respect to the fencers. ($p < 0.001$) and squash players (8.5 + 7.3, $p = 0.002$). In the subcategories it was observed that, with the exception of sport food ($p = 0.130$), there were differences between sports modalities ($p < 0.05$). In this way, bodybuilders had a higher consumption of medical supplement vs. fencers (3.9 + 1.4 vs. 0.8 + 1.0, $p = 0.001$). In group A there were differences between powerlifter and fencers (2.1 + 0.9 vs. 0.5 + 0.8, $p = 0.001$) and bodybuilders (2.5 + 0.8) with respect to fencers (0.5 + 0.8, $p < 0.001$) and squash players (0.8 + 1.0, $p < 0.001$). In group C, differences were observed in powerlifter vs. fencers (2.6 + 2.6 vs. 0.3 + 0.5, $p = 0.049$) and bodybuilders (4.5 + 2.6) with fencers (0.3 + 0.5, $p < 0.001$) and squash players (1.3 + 1.5, $p = 0.002$). On the other hand, group B showed differences between powerlifter and fencers (2.6 + 1.8 vs. 0.5 + 0.7, $p = 0.007$) and bodybuilders and fencers (3.7 + 1.1 vs. 0.5 + 0.7, $p < 0.001$). In group D, differences were observed between bodybuilders (2.0 + 1.3) and fencers (0.0 + 0.0, $p < 0.001$) and squash players (0.1 + 0.3, $p = 0.001$). **Discussion:** Our results confirm that the NS consumption is in a wide margin according to the sport modality [1], being more frequent the NS consumption in athletes of international level of force modalities (e.g., powerlifting and bodybuilding) with respect to sports such as fencing and squash. **References:** [1]. Australian sports commission, A.I.S. Classification:AIS:Australian Sports Commission. [Online]. Available at: <http://www.ausport.gov.au/ais/nutrition/supplements/classification>. Accessed: March 23, 2018. [2] Knapik, J, Steelman, R, Hoedebecke, S, Austin, K, Farina, E, and Lieberman, H. Prevalence of Dietary Supplement Use by Athletes: Systematic Review and Meta-Analysis. *Sports Med* 46: 103–123, 2016. [3] Sánchez-Oliver, A.

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MOBILITY TEST TO IDENTIFY FALLERS UNDER HIGH PHYSICAL FITNESS IN OLDER COMMUNITY-LIVING WOMEN

GARRUES M.A.,¹ ARAOLAZA M.,¹ LABORDA F.J.,² SANTISTEBAN L.,¹ VALDIVIESO P.,¹ DELGADO S.,¹ AND BENGOCHEA A.M.³

¹University of the Basque Country (UPV-EHU), Spain; ²Bilbao Musika, Spain; and ³Université libre de Bruxelles (ULB), Belgium

Introduction: The holistic definition of human physical fitness represents the adaptability to cope with various situations. Falls are common adverse events among older populations [1] and functional performance (balance, strength, and gait) predicts falls [3] and injurious falls [4]. Exercise improves functional performance and can prevent falls as well [2]. The aim of this preliminary study was to explore the comparative ability of standardized mobility tests to identify a previous faller under a high physical performance status. **Methods:** The study was carried out with physically active independent community-living women ($n = 44$, 60–72.49 years). Falls were collected retrospectively for the previous year, and functional performance was assessed with the timed up and go test (TU&G), the 5 repetitions sit to stand test (5-STST), and maximum gait velocity (MGV) was determined with GAITRite. **Results:** Only 18.02% of these active older women reported a fall in the previous year. When dichotomized using cut-off points from receiver-operating characteristic (ROC) curve analyses, a lowered time to perform the TU&G demonstrated reasonable ($p = 0.021$) sensitivity (0.75) and specificity (0.78) in identifying the previous faller. The OR for not being a faller was 10.53 ($p = 0.01$) for the participants that did more than 4.49 seconds in the TU&G. The predictive probability of identifying a previous faller increased when the participant sustained high performances in 2 of the mobility tests compared with the timed up and go test alone. **Conclusions:** High functional status decreases the rate of falls in older women [4]. As falls in older populations are multifactorial, fall risk assessment requires a multifactorial and multicomponent exam. Under high physical fitness and cognitive status and a lowered concern about falls, tailored interventions might focus attention not only in functional performance, but in other factors like risk-taking management during activities performed in daily life. **References:** [1] Rubenstein, LZ. Falls in

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REPRODUCIBILITY AND SENSITIVITY OF SPRINT AND AGILITY TESTS IN YOUNG HANDBALL PLAYERS

