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Book of Abstract–German Exercise Science & Training Conference (GEST19) of the German Society of Sport Science (dvs), February 20th–22nd 2019

Preface

On behalf of the Section „Exercise Science and Training" of the German Society of Sport Science (dvs) we welcome you to the Biannual Meeting „German Exercise Science & Training Conference"–GEST19.

The organizers of the conference, together with the valuable input and knowledge of numerous colleagues from different backgrounds, coaches from different disciplines and governing bodies rounded out the creation of the conference program.

The conference topics include multiple aspects of training and testing from a wide variety of sports and settings. With more than 100 submitted abstracts the conference will prove to not only be interdisciplinary but also deal with a multitude of aspects from training and testing of different populations–from recreational to elite, young to old, men and women.

Our program covers many facets, including various innovative forms of endurance and neuromuscular training and testing. It includes new insights in training and testing of individual, team, racquet, and winter sports. It also includes modern aspects of nutrition and biomonitoring at the molecular and systemic level.

We are proud to host over 160 delegates from 15 countries. Above all, we are proud to host more than 50 young researchers! The opportunity for sharing the latest research and practice is real. GEST19 provides each and every one of us with the opportunity to tackle the unique challenges of implementing and scaling up exercise science and training.

We are truly delighted with the quality of the conference program and the activities developed by our Scientific and Organizing Committees and we thank them for all of their efforts. We also thank all speakers, chairs, volunteers and sponsors for providing their valuable expertise, input and support for realizing GEST19.

Last but not least, we thank you as participants and the scientific and applied community for living and breathing Exercise Science and Training and making GEST19 the memorable experience we know it will be.

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Australian Catholic University, Melbourne, Australia

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New Aspects in Whole-body Electromyostimulation

The effectiveness of the Bodystreet EMS standard program with different duration of intervention

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Since 2007 full-body EMS workout has developed rapidly. The literature reported effects with muscle mass gain and body fat reduction (Kemmler & von Stengel, 2013). To evaluate the effects of the Bodystreet EMS standard program, a project was initiated at the DHfPG in 2016. Up to now, 150 participants have been analyzed, including 79 women (age: M = 39.91, SD = ±9.93) and 71 men (age: M = 32.65, SD = ±9.81). Using an exploratory factor analysis with the parameters body weight, BMI, THQ, fat percentage, and muscle mass we decided with a total of variance explanation of 79.3% to analyze women and men separately. The data were differentiated in groups of 6 weeks (58 participants), 8 weeks (52 participants) and 12 weeks (40 participants). The pre-post intervals were initially analyzed for differences with paired-samples t-tests for women and men ($p \leq 0.05$). In women, we found significant differences with large effect size on body fat reduction and a medium effect in reducing body weight and BMI and in men, on body fat reduction and muscle mass gain at medium effect. So far, we have not been able to find any differences in the duration of the intervention calculated by a repeated measures ANOVA. The analysis will continue with a larger number of participants.

Effects of novel technologies on chronic non-specific low back pain–a multicenter study

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Back pain is a serious orthopedic problem in modern societies that might collide with conventional training due to its clinical profile. Novel training technologies such as whole-body electromyostimulation (WB-EMS) and whole-body vibration (WBV) attempt to reduce these barriers by a joint-friendly, time-effective and highly customized training protocol. The aim of this randomized controlled multicenter trial is to compare novel training technologies with a conventional back-strengthening exercise

protocol (CT) to determine the corresponding effects on chronic, non-specific low back pain (LBP) in people suffering from this condition.

165 LBP patients, 40–70 years old, were randomly assigned into three groups (WB-EMS: n = 55; WBV; n = 55; CT: n = 55). All groups completed a 12-week program specifically dedicated to LBP. Primary study endpoint was average pain intensity at the lumbar spine. Secondary study endpoints were maximum isometric strength of the trunk (extension, flexion).

Mean pain intensity of LBP decreased significantly ($p = 0.001$) in all the training groups, however, without significant intergroup difference ($p = 0.349$). An analogous result was observed for the secondary endpoints. The increase in both abdominal and back strength was highly significant in all the groups ($p = 0.001$), without any significant difference in comparison (extension: $p = 0.399$; flexion: $p = 0.495$).

In summary, all training methods are comparable effective in reducing chronic, non-specific LBP, without relevant differences between the methods. Although the calculated power has not been achieved yet, from the perspective of those affected, the preliminary results indicate, that subjects can decide individually which method suits them best.

[YIA] Effects of a 10-week WB-EMS training program on specific sport performance parameters

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The use of different stimulation parameters, especially the frequency, has been discussed since the use of whole-body-electromyostimulation training (WB-EMS). However, the efficacy of different frequencies is hardly examined, whereby frequencies >50 Hz seem to be most adequate for strength gains. Therefore, the aim of this study was to analyze possible differences in sport related performance parameters after a 10-weeks application of WB-EMS with 20 and 85 Hz.

A total of 53 participants (24.9 ±3.9 years, 72.4 ±16.4 kg, 174 ±8.9 cm) were randomly divided into three groups, one control group (CG) and two training groups (T2 = 20 Hz; T8 = 85 Hz) that completed a 10-weeks training program with 1.5 sessions/week and equal content. Before and after the treatment, all participants absolved a jumping (counter movement jump (CMJ), squat jump (SQJ), drop jump (DJ)), and a sprinting (5 m, 10 m, 30 m) test battery. ANOVA with repeated measurement was used to calculate parameter changes and post hoc Fischer tests for group differences. There were significant differences for group*time interaction for CMJ ($p = 0.01$) and SQJ ($p = 0.02$) but none for DJ ($p = 0.26$) and sprinting parameters (5 m: $p = 0.74$; 10 m: $p = 0.53$; 30 m: $p = 0.51$).

These results seem to be an indicator for the unspecific, non-selective recruitment pattern of muscle fibers during WB-EMS (Gregory & Bickel, 2005). Therefore, the compatibility and applicability of different frequencies seems to be more important than the difference in the effectiveness.

References
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[YIA] Effects of Whole-Body Electromyostimulation (WB-EMS) on the energy-restriction-induced change in muscle mass during intended weight reduction

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An increasing percentage of people suffer from overweight and obesity. A negative energy balance via energy restriction promises success in weight loss–however, the focus should be on a decrease in body fat, not muscle mass. Evidentially, protein supplementation and strength training can reduce the loss of muscle mass. The study's purpose was therefore to evaluate the effects of WB-EMS on body composition during negative energy balance but maintained protein intake.

Ninety overweight-obese premenopausal women were randomly assigned into three intervention groups ($n = 30$). All groups were supplemented with protein. One group focus on energy restriction (CG), two groups combined energy-restriction and physical activity (PA) to generate changes in energy balance of 500 kcal/d. In addition, the WB-EMS-group exercised 1.5×20 min/week. Our hypothesis was that WB-EMS leads to more favorable changes in lean body mass (LBM) than the "PA-only" or the CG, while all three groups show comparable and significant reductions in body fat mass (BFM).

LBM decreased in the "PA-only" ($p < 0.05$) and CG and non-significantly increased in the WB-EMS-group, resulting in significant intergroup differences in favor of the WB-EMS-group ($p < 0.05$). BFM significantly decreased in all groups (2.2–3.9 kg, $p < 0.001$), with the highest reduction in the "PA-only" and WB-EMS groups.

WB-EMS, as an alternative training technology in the field of resistance exercise training, completely prevented the decrease of muscle mass during weight reduction. Thus, WB-EMS combined with protein supplementation might be a time-effective, feasible strategy during energy restriction.

[YIA] Effects of wb-EMS-Training for Amateur Ice Hockey Athletes

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Electrical muscle stimulation has long been an established method for strength training of specific muscle groups. Primarily established as a rehabilitation concept has since found its way into systemic training and recreational sports. In wb-ems training, the muscles of the upper and lower extremities and the trunk muscles are trained by application of electrical impulses. Studies for various sports have shown that this system works for professional athletes.

The present study included 30 male ice hockey players from two lower leagues aged 18 to 48 years. Anthropometric data were collected. In a randomized cross-over design, one group was first trained for 12 weeks with wb-ems in addition to normal training, then the second group performed wb-ems. Shot speed, counter-movement-jump, 10-metre sprint test, isometric high-speed force and maximum force in the shot movement and the legs and the subjective performance in a questionnaire were recorded. The measurements were performed at baseline, after 6 and 12 weeks. The washout phase was tested 16 weeks after the start of training.

We were able to demonstrate a significant training effect, which decreased during the washout phase, but we could not demonstrate any significant evidence that wb-EMS training reduces the frequency of injuries. Jump height, sprint speed, speed force and maximum force at the M. quadriceps improved significantly. There was no significant changes of shooting speed. We found additional wb-ems training suitable for lower league ice hockey athletes, since it improved their physical performance significantly.

[YIA] The effects of electrical whole body muscle stimulation (WB-EMS) in patients with chronic unspecific back pain–A controlled clinical intervention study

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The preferred intervention for treating patients with chronic nonspecific back pain, is active resistance training. Whole body Electromyostimulation (WB-EMS) is becoming increasingly popular as efficient training method. Therefore, applying this kind of training seems logical in patients with chronic unspecific back pain.

In this ongoing prospective clinical trial, two different therapeutic approaches are compared on patients with chronic nonspecific low back pain, in terms of their effectiveness.

One group received a "classic" treatment of physiotherapy. The second group received a WB-EMS Training once a week for 20 min. A control group was formed from subjects with a "healthy back" In all groups Biome-

chanical tests and established Questionnaires are used: In the intervention group measurements are carried out at T0: before beginning; T1: after 6 weeks; T2: after 12 weeks; T3: after 24 weeks. In the active control T0 was carried out before beginning, T1: 4 weeks after beginning.

90 patients have been enrolled for Intervention, 32 in the active 25 in passive control group. The pain sensation averages on the Numeric Rating Scale (NRS; 1–10) improved significantly ($p < 0.05$). by 1.198, The Ostwestry Disability Index (ODI) improved significantly, resulting in a significant 3.37% reduction. The NASS improvement 0.51 points. The pain value of the SF 36 questionnaire improved by 8.88.

By training with WB-EMS, all used back and pain parameters could be improved. In the further course of the study, a comparison with the traditional physiotherapy program and healthy subjects will further show the efficiency.

Player Tracking Technology in Team & Racquet Sports

Monitoring external loads and internal demands by positioning systems in team sports: A technological overview

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In this talk, we provide a technological overview of positioning systems to monitor external loads and internal demands in team sports. First, potential application fields of positioning systems are introduced. Then, technological backgrounds of different positioning systems with respect to their measurement principles and accuracies are given. Also, various progressive data processing procedures to estimate not only external loads, but also internal demands are presented. Finally, future perspectives to develop positioning systems for team sports are discovered.

Can Positioning Systems Replace Timing Gates for Measuring Sprint Time in Ice Hockey

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This study explores whether positioning systems are a viable alternative to timing gates when it comes to measuring sprint times in ice hockey. We compared the results of a timing gate with the results of an optical positioning system and two radio-based positioning systems. The testing protocol consisted of two 40 m linear sprints, where we measured sprint times for a 11 m subsection (Linear Sprint 11), and a shuttle run (Shuttle Total). We quantified the difference between measured sprint times e. g. by Mean Absolute Error (MAE) (s), Intra Class Correlation (ICC) and Coefficient of Usefulness (CU). Results showed that radio-based systems had a higher accuracy compared to the optical system. This concerned Linear Sprint 11 (MAE_Optical = 0.16, MAE_Radio1 = 0.01, MAE_Radio2 = 0.01, ICC_Optical = 0.38, ICC_Radio1 = 0.98, ICC_Radio2 = 0.99) as well as Shuttle Total (MAE_Optical = 0.07, MAE-Radio1 = 0.02, MAE_Radio2 = 0.02, ICC_Optical = 0.99; ICC_Radio1 = 1.0, ICC_Radio2 = 1.0). In Shuttle Total, all systems were able to measure a SWC of 0.10 s with a probability of >99% in a single trial (CU_Optical = 4.6, CU_Radio1 = 6.5, CU_Radio2 = 5.1). In Linear Sprint 11 an SWC of 0.01 s might have been masked or erroneously detected where there were none due to measurement noise (CU_Optical = 0.6, CU_Radio1 = 1.0, CU_Radio2 = 1.0). We conclude that the tested positioning systems may in fact offer a workable alternative to timing gates for measuring sprints times in ice hockey over long distances like shuttle runs. Limitations occur when testing changes/differences in performance over very short distances like an 11 m sprint, or when intermediate times are taken immediately after considerable changes of direction or speed.

Enhanced sprint performance analysis in soccer: Insights from a GPS-based tracking system

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The purpose of the present investigation was to: 1) determine the validity of a GPS-based tracking system (Polar Team Pro System, PTPS) to estimate short-distance linear sprint performance variables; 2) evaluate additional, potentially useful performance indices to improve diagnostics of sprinting speed in team sports.

Thirty-four male soccer players (20 ± 4 years) performed a 20-m sprint test measured by timing gates (TG), and while wearing the PTPS. Both systems were synchronized at a threshold of 8 km/h. To evaluate the relevance of additional velocity-based parameters to discriminate between faster and slower athletes, the median-split method was applied to the 20-m times. Practical relevance was estimated using standardized mean differences (d) between the subgroups.

Differences between the criterion reference (TG) and the PTPS for the 10- and 20-m splits did not vary from zero (dt10: -0.01 ± 0.07 s, $P = 0.7$, d < -0.1; dt20: -0.01 ± 0.08 s, $P = 0.4$, d < -0.2). Although subgroups revealed large differences in their sprint times (d $= -2.5$), the average accelerations between 5 and 20 km/h as well as 20 and 25 km/h showed merely moderate effects (d < 0.5).

Results of timing gates evaluate the average sprint performance. Analyses of velocity curves derived from GPS-based wearables can help to clarify the occurrence of performance in outdoor sports. Thus, specific training consequences can be drawn which contribute to the differentiation and individualization of short-distance sprint training.

Cycling–Training & Testing

Correlations of physiological variables with a power-profile in cycling

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Several studies have demonstrated that physiological variables and performance data from laboratory tests predict cycling endurance performance. However, it is still unclear whether the predictors will change over different performance durations. The aim of this study was to assess the correlations between physiological variables/performance data and cycling time trials (TTs) with different durations.

34 trained male cyclists (VO2max $= 67.4 \pm 5.1$ mL/kg/min) performed 10 separate experimental trials. To determine physiological and performance variables, cyclists initially completed a 15 s sprint test (ST), a ramp incremental test (RT), and a lactate-minimum-test to determine maximal rate of lactate accumulation (VLamax), VO2max, ventilatory threshold (VT) 1 & 2, peak power output (PPORT), lactate minimum, and the power-index (PPORT/PPOST · 100). Afterward, 8 maximal cycling TTs of different durations (30 s, 60 s, 180 s, 300 s, 600 s, 1200 s, 2400 s, 3600 s) were performed on separate days in a randomized order.

The main results showed that the physiological/power measures from performance testing strongly correlated with TT performance >180 s. Thereby, the TT mean power output showed the highest correlations with PPORT (r $= 0.83$–0.92) and lactate minimum. (r $= 0.81$–0.92). Short-term performance (1 s–30 s) was most highly correlated with VLamax (r $= 0.65$–0.71) and the power-index (r $= -0.69$–0.85).

Trained cyclists should develop maximal aerobic power irrespective of the duration of the time trial, as well as enhancements in metabolic thresholds for long-duration time trials.

[YIA] Acute apnea does not improve 3 km time trial performance

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Intense exercise evokes a spleen contraction releasing red blood cells into blood circulation. This improves oxygen transport capacity which is beneficial for performance. The same mechanism is found following acute apnea, increasing [Hb] by 2 to 5%. Therefore, the aim was to examine whether pre-exercise apnea can improve performance in a 3 km time trial (TT) through apnea-induced spleen contraction before the onset of exercise.

11 healthy, recreationally active subjects (age: 21.6 ± 1.2 years, VO2peak: 52.5 ± 5.1 ml.min-1.kg-1), performed 3 km TT on a cycling ergometer following a 10′ warm-up and a 10-minute rest in 3 different conditions: an apnea (one maximal static apnea finishing 3 min before TT), control and placebo condition. Performance time and average power output were recorded, maximal heart rate and VO2 uptake were continuously measured. Lactate and venous [Hb] were sampled three times, at baseline, after warm-up and before TT.

Interaction effects ($p = 0.049$, $\eta = 0.240$) for [Hb] values revealed that including an apnea during the rest period evoked a positive change in [Hb] pattern. With completion times of 264.7 ± 14.0s for apnea, 264.4 ± 13.2s control and 263.9 ± 15.8s placebo, performance did not differ between conditions ($p = 0.840$, $\eta = 0.017$). Power output ($p = 0.584$, $\eta = 0.039$) and peak physiological parameters did not differ either (VO2 $p = 0.602$, $\eta = 0.049$; heart rate $p = 0.757$, $\eta = 0.049$; lactate $p = 0.185$, $\eta = 0.155$).

Although a small positive impact on the Hb values was seen, implementing a single apnea in the warm-up did not change the physiological parameters during nor improve the TT performance.

[YIA] The effect of a varied recovery interval on the reconstitution of W′

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Exercise above critical power (CP) takes place in the severe intensity domain, using a limited energy storage W′. Theoretical modeling, W′bal [1], gives the possibility to predict the available W′ at every time point during intermittent exercise. However, W′bal seems to be underestimated during short recovery intervals. Also individual characteristics might influence the reconstitution of W′.

CP and W′ were estimated by 3 constant work bouts in 16 male physical education students. Muscle fiber type distribution was non-invasively determined [2]. During 8 experimental conditions, subjects cycled in a first trial at a constant work load above CP till exhaustion, followed by 8 different recovery intervals at 90% of gas exchange threshold varying from 30 s to 15 min. Second trial was performed till exhaustion at the same intensity of the first trial.

W′bal gave an underestimation for recovery up to 10 min and an overestimation for recovery longer than 10 min ($p < 0.05$). Aerobic fitness (VO2peak in ml/min/kg) was positively (r $= 0.720$; $p < 0.05$) and muscle fiber type distribution negatively correlated (r $= -0.463$; $p < 0.10$) with the reconstitution of W′.

The theoretical model (W′bal) needs to be optimized, considering the duration of exercise and recovery, as well as individual characteristics. Short recovery intervals tend to underestimate reconstitution of W′. Greater aerobic fitness and a more type I oriented muscle fiber type distribution have a faster W′ reconstitution.

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[YIA] Training progression in recreational cyclists: no linear dose-response relationship with training load

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To assess the relation between training load (TL) and performance improvement in a homogeneous group of recreational cyclists, training with a self-oriented training plan.

Training data from 11 recreational cyclists was collected over a 12-week period. Before and after the training period, subjects underwent a laboratory incremental exercise test with blood lactate measurements to determine the maximal power output (PMAX), the power output associated with the aerobic threshold (PAT) and the anaerobic threshold (PANT). Mean weekly TL (calculated using Banister TRIMP, Edwards TRIMP, Lucia TRIMP and the individualized TRIMP) was correlated to the progression in fitness parameters. Training intensity distribution (TID) was also determined (% in zone 1 as < AT; % in zone 2 as between AT and ANT; % in zone 3 as > ANT).

No significant correlations between mean weekly TRIMP values and the improvement on PMAX (r = –0.22–0.08), PANT (r = –0.56––0.31) and PAT (r = –0.08–0.41) were found. The TID was significant in a multiple regression with PANT as dependent variable (y = 0.0088 + 0.1094 × Z1 – 0.2704 × Z2 + 1.0416 × Z3; $p = 0.02$; adjR2 = 0.53).

The present study shows that the commonly used TRIMP methods to quantify TL do not show a linear dose-response relationship with performance improvement in recreational cyclists. Furthermore, the study shows that TID might be a key factor to establish a relationship with performance improvement.

[YIA] Effects of a short-term cycling interval session and active recovery on non-linear dynamics of cardiac autonomic activity

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Measures of the complexity of physiologic variability of heart rate time series (HRV) provide new opportunities to monitor cardiac autonomic activity during exercise. Using detrended fluctuation analysis (DFA) technique to assess correlation properties, the present study examines the influence of exercise intensity and active recovery on total variability and complexity in non-linear dynamics of HRV. 16 trained cyclists performed an interval session with active recovery periods. During exercise heart rate (HR) and RR-intervals were recorded continuously. HRV time domain measures and fractal correlation properties were analyzed using short-term scaling exponent alpha1 of DFA. Lactate (La) and rating of perceived exertion (RPE) were also recorded in regular time intervals. HR, La, and RPE showed increased values during the interval blocks ($p < 0.05$). In contrast, all HRV values showed decreased values during the interval blocks ($p < 0.05$). It was also shown that DFA-alpha1 increased during the active recovery up to the level of the warm-up periods ($p < 0.05$) and remains at nearly the same rate until the end of the active recovery ($p = 1.000$). The present data verify a decrease in the overall variability as well as a reduction in complexity of the RR-interval-fluctuations due to the increased organismic demands. The acute increase in DFA-alpha1 following intensity based training stimuli may be interpreted with a counter regulation of the organism with a highly correlated behavior.