NASRI H.,¹ JABRI M.,¹ GUELMAMI N.,² AND BOUASSIDA A.²

¹Faculté des sciences de Bizerte, Université Carthage, Tunis, Tunisia; and ²Research Unit, Sportive Performance and Physical Rehabilitation, High Institute of Sports and Physical Education, Kef, University of Jendouba, Jendouba, Tunisia

Introduction: Literature data demonstrate that there are no standard tests for young handball players that seem close to the nature of handball patterns and can be used for the evaluation of specific motor skills [1]. Thus, the aim of this study was to identify the statistical characteristics of a battery of physical tests including sprint tests, change of direction and agility tests, usually employed in other team sports, on a population of young handball players (U13). **Methods:** Thirty male handball players (age 11.4 ± 0.7 years; height 147.0 ± 8.1 cm; weight 36.7 ± 6.7 kg and body mass index [BMI] 16.9 ± 2.4) participated during 11 days to 3 linear speed tests (5, 10 and 20 m), 2 change of direction tests (CODAT), a repeated speed test (20 m RSA), a repeated change of direction speed test (RCOD 100°) and 2 agility tests (T test and Illinois test). Absolute and relative reproducibility as well as the sensitivity of the various tests were examined statistically. Coefficient of variation (CV), Bland and Altman, Intra-class coefficient (ICC) smallest worthwhile and typical error were calculated for all tests. **Results:** The 10 m (ICC = 0.95, CV% = 1.97), 20 m (ICC = 0.9, CV% = 2.38), CODAT (ICC = 0.96, CV% = 2.09), T test (ICC = 0.9, CV% = 2.54) and Illinois (ICC = 0.92, CV% = 3.35) tests showed good absolute and relative reproducibility as well as good sensitivity. For the 5 m test, the results showed low absolute and relative reproducibility and average sensitivity (ICC = 0.74, CV% = 4.34). The CODAT results show good relative reproducibility,

good absolute reproducibility, and low sensitivity (ICC = 0.96, CV % = 2.09). The 100° RCOD test (ICC = 0.62, CV% = 42.38). The 20 m RSA test, a relative reproducibility index and a low sensitivity level, (ICC = 0.43, CV% = 43.56). **Discussion:** Statistics showed that 10, 20 m, CODAT, CODS 90, Illinois test and T test were reproducible and sensitive for the U13 handball players. Only the 5 m-sprint test is considered unreliable for this population. Also, the results showed that both the RCOD and RSA tests were not reproducible and sensitive for these players. This study provides results concerning physical performances (e.g., sprint and agility) in young handball players, which may help coaches to better assess and evaluate fitness performances. Moreover, these finding may help the talent identification process of young handball players. **Reference:** [1] Visnapuu, M and Jürimäe, T. Relations of anthropometric parameters with scores on basic and specific tasks in young handball players. *Percept Mot Skills* 108: 670–676, 2009. **Mail to:** nasrihoussemm@yahoo.com.

ENERGY EXPENDITURE AND DIFFERENT TIMES OF PHYSICAL ACTIVITY DURING GYMNASTIC TRAINING IN FEMALE ARTISTIC GYMNASTIC DURING PRECOMPETITIVE PERIOD

SALDAÑA ÁLVAREZ E.C., GARRIDO PASTOR G., AND ELEZ J.

Faculty of Physical Activity and Sport Sciences-INEF, Universidad Politécnica de Madrid, Spain

Introduction: Artistic gymnastic routines are composed of numerous skills that vary in difficulty and intensity. Elite level gymnastics train 6 days per week, for 5–8 hours each day (Benardot, 2000). The aims of this study were: to describe the anthropometry changes along 4 months at the precompetitive period; to determine the fragmentation of time expended at different physical activities during usual gymnastic training; to ascertain which types of physical activities are the most determining for the energy expenditure (EE). Artistic gymnast, Anthropometry, accelerometer: **Methods:** The study included 15 female artistic gymnasts from the current Female Spanish Artistic Gymnastic National Selection (age = 16.9 ± 1.8 year; height = 156.2 ± 5.7 cm; weight = 47.8 ± 5.0 Kg; training volume = 22.7 ± 15.1 h·wk⁻¹). They were assessed for nutritional status and EE during the same precompetitive period. Diet composition was estimated during 6 days by food weighing (Mettler-Toledo Scale accuracy ± 1 g) using for analysis the software Dial Alce. EE was estimated during 6 days using SenseWear Armband (SWA) accelerometers (Sense Wear Pro2 Armband, Bodymedia Inc, Pittsburgh, PA, USA). Body composition was estimated twice (at begin and 4 months later) by

anthropometry using an anthropometry kit (Holtain skinfold, Tape and Caliper Cescorf) according to the ISAK protocol. While hand grip strength (HG) of both hands was also measured in 2 same occasions (at the begin and 4 months later) using the Dynamometer Smedley III T19D. **Results:** Daily mean physical activity time was: light activity (LPAT) (6 hours 5 minutes ± 2 hours 52 minutes), moderate activity (MPAT) (4 hours 4 minutes ± 50 minutes), intense activity (IPAT) (36 minutes 54 seconds ± 18 minutes 36 seconds) and very intense (VIPAT) (4 minutes 2 seconds ± 3 minutes 36 seconds). Mean energy intake (EI) (2,070 ± 377 kcal·d⁻¹) was lower ($p = 0.191$) than EE (2,471 ± 271 kcal·d⁻¹). Active EE energy expenditure (1,106 ± 230 kcal·d⁻¹) was only correlated to MPAT ($p = 0.036$) and to IPAT ($p = 0.002$). Whereas the LPAT was related to total EE ($p = 0.043$) and to EI ($p = 0.035$). However, only the maximum EE energy expenditure was related to carbohydrate intake ($p = 0.016$). We found also a correlation between protein intake (g/d) and the percentage of lean body mass ($p = 0.027$). During these 4 month period we found an increase in wWaist hHip rRatio ($p = 0.016$), lean body mass ($p = 0.009$), body weight ($p = 0.004$) and height ($p = 0.035$). However, the HG hand grip tests had no significant difference along this period. **Discussion:** We found that the gymnasts completed a training time that has been suggested previous for elite team gymnasts (Benardot, 2000). We observed anthropometrical changes that are common for their pubertal age despite reducing their energy consumption EI. LPAT was the most determining factor for both values EE and EI. **Mail to:** emmy_sal@hotmail.com.

RELATIONSHIP BETWEEN PHYSICAL PERFORMANCE AND DEFENSIVE EFFICACY IN 1 × 1 SITUATIONS IN PROFESSIONAL BASKETBALL

DE PEDRO MÚÑEZ A. AND GARCÍA GARCÍA O.

Universidad de Vigo, Spain

Introduction: Basketball is a sport in which neuromuscular characteristics can determine competition performance [1]. The aim of this research is to study the relationship between different physical capacity manifestations and defensive efficacy in 1 × 1 situations, in professional basketball players of LEB SILVER league. **Methods:** The study sample has been 160 1 × 1 defensive situations, extract from 12 players in 60 trainings and 4 games. The situations were classified in: “defense to a player with the ball who is attacking facing the basket” “defense to a player with the ball who is attacking back to the basket” “defense to an outside player without the ball” “defense to an inside player without the ball.” The observational

analysis was made by 4 basketball coaches with experience and trained in observational studies following the protocol of [2]. A spreadsheet conformed by criteria and categories specifically made for this research was used. The inter-observer agreement was obtained through Cohen's Kappa (0.846). To connect the variables about defensive efficacy and physical performance, chi squared was used ($p < 0.05$). **Results:** We found a relationship between SJ and "ability to react to offense movements" ($X^2 = 22.44$; Cramer's $V = 0.412$; contingency coefficient = 0.581; $p < 0.05$) in "defense to an outside player without the ball" criteria. About "defense to a player with the ball who is attacking facing the basket" criteria, a relationship between maximum left single leg strength and "ability to change of direction" was found ($X^2 = 28.76$; Cramer's $V = 0.452$; contingency coefficient = 0.616; $p < 0.05$). Finally, in "defense to a player with the ball who is attacking back to the basket" criteria, there was a relationship between SJ and "dissociation ability" ($X^2 = 9.6$; Cramer's $V = 0.800$; contingency coefficient = 0.625; $p < 0.05$). **Discussion:** We were able to build an observational instrument which showed to be useful to analyse the 1×1 defensive efficacy in basketball. The main findings show that SJ and single leg maximum strength were related with the efficacy in several 1×1 defensive situations in professional basketball players of LEB SILVER league, for that reason it seems appropriate to keep researching about the influence the physical performance might have on these defensive situations. **References:** [1] Hellin, MD, Del Campo, VL, Navarrete, JSG, Gómez-Valades, JM, Murillo, DB, and Solana, RS. Differences in isometric strength tests and jump tests between professional and amateur basketball players. *Cultura Ciencia Deporte* 9-26: 155–162, 2014. [2] Anguera Argilaga, MaT, Blanco Villaseñor, and Losada López, JL. Diseños observacionales, cuestión clave en el proceso de la Metodología Observacional. *Metodología De Las Ciencias Del Comportamiento* 3-2: 135–160, 2001. **Mail to:** alvarodpedro@gmail.com.