[YIA] The reconstitution of W′ depends on both work and recovery characteristics

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This study aimed to investigate the effects of different work and recovery characteristics on the W′ reconstitution and to test the predictive capabilities of the W′BAL model.

Eleven male participants (22 ± 3 yr, 54.7 ± 3.6 mL.min-1.kg-1) completed three to five constant work rate tests to determine CP and W′. Subsequently, subjects performed twelve experimental trials, each comprising two exhaustive work bouts (WB1 and WB2), interspersed by an active recovery interval. In each trial, work bout characteristics (P4 or P8, i. e., the work rate predicted to result in exhaustion in 4 and 8 min), recovery intensity (33%CP or 66%CP) and recovery duration (2, 4 or 6 min) were varied. Actual (W′ACT) and model-predicted W′ reconstitution were calculated. No interaction effects were found ($P > 0.05$), but was found between work bout characteristics, recovery intensity and recovery duration ($P > 0.05$), but all parameters showed a main effect on W′ACT. After 2, 4 and 6 min recovery, W′ACT averaged 46 ± 2.7%, 51.2 ± 3.3% and 59.4 ± 4.1%, respectively ($P = 0.003$). W′ACT was 9.4% higher after recovery at 33%CP than at 66%CP (56.9 ± 3.9% vs. 47.5 ± 3.2%) ($P = 0.019$). P4 exercise yielded a 11.3% higher W′ACT than P8 exercise (57.8 ± 3.9% vs. 46.5 ± 2.7%) ($P = 0.001$). The W′BAL model underestimated W′ACT in the conditions P4–2 min (29.7%), P4–4 min (18.4%) and P8–2 min (18%) ($P < 0.01$).

This study demonstrated that the characteristics of a prior exhaustive work bout affect the W′ reconstitution. Furthermore, it was shown that the W′BAL model underestimates actual recovery, especially after shorter recovery.

Biomechanical Aspects of Training & Testing

Muscle activity patterns in imitation ski jumps

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The performance of the take-off in ski jumping creates high demands on the athlete's neuromuscular system and is associated with the length of the jump. However, investigations of muscle activity during take-off are limited to a few qualitative analyses as summarized by Schwameder (2008). A principal component analysis (PCA) can quantify relevant activation patterns across the measured muscles. For examples, Olree and Vaughan (1995) examined muscle coordination patterns during locomotion. The aim of this study was to examine muscle coordination patterns in imitation ski jumps using PCA.

EMG of eight leg muscles were recorded during imitations ski jumps from a fixed surface and a rolling platform (Ettema, Hooiveld, Braaten & Bobbert, 2016). PCA was conducted on the EMG across the eight muscles for each conditions separately.

PCA detected for both conditions two relevant muscle activation patterns explaining up to 80% of the EMG signal. The first component (PC1) significantly loaded on calf muscles and leg extensors and indicated muscle coordination at take-off. The handling of balance during take-off could be extracted from the second component (PC2). Small differences between conditions could be found in the weighting coefficients of PC1. The muscle activation pattern of jumping from a rolling platform had higher loads of hip and thigh muscles and lower loads of calf muscles.

The results provide insight into muscle coordination of imitation ski jumps. Limitations such as the footwear and the sample size highlight the importance of further investigations of muscle activity in actual and imitation ski jumping.

Abstracts

Jump performance measurements on rigid and sand surfaces in a standardized laboratory setting–using marker-based information to detect ground contact times

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Measuring vertical jump performance (JP) and ground contact times on sand surfaces is challenging because of properties of sand surface and limited access to high-end measuring systems on outdoor sand pitches, e.g. force platforms. Therefore, the aim of the present study was to evaluate jumping performance on sand and rigid surfaces in a controlled laboratory situation using marker-based information to detect ground contact times (GCT) to enable full jump performance analysis on outdoor sand situations.

41 team handball players performed CMJ and DJ on a rigid and sand surface in a controlled laboratory situation. JP and GCT were evaluated using marker- and forced-based systems. JP on sand surfaces was measured using a sand-box placed on 4 force plates. 3 trials for each jump and surface condition were performed. Statistics: repeated-measures ANOVA and Pearson correlations (α-level = 5%).

Significant influence of jump (DJ, CMJ) and surface (rigid, sand) on JP ($F_{(1,39)} = 75.6, p < 0.001, \eta p2 = 0.66$, $F_{(1,39)} = 15.5, p < 0.001, \eta p2 = 0.28$). Athletes jumped higher with CMJ compared to DJ and on rigid compared to sand surfaces. A significant effect was found for different detection methods of GCT ($F_{(2,80)} = 13.2, p < 0.001, \eta p2 = 0.25$). High correlations were found for vGRF, foot and back marker.

Jumping performance results are consistent with results from literature but more distinct due to consistent laboratory conditions, especially for sand surface. Results of different GCT detection methods show that using 3d-markers is most suitable to reliably detect GCT without using force plates thus enabling full JP analysis on outdoor sand situations.

Complex analysis of turns in 200 m freestyle short course races

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Turns in short course swimming races contribute–among other factors–to a considerable part to the final performance. Therefore, efficient turns can determine the final ranking in such competitions (Maglischo, 2003). However, Veiga and Roig (2016) noted that swim turns are still neglected in elite sport. Although, there are indications about an optimal movement pattern (Pereira et al., 2015), studies dealing with impacts of fatigue on turn execution are absent. Therefore, the aim of this study was to investigate the impact of fatigue on relevant parameters of turns in 200 m-freestyle short course (25 m) races. We conducted a pilot study with 8 (4 females) youth swimmers in a 200 m freestyle all out test on a short course. The kinematic parameters of the turns were captured with the model of movement phases of Puel et al. (2012) and Skyriene et al. (2017) from 2D-video footages. The parameters were analyzed by a re-peated measures ANOVA (IBM SPSS 24.0). The results show a significant decrease of velocity when approaching the wall and when pushing of the wall after wall contact. Furthermore, the results show significant changes for swimming velocities after wall contact, wall contact times, knee angles and the distance between head and wall at initiation of rotation. We found no sex differences for all parameter changes It remains open which strategies could be used by elite swimmers to prevent such kinematic changes due to fatigue to preserve a stable velocity profile (Robertson et al., 2009) during the race.

Development of mechatronic driven training devices for performance optimization and injury prevention in elite alpine ski racers

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Documenting mechatronic applications in strength training represents a lack in scientific literature/research. Therefore, the aim of this project was to develop and implement mechatronic based strength training devices for performance optimization and possible injury prevention in elite alpine ski racers.

Development of training devices: Three mechatronic training devices were developed and are in use in the Olympic training center: The Lifter is a lifting system, consisting of two columns with a drive spindle, a synchronized servomotor and a servo controller. Light grid sensors on the lifting arms continuously measure and monitor the bar. The Lifter allows safe eccentric overload squats with a free bar and improves maximal leg/core strength. The Evolution is a right/left leg independent system, each consisting of two synchronized servomotors, permitting horizontal/vertical linear movements as well as circles. Additionally, stochastic shocks can be introduced during work. The Evolution permits varied forms of concentric/eccentric leg extensions/flexions with skiing-specific shocks. The Active Motion is operated by three pneumatic actuators which generate unexpected droppings/perturbations of a stand plate. Length sensors determine the exact location of the plate. Stabilization based strength training on the Active Motion with sudden perturbations links rapid force production and balance control.

The mechatronic based training devices provide possibilities with great potential for performance optimization and injury prevention in elite athletes. Studies have shown that eccentric strength and core stability are key factors in ski racing. Furthermore, leg/hip axis stabilization and optimal balance performance under challenging situations are crucial when bumpy slope conditions are present.

[YIA] Effect of hip muscle strength on the relationship of dynamic trunk control and knee joint stability

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Lateral trunk lean (LTL) as a component of trunk control is associated with knee joint stability in dynamic tasks (Hewett & Myer, 2011). Varying hip muscle strength can lead to different lower and upper limbs coordination patterns (Smith et al., 2014). The present study investigated the effect of hip abduction strength (HAbS) on the relationship of LTL with knee valgus angle and moment (KVA, KVM).

3D full body kinematics and kinetics were recorded in 42 athletes (m = 28, f = 14; 20 ± 3 yrs; 174 ± 8 cm; 69 ± 10 kg) performing several drop jumps, landings and lateral jumps under stable and unstable ground conditions. HAbS was determined using an isometric device. A median split defined weak vs. strong HAbS. LTL, KVA and peak KVM were evaluated through the first 30% of ground contact time. An analy-sis of variance with two factors (trial and marker) was performed with HAbS and gender as between-subject factors. Pearson's correlation coefficients were calculated for trunk and knee. Alpha level was set at $p \leq 0.05$.

There were no gender differences. Positive correlations were found for KVA and KVM in all trials. Athletes with lower HAbS showed stronger associations. The strong HAbS group demonstrated reduced LTL only for side jumps, but highest KVA with similar KVM compared to athletes with weak HAbS. No significant correlations could be found between LTL and knee mechanics.

Mechanistic connection between upper and lower body are apparently more interesting in lateral movements than in vertical jumps. Presumably, stronger HAbS can cushion knee loads even when higher KVA results.

[YIA] Assessment of limb symmetry index as an injury risk factor in youth alpine ski racing

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Alpine ski racing is a sport with a high risk of injury. The role of lower limb asymmetries in injury prevention research in non-dominant sports like alpine ski racing has not been determined, so far. Therefore, the aim of the present study was to assess limb symmetry index (LSI) in performance relevant parameters as injury risk factor in youth alpine ski racers. Traumatic (TI) and overuse injuries (OI) of 67 Austrian elite youth ski racers (42 m, 25 f; 9–14 yrs) were prospectively recorded over two years. Unilateral sports specific performance tests (CMJ; stability: ST; jump coordination: SJ; leg extension strength: ILS) were assessed to define LSI (ratio of dominant and non-dominant leg). Binary logistic regression analyses were performed ($p < 0.05$).

In total, 61 TI and 15 OI were recorded (total injury rate/athlete: 1.13). The binary logistic regression analyses revealed that the LSI of ILS represents a significant injury risk factor for TI ($p < 0.001$; Wald $= 7.08$). Athletes sustaining TI had significantly higher LSI values in the ILS ($z = -2.645$; $p = 0.008$).