BASKETBALL WARM-UP STRATEGY: EXPLORATORY STUDY IN U-16 NATIONAL TEAM

AREDE J.,¹ FERREIRA A.P.,² AND LEITE N.¹

¹Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, University of Trás-os-Montes and Alto Douro, Portugal; and ²Faculty of Human Kinetics, University of Lisbon, Lisbon, Portugal

Introduction: A well-designed warm-up could elicit adequate physical and mental preparation, performance

improvements and decrease of risk of injury. However, investigation of warm-up strategies workload is sparse. The purpose of this study was to assess reliability of external and internal measures of on-field warm-up strategy in youth basketball players. **Methods:** Ten under-16 national team basketball players participated in 8 minutes warm-up in 4 non-consecutive sessions for 2 weeks. Warm-up consisted in (a) General Activation (Running Ahead) (b) Running (10 exercises/sets), (c) Dynamic Stretch/Strength (6 exercises/sets; 26 repetitions), (d) Core Stability (5 exercises/sets), (e) Plyometrics/Dynamic Balance (4 exercises/sets) and (f) Sprinting (5 exercises/6 sets). Workload data were collected via GPS technology, sampled at 15 Hz (SPI-Pro X II, GPSports, Australia), and housed tri-axial accelerometer (100 Hz). External workload consisted of (a) Player Load (AU), (b) Total Body Impacts (AU), (c) Very light impact (5.0–6.0 g), (d) Light to moderate impact (6.1–6.5 g), (e) Moderate to heavy impact (6.5–7.0 g), (f) Heavy impact (7.1–8.0 g), (g) Very Heavy impact (8.1–10 g) and (i) Severe impact (>10.1 g). Internal workload consisted of (a) Borg's 15-point scale (RPE), (b) Edwards' training load (AU), (c) Stagno's training impulse (AU), (d) Low Heart Rate Zone (HRZ) (<75% of HR_{máx}), (e) Moderate HRZ (75–84% of HR_{máx}) and (f) High HRZ (85–95% of HR_{máx}). Typical error (TE) with upper and lower confidence limits, coefficient of variation (CV) and intraclass correlation coefficient (ICC) were calculated using the published spreadsheet with the 95% confidence limit. **Results:** The RPE ranged between "somewhat hard" and "hard" (14.1 ± 1.9), high percentage of time was spent in Low HRZ (86.6 \pm 13.7%) and mainly occurred Very light impacts (35.4 ± 15.2). Almost Perfect agreement was found for RPE, and Low and High HRZ (ICC range = 0.81–0.88). Substantial agreement was found for Total Body Impacts, Very Light Impacts, Stagno's training impulses, Low and Moderate HRZ (ICC range = 0.62–0.78). **Discussion:** Current strategy seems to respect all key aspects of RAMP protocol (1) and elicit progressive and wide range of internal and external workload. More studies are necessary to understand external workload and effects in physical performance of this warm-up strategy. **References:** [1] Jeffreys, I. Warm-Up and Flexibility Training. In: Essentials of strength training and conditioning. Haff, G and Triplett, T, eds. Human Kinetics: 317–350, 2016. Financial support: This work was supported by a grant from the Foundation for Science and Technology (SFRH/BD/122259/2016) and by Project Symbiotic technology for societal efficiency gains: Deus ex Machina (DEM) (NORTE-01-0145-FEDER-000026). **Mail to:** jorge_arede@hotmail.com.

THE EFFECTS OF TWO DIFFERENT TYPES OF WARM-UP ON FITNESS TESTS

CAMPANA BONILLA M.V.,¹ AND
ALSOWAYAN M.N.²

¹Beijing Sport University, China; and ²King Saudi University
College of Sport Sciences & Physical Activity, Saudi Arabia

Introduction: The purpose of this study was to analyze the effects of specific warm-ups on physical conditioning in high school students. Passive and dynamic warm-ups have been studied, although research has shown that high-load dynamic warm-ups increase power and strength performance [3, 5], and can improve jumping, throwing, or sprinting results; thus, PE teachers and coaches should encourage specific warm-up methods before sports [1], physical activities, and physical fitness tests. **Methods:** The final group of 34 included 19 boys and 15 girls, with a mean \pm SD age of 15.44 ± 0.61 years, height 171.65 ± 7.53 , and weight 63.74 ± 17.79 kg. The experimental group included 4 boys and 10 girls, with 15 boys and 5 girls in the control group. Data was collected from a pretest, control test, and posttest. Students were evaluated in the 50-run and SLJ. The experimental group (EG) performed 8 weeks of 10-minutes dynamic warm-ups using ABC sprint drills [2] each student completed 2 sets of 3 repetitions in 30-m ABC sprint drills. The PE teacher guided correct technical execution. The control group (CG) performed 10 minutes of traditional PE warm-ups. After warm-up in PE class, the EG and CG continued with the teaching plan for PE class that included the following sports: table tennis (2 weeks); rugby (4 weeks); and track and field (3 weeks). **Results:** Standing Long Jump (SLJ) performance by girls was significantly improved using the DW protocol compared with that using the TW protocol ($p = 0.00016$). SLJ performance by girls in the last test was significantly better than performance in the first test ($p = 0.0001$). No significant differences were observed for SLJ performance by boys based on the means of DW and TW ($p = 0.765$). There were no significant differences in the 50-m run by both boys and girls between the 2 warm-up protocols ($p = 0.381$ and $p = 0.982$, respectively). **Discussion:** Our findings suggest that DW using basic sprint drills is more effective for muscular strength in girls than for power tests in boys; thus, data showed that sex did not necessarily influence SLJ performance. Thus, girls using DW showed significant differences compared with girls using TW; however, there were no significant differences using both protocols in boys. Our data showed that sprinting ability in boys improved by 0.05 seconds and jumping improved by 0.11 m girls, sprinting ability improved by 0.18 seconds and jumping improved by 0.20 m

following DW using ABC sprint drills. Samson et al. [4] reported that specific warm-ups using sprint activities increased performance, muscle temperature, and nerve conduction velocity, which are important physiological factors that help athletes improve their results in sprinting and jumping events. DW demonstrated improvement for power testing performance. The findings suggest that PE teachers can consider the effects of adequate warm-up conditions on fitness testing performance, especially when using a high-intensity warm-up. **References:** [1] Faigenbaum, AD, Mcfarland, JE, Kelly, NA, Ratamess, NA, Kang, J, and Hoffman JR. Influence of recovery time of warm-up effects in male adolescent athletes. *Pediatr Exerc Sci* 22: 266–277, 2010. [2] FEE, E. The Complete Guide to Running. Oxford: Meyer & Meyer Sport (UK) Ltd, 2005. [3] Mccrary, JM, Ackermann, BJ, and Halaki, M. A systematic review of the effects of upper body warm-up on performance and injury. *Br J Sports Med* 49: 935–942, 2015. [4] Samson, M, Button, DC, Chaouachi, A, and Behm, DG. Effects of dynamic and static stretching within general and activity specific warm-up protocols. *J Sports Sci Med* 11: 279–285, 2012. [5] Kar, S, and Banerjee, AK. Influence of active and passive warming up on motor performance of the athletes. *Int J Sports Sci Fitness* 3: 216–234, 2013. **Mail to:** ramones.12@live.com.

EFFECT OF WHOLE-BODY ELECTROMYOSTIMULATION ON CK, LACTATE, HR AND RPE DURING A SINGLE STRENGTH SESSION

RECAREY RODRÍGUEZ A.E., BURGOS POSTIGO S.,
TOBIA DEL BUSTO D., CLEMENTE-SUÁREZ V.J.,
FERNÁNDEZ A., FERNÁNDEZ ELÍAS V.E.

Physical Activity and Sports, Universidad Europea de Madrid, Madrid, Spain

Introduction: We evaluated the acute effect of whole-body electromyostimulation (WB-EMS) during and after dynamic maximum strength exercise on blood creatin kinase and lactate concentrations, heart rate and its variability, and rate of perceived exertion. **Methods:** Twenty healthy, physically active participants (10 men and 10 women) with strength training experience of $3\text{--}5 \text{ d}\cdot\text{wk}^{-1}$ during, at least, the last 2 years, enrolled in the study. They first performed a familiarization trial with the WB-EMS device and a 1RM test based on mean propulsive velocity analysis for bench press and full-squat to establish their exercise load (90% 1RM). Then, subjects performed 3 maximal strength sessions, in a randomized way, consisting of 5 sets of 5 repetitions with 3 minutes of