In general, small rates of TI and OI were recorded. Alpine ski racing is a symmetrical sport and bidirectional turns are required; thus, a high level of physical fitness that includes a high strength capacity in both limbs is necessary. The LSI of the ILS was found to be a significant injury risk factor for TI. This finding emphasizes the importance of having a well-developed, symmetrical strength capacity in both legs starting at a young age.

Workshop: Multi-Directional Sprinting & Agility in Elite Athletes

Multidirectional sprinting and agility in elite athletes

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A high multidirectional sprinting ability together with good agility are two major factors for success in most team and racket sports. The physiological profile of multidirectional sprinting (i.e. sprints with changes of direction) differs from straight sprinting since straight sprints do not show multiple acceleration and deceleration phases. This leads to different energetic demands which needs to be considered during training as well as during testing of athletes. Several different test protocols and evaluation tools are available to detect strengths and weaknesses of athletes in their performance level of multidirectional sprinting itself and in combination with an external stimulus. Due to the implementation of external stimuli into multidirectional sprinting, agility training can embed sports-specific neurocognitive demands into the physical training of athletes. This workshop will provide a practical insight into agility training and testing using the Speedcourt System in return to performance (RTP) of high-performance athletes in game sports. The objective is to present a theoretical background, case data and practical applications of agility as the link of motor and neurocognitive aspects of motor coordination in RTP scenarios.

Table Tennis: The Development of the Elite

Kinematic analysis of Table Tennis top spin forehand in two different targets

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The top spin forehand (TSF) is considered the most used shot in modern Table Tennis.

The purpose of this study is to compare the kinematic techniques of TSF used while hitting two targets: in the forehand (FC) and backhand corner (BC) at the other side of the table, respectively. Seven elite players participated in the study (age 22.2 ±3.2 years, height 177.4 ±4.2 cm, mass 72.9 ±11.0 kg).

Participants performed twenty TSF in FC and twenty TSF in BC trying to hit the two targets (40 ×65 cm) at the other side of the table, using the same racquet. A ball machine served balls in the forehand corner. For the kinematic analysis a stereo-photogrammetric system was used (Smart-D, BTS, 10 cameras, 500 Hz). A total of 44 markers were attached on the athletes' skin, 4 on the table, and 5 on the racquet.

Results showed differences in hitting the two different targets: FC (81.9% ±8.1) and BC (69.7% ±14.2). Results showed no differences in kinematics variables of upper and lower limbs (angles: shoulders-table, shoulder-racquet-table, pelvis-table, elbow flexion/extension, knee flexion/extension, feet-table, and racquet-table in the three axes) between TSF performed hitting the target or not, in both FC and BC.

In conclusion, this study shows a greater precision of TSF to hit a target in FC compared to BC, but the precision was independent from the kinematic variables considered.

Shot distribution in men's and women's elite table tennis matches

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Match analysis and notational analysis are two well-recognized approaches to provide information about technical and tactical performance in table tennis.

The aim of this study was to compare the shot distributions in men's (M) vs. women's (W) elite Table Tennis competitions.

Nine M and nine W matches were analyzed in slow motion with the software Kinovea by an expert coach. All players were ranked in the top 120 (M) and 111 (W) positions of the ITTF world ranking.

The results showed a lower number of shots per rally in M (4.7 ±0.4) compared to W (5.7 ±1.1). The top spin was the most frequent shot type in both M (27.5%) and W (28.3%), and the service was one of the most used shots by M (21.2%) and W (18.1%).

The push was mainly performed to return services and represented 16.7% and 13.7% of total shots in M and W, respectively. Relevant differences between W and M are linked to the shots used to continue the rallies. Indeed, men preferred to counterattack with a Top counter Top (M: 11.4%W: 6.0%,), while women used the block more frequently (W:20.0%, M:15.4%). Considering the forehand (F) and backhand (B) executions, men adopted a more offensive style of play (F: 65.2%, B: 34.8%) compared to women (F: 51.7%, B: 48.3%).

In conclusion, this study can be useful for performance analysts, coaches, and athletes to design specific training sessions for male and female table tennis players.

Practical performance analysis in table tennis

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In table tennis, many different approaches to scientific founded match analysis have been developed since the first ones in the 1960s. Besides different theoretical performance analysis approaches in table tennis, e. g. calculation of performance indices, more and more countries are putting more effort into practical performance analysis to support their national teams.

This presentation includes three 'best practice' examples. The first one describes the performance analysis procedure of China at the Olympic Games 2008 and 2012. Practical performance analysis in China is very comprehensive. Their framework includes the following steps: A fast real-time data collection, a more detailed after match data collection, the outline match analysis and a complete match analysis. The best practice example of Japan is the second one in abled-body table tennis and is more focused on the competition itself. During the 2012 Olympic Games, 136 matches played at the stadium of the table tennis event were analyzed for use by the Japanese national table tennis team. For the analysis, a computer program was developed to optimize the analysis procedure. This program was designed to conduct shot number-based analysis and an in-depth analysis of the played shots. The third example describes the practical performance analysis project of the German Para table tennis national team including the approach to build a data base of videos and match analyses, as well as the environment and practical performance analysis procedures before and during competitions.

Guidelines to identify and develop high potential in youth table tennis players

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Finding and guiding youth players with the potential to become an elite player is challenging. Table tennis and other racquet sports national associations try to select high potential youth players at an early age (10–12 years) to support them in their route to excellence. For this reason, trainers or scouts estimate a youth player's full potential using observations of current performance and performance outcomes. However, at such a young age, selections based on performance alone are influenced to a large extent by individual differences in growth, maturation, development and learning curves, training experiences, competition participation and environmental factors. These factors can create temporary advantages of disadvantages for performance at these young ages, but probably do not reflect a youth player's full potential which hinders the interpretation of the observational findings. These problems remain (partly) when monitoring players during their development for the selection of training facilities and competition. In the period from 2012 to 2018, research explored the opportunities to better estimate a player's potential in table tennis and to identify crucial indicators in individual pathways for success. The results provide new insights and implications to better set up the guidelines for talent development programs in table tennis and likely in other racquet sports as well.

Profiling elite youth table tennis players using a multidimensional approach

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Talent development in sports is suggested to be multidimensional by nature (Elferink-Gemser et al., 2011). Table tennis is not an exception. Table tennis is a complex sport in which players need to develop tremendously in several fields to be able to excel. Both physical and mental aspects need to be considered during the development and monitoring of players to have better idea about their status, development and also their potential (Faber et al., 2015). Besides this, it is important to take into account the environment and the interaction between the players and his/her environment (Faber, 2016). An evidence-based international multidimensional benchmark for elite youth table tennis is proposed to support table tennis talent development programs worldwide. For that reason, a multidimensional test battery was developed including tests for physical and mental aspects as well as the player's opportunities with regards to training and competition. The presentation will outline the rationale for the development and the content of the multidimensional assessment and two first explorative studies: the results of a small pilot-study which was conducted in Scotland (2016) (Doherty et al., 2018) and the results of an explorative study during the Euro-Talent Selection Camps of 2016, 2017 and 2018 in cooperation with the European Table Tennis Union. Finally, future perspectives will be proposed for discussion.

Donor sports for talent transfer in table tennis

Johan Pion[1], Jan Willem Teunissen[1], Irene Faber[2]

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Talent development in sports is suggested to be multidimensional by nature (Elferink-Gemser et al., 2011). Table tennis is not an exception. Table tennis is a complex sport in which players need to develop tremendously in several fields to be able to excel. Both physical and mental aspects need to be considered during the development and monitoring of players to have better idea about their status, development and also their potential (Faber et al., 2015). Besides this, it is important to take into account the environment and the interaction between the players and his/her environment (Faber, 2016). An evidence-based international multidimensional benchmark for elite youth table tennis is proposed to support table tennis talent development programs worldwide. For that reason, a multidimensional test battery was developed including tests for physical and mental aspects as well as the player's opportunities with regards to training and competition. The presentation will outline the rationale for the development and the content of the multidimensional assessment and two first explorative studies: the results of a small pilot-study which was conducted in Scotland (2016) (Doherty et al., 2018) and the results of an explorative study during the Euro-Talent Selection Camps of 2016, 2017 and 2018 in cooperation with the European Table Tennis Union. Finally, future perspectives will be proposed for discussion.

Sleep, Travel & Jet-lag

The importance of sleep for recovery in athletes

Sabrina Skorski
Saarland University, Saarbrücken, Germany

All in a good night's sleep: recovery and travel implications for sporting populations

Hugh Fullagar
University of Technology Sydney, Sydney, Australia

Workshop: Blood Flow Restriction

Blood Flow Restriction Training

Michael Behringer

Goethe University Frankfurt, Frankfurt, Germany

There is growing evidence that low load resistance training (~20–30% 1RM) is capable of inducing hypertrophy and strength gains when the blood supply to the working muscles is reduced. This ischemic condition is usually produced with the help of specially designed inflatable cuffs, which are attached proximal on the extremities. An alternative to these inflatable cuffs is elastic bandages, which are often used in practice due to their lower cost and better availability. To distinguish this form of training from classical blood flow restriction training with inflatable cuffs (BFR), the term practical blood flow restriction training (pBFR) is often used. For both BFR and pBFR there are already numerous studies available which confirm the effectiveness of these forms of training for individuals with different levels of physical fitness. That is, training effects in the form of muscle strength and mass gains have been shown both for patients with severely impaired physical capacity and for well-trained athletes. Interestingly, the effects of the BFR training are not limited to muscles whose blood supply is reduced during training, indicating that at least some systemic mechanisms underlie the effects BFR induced effects. In addition to the numerous documented positive effects of BFR training, it should be emphasized that this training method is associated with a low side-effect profile, at least in healthy individuals. However, some long-term effects, such as the effect on the vascular system, are still largely unknown and need to be investigated in more detail by future studies.

[YIA] Poster Presentation 1: Training & Testing

[YIA] Modeling Postural Control in Parkinson's Disease

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The fear of falling due to changes in gait leads to a decrease in quality of life in Parkinson's patients. However, the reasons for the changed walking style still remain unknown.

The goal of the scientific work is the evaluation of possible reasons for the changed walking pattern in Parkinson's disease. Walking is a largely unconscious action, which is believed to be generated by adjustable neural networks, so-called central pattern generators (CPG). It is investigated, whether Parkinsonian walking can result from changed CPG modulation. Based on gait data, differences between Parkinsonian and physiologic gait are replicated by a simplified walking model representing physiologic and Parkinsonian gait, respectively. We calculated the intersection point for the ground reaction forces with respect to body coordinates, the virtual pivot point (VPP, Maus et al., 2010).

In Parkinsonian gait, we observed different force and torque patterns compared to healthy walking with VPP location below the center of mass.

The model can represent physiologic walking. A negative VPP location as observed in Parkinsonian gait results in loss of gait stability as predicted by the model.

The newly developed gait model can represent the general dynamics of human walking. The model configuration of Parkinsonian gait does not result in stable walking. In Parkinsonian walking, patients use other compensating strategies for achieving stable gait, requiring additional effort to provide additional high-level motion control for stable gait. A changed modulation of CPG alone is not enough to achieve gait stability in Parkinsonian gait.

[YIA] Effect of age on reactive multidirectional speed in highly trained young soccer players

Daniel Büchel, Tim Lehmann, Jochen Baumeister

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Soccer is characterized by highly intermittent activity, including more than 700 changes of direction during one match. Therefore, reactive multidirectional speed seems to be a crucial ability for soccer players (Sheppard and Young, 2006). The aim of our study was to investigate age differences in a reactive multidirectional speed assessment in highly trained young soccer players. The results are important to adjust agility training to different age groups.

72 highly trained young soccer players (14.3 + 1.1 years, 61.3 + 11.1 kg, 172.0 + 9.8 cm) were tested in a modified reactive multidirectional test (RMT) (Achenbach, 2018). Furthermore, performance in Squat Jump (SJ), Counter Movement Jump (CMJ), Drop Jump (DJ) and 10-meter linear sprint (LS) was assessed from all players. ANOVA was performed to analyze the effect of age ($n = 16$ U-17, $n = 23$ U-16, $n = 16$ U-15, $n = 17$ U-14) on all outcomes ($p < 0.05$).

ANOVA revealed significant effects of age on RMT and also on LS, SJ and CMJ ($p = 0.01$). Post-hoc tests revealed that U-17, U-16 and U-15 players performed significantly better than U-14 players at all tests. Furthermore, U-17 ($p > 0.01$) and U-16 players ($p = 0.02$) revealed significantly higher values than U-15 players for SJ height. No differences in performance were observed between U-16 and U-17 players.

Reactive multidirectional speed is affected by age. Older players moved quicker than U-14 players. No further improvements in performance were observed from U-15 to U-17 players. Findings may suggest that adolescent players require specific training of agility to utilize increments in body mass and increase physical performance.

[YIA] Vertical Jump Performance in German Youth Soccer Players

Marco Backfisch, Oliver Ludwig, Michael Fröhlich

TU Kaiserslauternm Kaiserslautern, Germany

Explosive strength in form of vertical jumping is part of every training routine as well as talent selection in soccer. In spite of the popularity of soccer, only few studies have been carried out regarding physical traits and motor abilities of young athletes in a laboratory setting, especially with regard to leg muscle power. The aim of this study was to investigate the influence of age on typical jump parameters in male football players and to provide reference data.

376 male soccer players, all members of competitive soccer clubs, participated in the study. They were examined for anthropometric characteristics and absoluted a jumping test battery consisting of counter movement jump (CMJ), squat jump (SQJ), and drop jump (DJ) as a measure of jump performance. Four age groups were analyzed (age 11–12 years: $n = 69$, age 13–14 years: $n = 160$, age 15–16 years: $n = 115$, age 17–18 years: $n = 32$). ANCOVA was calculated for the anthropometric parameters and jump variables. There were significant differences between all age groups for weight, height, and vertical jump parameters (CMJ: $F(5) = 59.29$, $p < 0.001$; SQJ: $F(5) = 44.95$, $p < 0.001$; DJ: $F(5) = 42.27$, $p < 0.001$).

The main finding of this study is that age is an important factor on all tested jumping tests. All jumping parameters increased with age. The findings of this study could be useful for coaches and trainers in the context of talent identification and training optimization.

[YIA] Sports-specific differences in reactive multidirectional speed in team sports athletes using the Speedcourt©

Daniel Büchel; Michael Döring; Fides Berkel; Jochen Baumeister

Paderborn University, Paderborn, Germany

Reactive multidirectional changes play an important role in team sports like team handball and soccer. Only few studies investigated differences in multidirectional movements in response to visual stimuli between dif-

ferent team sports yet but indicate that adolescent soccer players perform better for both reactive lateral and diagonal movements compared to age matched handball players (Achenbach, 2018). The aim of this study was to investigate whether adult high-performance soccer and handball players also differ in reactive multidirectional performance.

Highly trained soccer ($n = 10$; $25.3 + 2.8$ years) and handball players ($n = 12$; $20.2 + 2.8$ years) were assessed by means of a Reactive Multidirectional Test (time), a Side-Hop Test (number of contacts) and a Tapping Test (number of contacts) using the SpeedCourt System (Globalspeed, Hemsbach, Germany). Independent t-test were used to analyze differences in outcome parameters between groups ($p < 0.05$).

Statistical analysis revealed significant differences between adult soccer and handball players in terms of Reactive Multidirectional Test performance ($16.4 + 0.7$ vs. $15.6 + 0.7$; $p = 0.03$). Results in the Tapping Test and Side Hop Test did not differ between groups.

Adult handball players demonstrate a better performance in reactive multidirectional speed compared to soccer players. Differences might be explained by sport specific demands in team handball. The implementation of reactive agility into athletes' assessment is promising due to new technologies as they seem to be sensitive to different sport specific demands. This might help to individualize and optimize training in different sport specific scenarios.

[YIA] Static Stretching: Effect of an Acute Fatiguing Intervention on Non-invasive Indexes of Muscle Function While Cycling in the Severe Exercise Intensity Domain

Alessandro Colosio, Emmanuele Baldessari, Silvia Pogliaghi

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We tested the hypothesis that static stretching (STRC), an acute, non-metabolic fatiguing intervention, reduces exercise tolerance by increasing muscle activation and affecting muscle bioenergetics during cycling in the "severe" intensity domain.

On 4 different days, eight active males repeated an identical constant load cycling test above critical power. Randomly, 2 of the tests were done in control conditions (CTRL) and 2 after STRC, that caused an acute, 5% reduction of maximal isokinetic sprinting power output. We measured: i) oxygen consumption (VO2); ii) Surface electromyography (Normalized Root Mean Square, nRMS); iii) Deoxyhemoglobin (HHb); iv) Blood lactate concentration ([La]–); v) time to exhaustion (TTE). Data from two identical repetitions were averaged and compared by 2-way RM-ANOVA (exercise time and condition). TTE was compared by paired t-test.

STRC significantly impaired TTE (CTRL:$14'00 \pm 3'48''$, STRC:$12'24'' \pm 3'06''$, $p = 0.013$). A significant effect of condition was detected for nRMS ($p < 0.001$) and HHb ($p < 0.001$), that were increased after STRC at a given time vs CTRL. However, no significant main effect of condition was detected for either VO2 ($p > 0.05$) and [La]– ($p > 0.05$).

As hypothesized, STRC significantly reduced exercise tolerance and increased muscle activation for a given load in the severe domain. This was accompanied by a significant increase in muscle deoxygenation, indicative of an increased mismatch between O2 utilization and delivery after STRC. However, STRC was not associated with a modification of the muscle bioenergetics. Increased peripheral muscle activation and deoxygenation seems to be the main cause of early exhaustion in our study.

[YIA] A systematic review and meta-analysis about the effects of high-intensity interval training on physical fitness, health parameters and patient-reported outcomes in cancer survivors

Nils Freitag[1], Hendrik Mugele[2], Jannik Wilhelmi[1], Yanxiang Yang[3], Sulin Cheng[4], Wilhelm Bloch[1], Moritz Schumann[1]

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This systematic review with meta-analysis aimed to elucidate the physiological adaptations of high-intensity interval training (HIIT) compared to moderate-intensity continuous training (MICT) or usual care (UC) on physical fitness, health parameters and patient-reported outcomes in cancer survivors.

The electronic databases PubMed, Web of Science and EMBASE were searched according to PRISMA guidelines until October 4th, 2018. Adult patients of various cancer entities, performing HIIT compared to MICT or UC were eligible for inclusion. The primary outcome of interest was cardiorespiratory fitness (VO2peak). Secondary outcomes included body composition measures, blood-borne biomarkers as well as the patient-reported outcomes quality of life and cancer-related fatigue. Mean differences (MD) were calculated and pooled to generate effect sizes for VO2peak. A total of 1453 studies were identified with finally 12 articles included. Mean intervention duration was 6.7 ± 3.0 weeks, with 2.8 ± 0.5 trainings per week. Pooled analysis for VO2peak revealed greater effects of HIIT compared to UC (MD 3.73; 95% CI: 2.07, 5.39; $p < 0.001$) but not MICT (MD 1.36; 95% CI:–1.62, 4.35; $p = 0.370$). Furthermore, HIIT showed to be more beneficial in reducing fat mass compared to MICT, but no superior effects were found of HIIT compared to MICT for changes in quality of life, cancer-related fatigue or lean mass.

HIIT appears to be more beneficial than UC in cancer survivors for most of the outcomes of interest. However, HIIT may not be superior to MICT in terms of improving physical fitness or patient-reported outcomes.

[YIA] Correlation between physical performance parameters and race performances during an incremental step test in highly trained flat-water sprint kayak athletes on a kayak-ergometer

Manuel Matzka[1], Philipp Kunz[2], Christoph Zinner[3], Billy Sperlich[2]

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The aim of the present study was to analyze the correlation between aerobic performance measures during an incremental test on a kayak-ergometer and on-water competition race times in highly trained kayakers.

Fourteen participants performed an incremental test on a kayak ergometer one to two weeks post an official competition where they performed at least two of the three Olympic distances (1000 m, 500 m, 200 m). The incremental test consisted of five 1500 m-trials, starting at 60% of maximum heart rate and ended with a maximal effort. Oxygen consumption (VO2) and power output were measured throughout each increment, while blood lactate samples were taken after each stage.

Race times (mean $\pm$ SD) for 200 m, 500 m, and 1000 m were 41.61 ± 4.15 s, 112.38 ± 8.18 s and 251.29 ± 25.31 s, respectively. Significant correlations for all three distances were found for average power output during the last stage (POmax) of the incremental test, with the highest correlation for the 500 m race time (200 m: $r2 = 0.75$, $r = 0.87$, "$p < 0.001$"; 500 m: $r2 = 0.86$, $r = 0.93$, "$p < 0.001$"; 1000 m: $r2 = 0.66$, $r = 0.81$, $p = 0.002$). Correlation was also found between race performances and VO2max (200 m: $r2 = 0.69$, $r = 0.83$, "$p < 0.001$"; 500 m: $r2 = 0.72$, $r = 0.85$, "$p < 0.001$"; 1000 m: $r2 = 0.58$, $r = 0.76$, $p = 0.007$).