rest between sets of bench press and full-squat using different protocols: WB-EMS with continuous stimulus (85 Hz, 250/350 μ s; Cont-EMS), WB-EMS with stimulus coordinate with the movement concentric phase (85 Hz, 250/350 μ s, 1 second strain to 2 seconds rest; Coord-EMS) and a session without WB-EMS (No-EMS). **Results:** During the strength sessions, HR was similar in all set in both bench press (116 ± 20 b \cdot min $^{-1}$) and full squat exercises (132 ± 14 b \cdot min $^{-1}$). Also, RPE reported was similar in all sessions, being significantly greater in the last 2 sets (1-fold over 10; $p < 0.05$). After exercise, CK significantly increased in the 3 trials (19 ± 13 , 15 ± 14 and $30 \pm 23\%$ for Cont-EMS, Coord-EMS and No-EMS respectively; $p < 0.05$) being significantly greater only when comparing No-EMS with Cont-EMS (148.5 ± 145.0 vs. 99.0 ± 71.7 IU/L; $p < 0.05$). Lactate significantly increased in the 3 trials (1.7 ± 1.0 to 2.7 ± 1.7 mmol/L for Cont-EMS; 2.0 ± 0.9 to 2.9 ± 1.8 mmol/L for Coord-EMS; 1.7 ± 0.8 to 2.7 ± 1.1 mmol \cdot L $^{-1}$ for No-EMS; all $p < 0.05$), with no differences between trials. Further, HR variability (Square root of the mean value of all sum of squared differences of all R-Rs following intervals [RMSSD]; Low Frequency band [LF]; High Frequency band [HF]) did not change after trails. **Discussion:** According to these data, for healthy, physically active and with strength training experience subjects, the use of WB-EMS devices, with continuous or coordinate with the muscle contraction stimulus protocol, did not have a greater effect on the internal load of a maximum strength training session and thus, it may be an effective and secure training method. **References:** [1] Jee, YS. *J Exerc Rehabil* 14:49–57, 2018. [2] Herrero, A, et al. *Rev Andal Med Dep* 8:155–162, 2015. [3] Kemmler, W, et al. *J Strength Cond Res* 2010; 24:1880–7. **Mail to:** davidtobiadelbusto@gmail.com.

CORRELATION BETWEEN MUSCLE ACTIVATION AND MUSCLE SWELLING AFTER BLOOD FLOW RESTRICTION EXERCISE

PICÓN-MARTÍNEZ M.,¹ CHULVI-MEDRANO I.,¹
CORTELL-TORMO J.M.,¹ ALONSO-AUBIN D.,¹
ALAKHDAR Y.,² ALONSO-ROCA D.,² AND
LAURENTINO G.³

¹University of Alicante, Spain; ²University of Valencia, Spain; and ³University of São Paulo, Brazil

Introduction: Low-intensity resistance training with blood flow restriction (LI-BFR) has been an alternative strategy to high-intensity exercise (HI) to enhance strength and muscle

size. Moreover, similar levels of muscle activation have been previously reported between LI-BFR and HI resistance training [2]. However, it is unknown whether LI-BFR and HI-induced muscle activation impacts on muscle swelling. Therefore, the purpose of this study was to investigate the relationship between acute muscle activation and muscle swelling (muscle thickness) following a single bout of LI, LI-BFR and HI protocols. **Methods:** Fifty-two untrained men (27.3 ± 7 years; 177.6 ± 11 cm; 72.2 ± 13.7 kg) volunteered for this study were allocated into 3 groups: low-intensity exercise without (LI, $n = 13$); and with blood flow restriction (LI-BFR, $n = 24$), and high-intensity exercise (HI, $n = 15$). Participants from LI and LI-BFR groups performed 4 sets ($1 \times 30 + 3 \times 15$ reps) at 30% 1RM and HI group performed 4 sets (1×30 reps at 30% 1RM + 3×10 reps at 75% 1RM). All groups performed plantar flexion exercise in leg press. For LI-BFR group a cuff was positioned on the dominant calf and inflated at 30% of the individual's occlusion pressure (47.6 ± 19.8 mm Hg). Surface electromyography activity (EMG) was recorded from the gastrocnemius (G) and anterior tibial (AT) muscles across the sets of exercise. Muscle thickness of G and TA were measured immediately after exercise protocols using Doppler Ultrasound. Pearson's correlation coefficients were performed to assess the relationship between acute muscle activation (EMG) and muscle swelling (muscle thickness). Significance level was set at $p < 0.05$. **Results:** There was no significant correlations between muscle activation and muscle swelling of G for any groups (LI: $r = -0.018$, $p = 0.952$; LI-BFR: $r = 0.034$, $p = 0.872$; HI: $r = -0.134$, $p = 0.632$), as well as AT muscle (HI: $r = -0.026$, $p = 0.926$; LI-BFR: $r = -0.038$, $p = 0.857$; LI: $r = -0.134$, $p = 0.661$). **Discussion:** These findings could be attributed to low blood restriction pressure used (i.e., 30% of occlusion pressure) and/or lower muscle mass involved in the movement (i.e., calf muscle). Altogether, these factors would have a little effect on muscle swelling. Future studies are necessary to investigate possible relationships between previous reported parameters with the use of higher restriction pressures and different muscle groups (i.e., quadriceps, pectoral) since the magnitude of neuromuscular activation varies as a function of relative BFR pressure [1]. Our results suggest that no direct relationship occur between muscle activation and muscle swelling. **References:** [1] Fatela, et al. Acute effects of exercise under different levels of blood flow restriction on muscle activation and fatigue. *Eur J Appl Physiol* 116: 985–995, 2016. [2] Takarada, et al. Effects of resistance exercise combined with moderate vascular occlusion on muscular function in humans. *J Appl Physiol* (1985) 88: 2097–2106, 2000. **Mail to:** anel1115.recarey@gmail.com.