The athlete's ability to produce a high POmax as well as to achieve high aerobic capacities during an incremental test on a kayak-ergometer correlates highly with on water race performance, with the highest correlations being evident for the 500 m-distance.

[YIA] The Attractor Method–Striking a new path on cyclic sports analyses

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Kinematics of cyclic sports like running appear simple. However, there are many issues regarding individuality, efficiency, rhythm, and variables describing motion. Further insights of human locomotion may provide tips to enhance athletes' performance. The Attractor Method combined with cost-effective MEMS sensors aim to meet these targets. Limit-cycle attractors represent equilibrium regions in phase space describing movement dynamics over a whole measured interval. It can be used in training science to improve techniques via accelerometry, velocity, and coordinate perspectives.

The study included (1) a comparison of skiers at different performance levels, (2) analyses of an athletes' stride running at increasing paces, and (3) assessing short- and mid-distance swimmer's forearm acceleration.

Results: (1) Showed similar global patterns for techniques, but between skiers, clear distinctions existed. (2) Described a clear recognizable course, independent of the conditions and a significant characteristic of the toe-off push and heel swing increasing with running pace. (3) Despite no statistical difference in acceleration of the groups, distance specific attributes were clearly seen.

This method enables the transfer of raw data into daily training to evaluate current performance and make suggestions to improve. Thus, the approach represents a low-priced, easy-to-use tool to assess cyclic motion. A plug and play solution for public use is in progress.

[YIA] Pressure Level in German Junior Bundesliga Soccer

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Small-sided games (SSGs) are a constraints-based form of game specific training where exercise intensity can be prescribed by different constraints. To ensure a suitable usage of the 4vs4 SSG in soccer practice, the optimal pitch configuration design should correspond to competition demands and thus be derived from game analysis. Whereas current studies primarily concentrated on the effects of the pitch design regarding the physiological demands the aim of the present study was to diagnose the pressure level on the player with the ball (PwB) at the highest youth competition level in Germany. 6 games in the age groups U15/U17 were tape-recorded, and player's positions were tracked and analyzed by direct linear transformation (2D-DLT). The pressure on the PwB was determined by the smallest rectangle that includes the PwB plus his nearest 3 teammates and the 4 nearest opponents. We hypothesized and showed that the pressure on the PwB affects (i) the win or loss of the game ($p < 0.05$), as well as (ii) the success rate of the received and released balls of the PwB, which significantly correlated with the pressure on the PwB ($p < 0.05$) in the U15 age group, whereas the U 17 players only showed a statistical tendency ($p = 0.81$) in this direction. Based on our results the pitch size for SSG 4-4 in training should range between 450–500 m² to correspond with competition demands. Our results indicate that the pressure level is a valuable variable that should be considered within the training process.

[YIA] The influence of synchronous music on aerobic endurance performance, perceived exertion, flow and enjoyment

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According to a preliminary study and research this study examined perceived exertion, flow and enjoyment by comparing the 6 min run of a selected number of probands without music vs. with music. Because there is limited research in this area (Terry & Karageorghis, 2006), synchronous music was used.

11 sport students (7 male, 4 females, age: 22.2 ± 1.7 years) performed the 6 min run three times. The first one as a pretest, the second run without music and the third run with specially selected music adapted to the average heart rate of the pretest (164 bpm). Each test was done under equal conditions. Validated questionnaires (Borg-RPE-scale, Flow-short-scale, PACES) assessed perceived exertion, flow and enjoyment after each run. Reached distances were not significantly higher ($p > 0.05$) as well as the maximum and average heart rates showed no significant change ($p > 0.05$). Analysis of the questionnaires showed no difference in perceived exertion ($p > 0.05$), flow ($p > 0.05$) and enjoyment ($p > 0.05$).

Music synchronized to the heart rate has no influence on the aerobic endurance performance, (perceived) exertion, flow and enjoyment. According to the average results music leads to no significant change in both, negative or positive side. Just the assessment of individual experimentee leads to the assumption of music having a diversionary effect which, however, does not affect the overall evaluation.

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[YIA] Pressing Evaluation in the German Bundesliga Season 2016/17 Using Positional Data of Defensive Actions

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The aim of this study was to evaluate the relationship between the quality of a high press and teams' success in soccer by developing a new way to measure pressing based on the positions of ball recoveries in the opposition half. Additionally, the effect of managerial changes during the season, on the so-called pressing output, should be identified. Therefore, all 306 games of the season 2016/17 of the German Bundesliga were analyzed post-event. Top teams had significantly higher pressing outputs than average teams and weak teams ($p < 0,05$). However, even though the correlations between the new metric and team success were significant ($p < 0,01$), in comparison to other defensive metrics they were small. Moreover, in most cases differences between the pressing outputs before and after managerial changes could not be verified.

The results of this study imply that top teams press higher, more intensive or with a greater focus on recovering the ball in offensive areas compared to the rest of the league, while the intensity and height of a press seem to be the more influential parameters. Furthermore, the survey indicates that clubs tend to hire coaches that retain the existing playing style of the team after in-season managerial sackings.

Energy Balance & Energy Expenditure; from Whole Body to Cellular Adaptations

Energy expenditure during and following aerobic and resistance training

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Energy availability is an important contributor to athletic performance as low energy expenditure has been associated with impaired physiological function and increased injury risk. In order to ensure sufficient energy intake accurate information on total daily energy expenditure is necessary. While activity trackers may provide accurate estimations of energy expenditure during habitual physical activity, they generally perform poorly at higher intensities, which are commonly experienced during training sessions. Further, activity trackers may be limited in the ability to account for increased energy expenditure following exercise (i. e. excess post-exercise oxygen consumption, EPOC). Using indirect calorimetry, available research indicates greater energy expenditure during aerobic training (continuous as well as interval training) compared to resistance training. Between different resistance protocols, higher intensities with a

lower number of repetitions have been associated with greater energy expenditure. Strength-endurance training with lower intensities and a higher number of repetitions, however, has been shown to result in a more pronounced increase in energy expenditure after the exercise bout, which mitigates differences in total energy expenditure associated with different resistance training protocols. Even though EPOC has been shown to remain for up to 72 h following exercise, both, high-intensity interval training as well as high intensity resistance training, have been associated with declines in resting energy expenditure during the initial 90 min following the training bout when energy intake was restricted. Adequate dietary intake, therefore, plays an important role in ensuring physiological function, particularly following intense training bouts.

Energy Balance and Nutrition in Elite Sports–Insights into Metabolic Adaptations and Implications for Practice

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Among the unique features of competitive athletes is their sustained, high level of energy expenditure during training and/or competition, placing at an increased risk of becoming energy deficient if not balanced by adequate nutrition. While a negative energy balance may be encouraged in certain sports that emphasize leanness or low body weights, chronically low levels of energy availability result in metabolic adaptations that bear the potential to negatively impact an athlete's health and performance. These metabolic adaptations are quantifiable as measurable declines in resting metabolic rate, the amount of energy an individual expends to sustain normal metabolic functions, indicating a state of energy conservation in which energy is steered away from non-vital processes, including growth and reproduction. Metabolic adaptations relevant for athletes include the downregulation of key anabolic pathways, including the growth hormone/IGF 1 axis and the hypothalamic-pituitary-gonadal axis, and downstream effects on synthesis and breakdown rates of muscle protein and bone tissue. In addition to an increased risk for musculoskeletal injuries, there is emerging evidence that athletic performance is also impacted negatively in the energy-deficient state. Dietary and training strategies that have the potential to alleviate the detrimental effects of energy deficiency in athletes include site-specific exercise and increasing dietary protein intake.

Resistance exercise and mechanical stress: Between muscle anabolism, damage and mechanoprotection

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Resistance exercise exerts significant skeletal muscle growth and increased strength abilities. One of the major mechanisms responsible for initiating these effects is the mechanical tension which is applied on sarcomeres during contraction. Although the exact amount of mechanical tension necessary to optimize the adaptive response of human skeletal muscle is still debated, it is known that extended time courses of low mechanical tension induce de-adaptation while augmentation of eccentric contractions may enhance skeletal muscle adaptation. However, as a result of high mechanical tension due to high intense and eccentric muscle loading, protein anabolism as indicated by increased mTOR-related signaling is increased, while simultaneously, specific protein degradation systems are upregulated. This ensures a tight coupling between synthesis of myofibrillar proteins and the degradation of mechanically damaged sarcomeric and Z-disk proteins. Chaperone assisted selective autophagy (CASA) does not only degrade damaged or partially unfolded Filamin proteins (FLNc) in skeletal muscle Z-disks, but also offers a mechanism by which repeated mechanical strain is linked to increased expression of FLNc, thus regulating enhanced sarcomeric stability in response to repeated mechanical strain. While high intense eccentric contractions are associated with significantly increased phosphorylation of important mTOR-related signaling molecules when compared to low intense resistance exercise, sarcomeric substructures are substantially degraded upon eccentric contractions. Under these conditions CASA subsystems are also significantly increased within 24 h after eccentric but not low intense resistance exercise. Interestingly, repeated resistance exercise over several weeks with either progressive or constant loading, oriented along resistance exercise intensity, does not differ substantially in the maintenance of the anabolic response and the amount of hypertrophy. Instead, progressive but not constant loading is associated with permanently increased CASA associated with enhanced incorporation of FLNc within sarcomeres after several weeks. This reponse is associated with decreased sarcomeric damage and may provide a mechanism contributing to the repeated bout effect.

These observations suggest an important role of a yet hard to define magnitude of mechanical loading on skeletal muscle adaptability during resistance exercise programs. They offer also an opportunity for the coach and the athlete to reconsider extended phases of resistance training as a stimulus that substantially enhances sarcomeric infrastructure and stability, importantly beyond the hypertrophy dogma.

Acute and chronic effects of resistance exercise on the stress response in skeletal muscle fibers

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A key element of resistance exercise is high mechanical strain which acts on skeletal muscle. On the one hand, mechanical strain provides the basis for the development, maintenance and increased functional capacity of skeletal muscle. On the other hand, acute unfamiliar mechanical strain can lead to deterioration of myofibrillar integrity in the form of z-disc streaming and mechanical unfolding as well as degradation of cytoskeletal proteins, which collectively is referred to as "stress".

The conservation and improvement of mechanical stress-resistance and hence functional capability of skeletal muscle is a main challenge in aging, rehabilitation as well as elite sport. Skeletal muscle cells have developed systems to cope with cell stress in order to maintain proteome stability. In this context, small heat shock proteins, including α-B crystallin (CRYAB) play an important role. CRYAB acts to protect cell integrity by stabilizing the cytoskeleton and by trapping unfolding proteins in prevention of their aggregation and for guiding them to proper refolding or degradation pathways.

Based on CRYAB induction-patterns, it will be presented how varying resistance exercise-methods and volumes exert acute stress on skeletal muscle fibers and how they affect different fiber entities (type I and type II fibers). Further, the influence of systematic repeatedly applied resistance-exercise on CRYAB induction and hence mechanical stress-sensitivity of skeletal muscle fibers will be depicted as well as the influence of cessation of this exercise.

Individualization in Recovery Science

Individual effects of different recovery interventions: a review on six years of REGman research

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The presentation will give an overview about multiple crossover intervention studies completed during the last six years of the multicenter long-term REGman-project: regeneration management in sports. Studies with elite athletes in Volleyball, Olympic Weightlifting, Tennis and Long-distance Running about the effects of active recovery, cold-water immersion, massage and foam rolling showed trivial to small positive effects for all recovery interventions on a group-statistical level. These data will be reanalyzed to quantify all single-case performance-enhancing effects by using an individual statistical approach. Therefore, we identify those athletes in each

study having a likely and practical relevant effect on performance markers (i. e., individual response exceeds the typical error of measurement). **Exemplary results:** Six competitive German weightlifters from the Olympic national team participated in a crossover-designed intensive micro-cycle. Each training was followed either by active (ACT) (submaximal rowing-ergometer exercise) or passive recovery (PAS). The effects on maximal barbell velocity during the clean pull (CP: 85, 90 and 95% of 1RM) were measured before and after the micro-cycle. The training block induced small performance decrements between Pre and Post over all relative CP intensities (CP85, ACT: Effect size (ES) = –0.20, PAS: ES = –0.50; CP90, ACT: ES = –0.29, PAS: ES = –0.35; CP95, ACT: ES = –0.41, PAS: ES = –0.20). There were neither significant recovery type × time interactions nor meaningful differences in pre-post changes between ACT and PAS in all analyzed variables. However, two athletes showed a likely beneficial response to ACT versus PAS, whereas one athlete showed a likely detrimental effect to ACT versus PAS.

Individualized reference ranges for muscle recovery assessment in football

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In football, monitoring fatigue and recovery is considered essential to prevent injuries and to optimize performance. However large interindividual variability impedes on the diagnostic accuracy of all parameters known to date. To address this shortcoming, an individualization algorithm has been recently developed and shown to significantly improve diagnostic accuracy of creatine kinase (CK) and urea in endurance sports (Hecksteden et al., 2016). In this study, applicability and benefit of this algorithm was evaluated using repeated measures data from 44 professional German football players monitored during the 2015–2017 seasons. Group-based reference ranges were derived from that same dataset to ensure a best possible reference for comparison. A Fisher's Exact test was conducted to analyze differences in error rates between individualized and group-based classifications. CK values showed significantly lower error rates in the assessment of muscle recovery for the individualized approach ($p < 0.001$; X2 = 16.1, test-pass: 17 vs. 33%; test-fail: 31 vs. 10%), whereas only test-fail error rates were different for urea ($p = 0.001$, 25 vs. 49%, test-pass: $p = 0.05$, 11 vs. 39%). Also, in football, assessment of muscle recovery by individualized interpretations of blood-borne markers may offer higher diagnostic accuracy as compared to a sample specific group-based approach.

The effects of Foam-Rolling (FR) and Cold-Water-Immersion (CWI) on recovery in elite Volleyball-player after a standardized simulated match

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For the efficacy of different recovery strategies, a lack of knowledge for the positive effects on objective recovery markers following match intensities in team sports is existent. For these reasons, this work compares the effects of two currently highlighted recovery tools, Foam rolling (FR) and Cold-Water Immersion (CWI), in response to a simulated volleyball match in young elite athletes. 12 male volleyball athletes (Height: 193.9 ±4.6 cm; Mass: 89.7Kg ±7.9 Kg; Age: 18.1 ±0.5 years) were randomly assigned to the three groups i) FR, ii) CWI and iii) Control. Creatinkinase (CK) and vertical jump height (CMJ) without arm swing were measured pre, post, post 6 h and post 24 h to a standardized match simulation. No significant temporal changes were detected for CK and CMJ pre to post 24 h by ANOVA. No group (regeneration) or interaction (time*regeneration) effects could be found. CK mean percentage changes from pre to post 24 h were +47% (FR), +46% (CWI), +40% (Control) and +1%, 0%, –1% for CMJ. Altogether two subjects (FR), four subjects (CWI) and two subjects

(Control) were above their biological variance (CV) in CMJ performance post 24 h while three, one and three were below and six, six and six subjects were within. This is the first study analyzing the effects of different recovery tools (FR and CWI) in response to a standardized match simulation in volleyball. Although percentage changes failed for statistical significance, more subjects seem to positively respond to CWI for functional jumping.

Using heart rate monitoring to individualize training and recovery prescription

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Heart rate (HR) measures are attractive tools to monitor individual training and recovery response as they provide non-invasive and time-efficient insights into the status of the autonomic nervous system (ANS) and aerobic fitness [1]. The presentation will provide an overview of several intervention and observational studies using resting or exercise-related HR measures which were conducted within the long-term REGman-project (regeneration management in sports).

Within the sport scientific literature, all HR markers have been discussed for assessing fatigue, recovery, fitness and performance changes [1]. If different HR measures can provide similar information, it may be advisable to use as few markers as possible considering the economy of test administration. Therefore, data from well-trained, semi-professional and elite athletes in different training settings (overload, training mesocycle, competitive seasons) will be reanalyzed focusing on the association between HR markers on the group- and individual-level.

Exemplary results: Eighteen well-trained athletes participated in a six-day running-based high-intensity interval training overload microcycle, showing substantial performance impairments post training (Cohen's d > 0.3). Concomitantly, daily resting HR and HR variability (HRV) in the standing recording were clearly inversely altered on average (d > 0.4). Daily HR and HRV were strongly correlated on the individual-level (average Pearson's r = –0.8, range: >–1.0 to –0.3) as well as for pre-post changes (r = –0.7). Neither HR nor HRV were clearly superior regarding a categorial association to performance changes. In this study, using only one HR measure may be appropriate on the group-level, but not for all single-case analysis.

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[YIA] Individual monitoring of national-ranked tennis players regarding the effects of a four-week foam rolling intervention–a REGmon based analysis

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Athlete monitoring provides various opportunities such as assessing the effects of recovery interventions like foam rolling (FR), which is increasingly popular in competitive tennis. Thus, the aims of the present study were (1.) monitoring physical loads of national-ranked tennis players and (2.) to investigate the effects of an additional daily FR-program on selected psychometric parameters.

So far, eight tennis players (23 ±5 years) participated in an ongoing longitudinal study. A minimum of six weeks of baseline-phase (BP) was followed by a four-week FR-intervention-phase (IP). Monitored parameters included perceived stress and recovery (Short Recovery and Stress Scale (SRSS)) as well as training and competition loads. Four matched weeks of each BP and IP were included in the analysis. Individual averages and standard deviations (SD) were calculated and paired t-tests were conducted to analyze differences. Effect sizes were evaluated with the Δ-index method [1].

No significant group-differences were observed besides a significant ($p < 0.05$) increase in the duration of recovery strategies. However, 5 of 8 athletes showed positive tendencies from BP to IP in SRSS items 'Muscular

Stress' (MS)', 'Physical Performance Capability' (PPC)' and 'Overall Recovery' (OR)' with mainly medium effect sizes. Exemplary results of one participant in BP versus IP were 2.4 – 1.5 in MS, 3.8 – 4.3 in PPC and 3.7 – 4.3 in OR.

Although no significant group effects were observed, positive tendencies on an individual level showed that single athletes may benefit from FR regarding perceived stress and recovery.

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Training & Testing–Varia 1

[YIA] Variation and progression in performance of German national junior athletes and their development to national senior athletes

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In high performance sport, it is important to predict future performance in junior athletes. In swimming, different selection criteria have been tested in past research papers. The purpose of this study was to investigate if variability could be a selection criterion in junior athletes. We analyzed more than 1300 competition results of German national team athletes over seven consecutive years to investigate the development of junior into high performance athletes. We found that variability in general could be a predictor for future success. Different subgroups varied in the age their performance showed less variability. Our investigation showed that variability could be a predictor in junior athletes by looking at specific subgroups.

[YIA] Development of performance diagnostics for the Olympic combined climbing format

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The aim of the study was to develop performance diagnostics for the Olympic Combined competition in sports climbing. In a first step, we carried out expert interviews with national squad coaches of German-speaking countries with the guiding question, which attributes characterize elite-level climbers. The influence of all those components on climbing performance has to be empirically tested (Hohmann, Lames & Letzelter, 2012). Therefore, we applied to different levels of climbers the existing test battery of the International Rock Climbing Research Association (IRCRA, 2015) as well as new developed tests for the components, which had been identified as relevant, but have been neglected so far. Our results with regional youth squad athletes and athletes of the Bavarian youth squad ($n = 33$, 14.85 ± 2.8 years) are indicating, that the relevant parameters differ between the single disciplines and the combined format. Speed strength of the upper body was especially relevant for speed climbing, whereas finger strength, rotational hip flexibility and a low body fat percentage was important for all disciplines. This data is the first step to create an empirically based structural performance model, which may improve performance diagnostics by generating individual performance profiles and quantifying individual strong and weak points in the single disciplines.
Keywords
performance analysis
Olympic combined climbing format

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[YIA] Denotation, connotation and association of the term ‚training'

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Separate from the field-specific definition of the German term 'training' in training science, there is an everyday understanding which is rarely empirically described. Therefore, this study will analyze (1) the relationship between personal characteristics and the subject-related importance of training, (2) the assigned relevance of training in various settings of application and (3) the everyday understanding.

Based on a mixed methods design with a focus on an online survey, 541 persons were asked for association ratings of training with their own activity and activities which map to sport models. The denotative and connotative meanings of the term were collected by semantic differential. Statistical analysis was made considering the alpha-error accumulation (Holm-Bonferroni Method).

(1) Individual characteristics significantly predict the criterion 'assignment of training to one's own physical activity', $F(5,532) = 112.62$, $p < 0.001$, $R2 = 0.51$, ($\alpha = 0.002$). (2) There are significant differences in training relevance among sport models, $F(5,34) = 10.21$, $p < 0.001$, $\eta p2 = 0.60$ ($\alpha = 0.003$). (3) Different understandings of the term can be demonstrated on the basis of four factor-analytically determined dimensions of meaning. In everyday understanding, training is perceived as targeted, planned and systematic; moreover, the term is predominantly connected with positive attributes. Only a slight polarization towards an extended understanding can be observed in the semantic differential.