THE EFFECT OF CONCURRENT TRAINING IN PATIENTS WITH CORONARY HEART DISEASE: A PILOT STUDY

MANRESA-ROCAMORA A.,¹ SARABIA J.M.,^{1,2} AND MOYA-RAMÓN M.^{1,2}

¹Sport Research Centre, Miguel Hernandez University Av, Universidad s/n, Elche, Spain; and ²Department of Health Psychology, Miguel Hernandez University, Elche, Institute for Health and Biomedical Research (ISABLAB-FISABIO Foundation), Alicante, Spain

Introduction: Previous evidence has shown that Exercise Based Cardiac Rehabilitation (EBCR) is effective to improve health in patients with Coronary Heart Disease (CHD) [1]. However, the effect on several variables is unclear yet. The aim of this study was to know the influence of concurrent training (endurance and resistance training in the same session) on cardiorespiratory fitness ($\dot{V}O_2$ peak, O_2 pulse, and $VE/\dot{V}CO_2$ slope), ventricular function (left ventricle area and left ventricular ejection fraction [LVEF]), and cardiovascular risk factors in patients with coronary heart disease (CHD).

Methods: Six men with CHD took part in this study (mean age 61.83 ± 11.69 years; mean LVEF $64.67 \pm 7.11\%$). They carried out a supervised 12-week cardiac rehabilitation program of 3 weekly sessions. Cardiopulmonary exercise test (CPET), echocardiogram and blood analysis were performed before and after the training program. Sessions started with moderate continuous training (20–35 minutes; 60–80% of peak heart rate) on a treadmill or bicycle and continued with strength training (35–60% maximal repetition). Training load increased throughout the training program. Statistical and clinical significance were analyzed using paired t test and Effect Size (ES), respectively. Clinical relevance was interpreted using Rhea's criterion to untrained people. **Results:** The effect of EBCR on $\dot{V}O_2$ peak reached statistical and clinical significance. O_2 pulse, LVEF, left ventricle area, fibrinogen, triglycerides, and lactate dehydrogenase showed a change clinically relevant. **Conclusions:** A short-term training program based on concurrent training seems suitable to improve health and cardiovascular condition in patients with CHD. The magnitude of the effect sizes are showing that EBCR could be suitable to enhance ventricular function and some cardiovascular risk factors related to the pathology. **Reference:** [1] Anderson, L, Oldridge, N, Thompson, DR, Zwisler, AD, Rees, K, Martin, N, and Taylor, RS. Exercise-based cardiac rehabilitation for coronary heart disease: Cochrane systematic review and meta-analysis. *J Am Coll Cardiol* 67: 1–12, 2016. **Mail to:** amanresa@goumh.umh.es.

COMPARISON BETWEEN DIFFERENT 10-WEEK MULTICOMPONENT EXERCISE PROGRAMS IN OLDER WOMEN

CUELLAR CAÑADILLA R.,¹ GONZÁLEZ RAVÉ J.M.,¹ JUÁREZ SANTOS-GARCÍA D.,¹ AND GARCÍA PASTOR T.²

¹Universidad de Castilla la Mancha, Spain; and ²Universidad Camilo José Cela, Spain

Introduction: The aim of this study was to analyze the effects of various multicomponent sessions implemented in 10-week and 4 weeks of detraining on the physical fitness (PC), body composition (BC) and hematology of women older than 60 years. **Methods:** Forty-five women (65.7, $s = 4.5$ years; 75.3, $s = 11.1$ kg) were randomly assigned to 4 groups: a physical conditioning group (GPCG; $n = 13$) with 2 weekly sessions; a GPCG with an extra-session aimed at hypertrophy (GPCGH; $n = 12$), a GPCG with an extra-session in a shallow pool (GPCGP; $n = 12$); and a control group (CG; $n = 8$). The dependent variables were: hematology (HDL, LDL and total cholesterol, hemoglobin, glycated hemoglobin, hematocrit and glucose), countermovement jump (CMJ) and Abalakov (ABK), 30-s chair-stand test, biceps curl repetitions with 2.5 kg for 30 seconds and 6-minute walk test. **Results:** After 10 weeks, the GPCGH achieved an increase ($p < 0.01$; $d = 0.7$) in ABK. In CMJ, we observed differences between the CG and the other groups ($p < 0.01$; $\eta = 0.61$, with the GPCGH; $p < 0.01$; $\eta = 0.25$, with the GPCGP; $p < 0.05$; $\eta = 0.12$, with the GPCG) after the training program. GPCGH and the GPCGP still showed higher values than the initial values ($p < 0.01$; $d = 0.5$, in the GPCGH $p < 0.01$; $d = 0.6$, in the GPCGP). There were improvements in the chair-stand test in the GPCG ($p < 0.01$, $d = 0.5$) and GPCGH ($p < 0.01$, $d = 1$). **Discussion:** The various physical conditioning programs resulted in improvements in HDL, LDL, baseline glucose and glycated hemoglobin. In conclusion, a program with an extra-session oriented at hypertrophy represented a greater improvement in strength in the upper and lower extremities. The 4-week detraining period resulted in no significant changes in BC, PC and hematology. **Mail to:** cuellarcanadilla@yahoo.es.

INTRA-RATER RELIABILITY OF THE BACK SQUAT ASSESSMENT IN PRE- AND POST- PEAK HEIGHT VELOCITY MALE CRICKETERS

DOBBS I., WONG M., MOORE I., OLIVER J., AND LLOYD R.

Cardiff Metropolitan University, United Kingdom

Introduction: Improving movement competency is linked to enhanced athletic performance in young athletes [1]. The back

squat assessment (BSA) is a novel screening tool that evaluates an athlete's movement competency and identifies technical deficits in a squat pattern [2]; however limited information is available regarding the measurement error with the screen. Specifically, the intra-rater reliability of the BSA is unknown. Therefore, the purpose of this study was to determine intra-rater reliability of a single BSA trial across 3 separate sessions.

Methods: Fifteen pre-peak height velocity (PHV) (age = 11.2 ± 0.7 years; height = 147.8 ± 5.7 cm; mass = 39.8 ± 8.9 kg; maturity offset = -2.2 ± 0.6 years) and 11 post-PHV (age = 15.4 ± 0.9 years; height = 171.9 ± 8.4 cm; mass = 64.4 ± 9.2 kg; maturity offset = 1.3 ± 1.3 years) male cricketers participated in the study. The BSA is scored off a 10 point-criteria with one-point given for each fault, with a lower total score reflecting more favorable squat technique. Participants were instructed to perform the BSA according to published guidelines, which includes 10 continuous repetitions with a dowel on their back and descending until thighs are parallel to the ground [1]. All repetitions were recorded using two 2-D cameras placed 5 meters away and one meter high from the participant in both frontal and sagittal planes; with BSA scoring conducted retrospectively. Each participant performed one trial of the BSA, with the same trial scored on 3 separate occasions to determine intra-rater reliability. Intra-class correlation coefficients (ICC) were calculated for BSA total score and Cohen's kappa (k) was used to determine levels of agreement for each of the ten-point criteria [3]. **Results:** ICC for BSA total score was very good in the post-PHV group ($r = 0.95$) and the pre-PHV group ($r = 0.87$) across all sessions (Table 1). The great-

est ICC for both groups was observed between sessions 2 and 3. Of the 10 criteria, the post-PHV group had good to perfect levels of reliability in sessions 2 and 3 (Table 2). In the same sessions, the pre-PHV group had a fair (k) score for foot position (0.42) and ascent (0.44), with all other criteria having good or very good levels of reliability. **Discussion:** The ICC were greatest in sessions 2 and 3 which indicates users need to observe the BSA more than once with pre-PHV athletes. The levels of agreement were near perfect for post-PHV BSA total score in all sessions, suggesting users can reliably rate older athletes immediately. All the individual criteria can be rated reliably in the pre- and post-PHV groups during the BSA. Criteria in movement mechanics had the lowest (k) scores across sessions and is more difficult to rate than upper and lower body positions. The BSA is a reliable test to measure squat movement competency in male youth cricketers, however, there is a systematic bias for rating pre-PHV athletes which requires familiarization. **References:** [1] Myer, G, Fajgenbaum, A, Ford, K, Best, T, Bergeron, M, and Hewett, T. When to initiate integrative neuromuscular training to reduce sports-related injuries and enhance health in youth? *Curr Sports Med Rep* 10: 157–166, 2011. [2] Myer, G, Kushner A, Brent, J, Schoenfeld, B, Hugentobler, J, Lloyd, R, Vermeil, A, Chu, D, Harbin, M, and McGill, S. The back squat: a proposed assessment of functional deficits and technical factors that limit performance. *Strength Cond J* 36: 4–27, 2014. [3] Altman, DG. Practical statistics for medical research. Chapman and Hall; 1999. **Mail to:** ijdobbs@cardiffmet.ac.uk.