The separation of the everyday understanding from the field-specific definition primarily takes place at the level of the extended understanding. Due to heterogeneous feature assignments to activities within the same model, application of the term 'training' to the current study's sport models seems unsuitable.

Concurrent Validity of a Contact Mat and the My Jump 2 App for Android for Measuring Vertical Jump Performance

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To investigate the concurrent validity of the Haynl-Elektronik contact mat and the My Jump 2 App for Android for measuring countermovement jump (CMJ) and drop jump (DJ) performance.

Twenty male volunteers performed maximal CMJs and DJs on the contact mat that was placed on top of a force platform (criterion method) while simultaneously being recorded using the My Jump 2 App. For the CMJ flight time (FT), jump height (JH) and average concentric force (F), power (P) and velocity (v) were calculated while for the DJ FT, JH, ground contact time (GCT) and reactive strength index (RSI) were determined from all three systems. In total, 20 data points per jump were compared using effect size estimates, coefficient of variation (CV%) and Pearson's correlation coefficient.

For the CMJ, both FT and JH were slightly overestimated for the contact mat while systematic biases for My Jump 2 were trivial. Small to large differences were evident for P, F and v for both devices. However, CV% values were all <10% except for P and correlations ranged from very large (F, P, v) to almost perfect (FT, JH). For the DJ, systematic bias was trivial for My Jump 2 but small for the contact mat for all variables. There were almost perfect correlations between devices with CV% of <10% for all variables. While the My Jump 2 App provides a valid method to measure DJ performance and CMJ JH systematic bias should be considered when interpreting data derived from the contact mat.

Suitability and reliability of stress and recovery markers in endurance sports

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The current study aims to analyze the reliability of various subjective, functional and biochemical markers in endurance exercise, thereby evaluating their suitability for monitoring training and recovery cycles.

Sixty-two healthy subjects (age 19–43) completed two identical 60-minutes continuous endurance field tests intermitted by a recovery period of four weeks. Exercise protocol consisted of 40 min running at an intensity corresponding to 95% of heart rate at individual anaerobic threshold (IAT), followed by 20 min at 110%. Before, immediately after (IA), three hours after (3 h), and 24 h after (24 h) each exercise bout, maximum voluntary contraction (MVC), 5-bound test, Borg scale (BS), Multidimensional Mood State Questionnaire (MDMQ), blood cells, and plasma concentration of creatine kinase (CK) and thiobarbituric acid reactive substances (TBARS) were assessed. Statistical analysis was performed using two-way ANOVA, Bonferroni post hoc analysis, and intraclass correlation coefficient (ICC).

Concentrations of CK, TBARS, blood cell markers, MVC, BS, and MDMQ changed significantly over time ($p < 0.05$). We proved excellent reliability for the MVC and 5-bound test (ICC > 0.90), followed by a good reliability for hemoglobin (ICC = 0.86) and platelet concentration (ICC = 0.77). For TBARS, CK and BS only moderate reliability was found (ICC < 0.75). The excellent to good reliability of the parameters MVC (knee flexion), hemoglobin and platelet concentration may implicate their suitability as stress and recovery markers for monitoring athletes training.

Poster Presentation 2: Training & Testing

Evaluation of the Bourban trunk muscle strength test using electromyographic parameters

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A functionally trained and stable trunk musculature is of an overall sports importance with a preventive function. The determination of the trunk muscle strength usually takes place with the help of technical equipment. However, in the field of recreational sports device-based diagnostics are limited due to the test economy, practicability and the effort-benefit ratio. The Bourban test supposedly is an economic alternative (Tschopp et al., 2001). The aim of the evaluation study was to check whether the selected exercises of the Bourban test actually fatigues the main muscle groups of the trunk and is thus a valid diagnostic tool.

A total of 30 healthy, male subjects completed the standardized bourban test consisting of four exercises for the ventral (plank), lateral right and left (side plank) and dorsal chain (hyper extension). According to authors guidelines the movement speed and range of motion was standardized and controlled by means of a metronome and spanned ropes. All exercises were performed up to the point of subjective complete exhaustion or stopped in case of deviation from the instructions. Operationalization was carried out in pre-post-design using the electromyographically determined median frequency. Analyzed were M. rectus abdominis, M. obliquus externus abdominis, M. erector spinae lumbalis and thoracalis.

The data acquisition is still in process. Results and interpretation will follow.

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The effect of current race position on change-over time in swimming relay races

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Short change-over times (COT) in swimming relays can play an important role in winning a race. Therefore, experts recommend to specifically train change-overs between swimmers to minimize COT (Maglischo, 2003; Siders, 2010; Saavedra et al., 2014). However, in a real competition, COT could be affected by other factors such as the race position of a relay team and the order of fast and slower team members. Related to the New Prospect Theory (NPT) of Kahneman and Tversky (1979) we hypothesized that relay teams whose current race position is located close to the medal ranks exhibit shorter COTs (to take the chance of reaching the medal ranks) than relays whose current race position is within the medal ranks (to avoid the risk of a false start, thus losing the race). Therefore, top-class international 4×100 m freestyle races were analyzed across a 10-year period including three Olympic Games and five European and World Championships. A total of 220 swimmers (116 female, 104 male) were included in this study with an average participation of 1.7 ± 1.2 races. The results confirm our hypothesis for female relay races only. Shortest COTs were shown by female swimmers of relay teams currently positioned on rank 4. In contrast, male swimmers of relays currently positioned on rank 2 showed shortest COTs, while relay swimmers whose current race position is rank 4 showed the longest COTs. The results are discussed within the concept of NPT.

Electromyographic activity profiles of the vastus medialis and gastrocnemius during single scull rowing in the field

Steffen Held[1], Tobias Siebert[2], Lars Donath[1]
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Addressing temporal and electromyographic characteristics of stretch-short cycles (SSC) are crucial for the conceptualization of discipline-specific testing and training. Thus, the present study aimed at elucidating whether the SSC in rowing can be attributed to slow or fast SSC. Male rowers of the national-squad ($n = 10$, 22.8 ± 3.1 years, 190 ± 6 cm, 82.1 ± 9.8 kg) were included in this cross-sectional study with repeated testing design. Surface-electromyographic-activity (sEMG) of the vastus medialis (VM) and gastrocnemius (GM) was captured using bipolar electrodes during rowing (single scull) and subsequently compared to muscle-activity in slow (countermovement jump, CMJ) and fast (drop jump, DJ) SSC. In order to identify reflex-activity, the elapsed time between the onset of EMG-activity and start of eccentric-phase was monitored, with periods up to 120 ms assigned to the reflex-induced phase (RIA). Notable muscular-activity was observed during DJ before the start of eccentric-phase (PRE, $p < 0.001$) as well as during the reflex-induced phase (RIA, $p < 0.001$). By contrast, neither the CMJ nor rowing revealed EMG-activity in these two phases. Only a late EMG-response was observed in all examined muscle-actions (DJ, CMJ, and rowing, $p < 0.001$). In addition, the EMG-onset at CMJ and rowing was considered in relation to the center-of-mass (CoM) turning-point (start of concentric-phase). In this context, CMJ ($p < 0.05$) and race-specific rowing ($p < 0.05$) showed an EMG-onset during the eccentric-phase. As a consequence, the SSC in rowing is most-likely attributable to a slow SSC.

Abstracts

Maximum power in stretch-shortening-cycle during rowing

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As a basic principle, each stretch-shortening-cycle (SSC) in elite sports (e. g. jumping, cycling), is characterized by utilizing optimal movement-parameters (e. g. muscle shortening velocity) for maximum power-output (jump height, cycle velocity). It is however unclear if relevant SSC movement-parameters in rowing, such as stroke-rate and gearing, have to be maximized to obtain maximum power-output or if an optimum relation emerges. Thus, we measured rowing-power-output (Prow), leg-power-output (Pleg) and work-per-stroke (WPS) in dependence of varying stroke-rates (20–45 spm), gearings (inboard-changes 0.87–0.90 m) and drag-factors (100–180 Ws3/m3) during ergometer and in-field rowing. Experienced sub-elite young athletes performed sprint-series on (single scull, $n = 69$, 20 ± 2 years, 186 ± 7 cm, 84 ± 9 kg) and off the water (rowing-ergometer, $n = 30$, 19 ± 3 years, 185 ± 11 cm, 77 ± 19 kg). Prow increases with stroke-rate for the ergometer-test ($r = 0.97$, $p < 0.001$) and the boat-measurements ($r = 0.98$, $p < 0.001$) by 2.7%/stroke and 4.4%/stroke, respectively. Interestingly, stroke-rate had a high impact on WPS ($r = 0.79$, $p < 0.001$) during boat-measurements, compared to no (or specifically no high) impact on WPS ($r = -0.10$, $p = 0.166$) during ergometer-measurements. Drag-factor (ergometer: $r = 0.83$, $p < 0.001$) and gearing (boat: $r = 0.60$, $p < 0.001$) yielded moderate to high correlations to Prow. These results indicate, that no optimum stroke-rate, gearing and drag-factor exist for maximum power-output in rowing (sprint-measurement-range). Accordingly, the measurements yielded maximum power-output for maximum stroke-rate, gearing, and drag-factor.

No gender specific difference in strength performance by non-specific but well-trained persons

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Gender was believed to be a major determinant for strength performance with men reaching higher relative values than women. However, recent evidence seems to put this opinion in perspective and, thus, the aim of this study was to investigate strength performance of well-trained men and women with similar experience in strength training and comparable body composition values.
A total of 34 participants (m = 18, w = 16) were categorized into specific-trained (STA) or non-specific-trained (NSTA) athletes. STA was defined by a minimum of 3-years' experience of systematic resistance training with a mean workload of five training sessions per week while NSTA was defined as only one of the two criteria fulfilled. Outcomes measures included 1-repetition maximum (1-RM) for back squat (BS) and bench press (BP) as well as bioelectrical impedance analysis to determine body composition markers (lean mass, muscle mass and fat mass).
Body composition analysis revealed significant differences ($p < 0.05$) between men and women in both groups for lean mass or muscle mass. Furthermore, significant differences were observed for 1-RM performance in BS or BP between STA and NSTA, with no statistical differences for relative strength between men and women within the NSTA group.
This study provides evidence, that gender is not the main determinant for strength-performance in either non-specific strength-trained athlete. Despite a small but significant difference in body composition, relative strength was equal between men and women. However, this study underlines the fact, that training experience and body composition needs to be particularly matched.

The influence of the „kick-out" during a back-tuck somersault on gaze behavior in trampolining

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This study aims at investigating the gaze behavior of trampoline gymnasts during a back-tuck somersault. The back-tuck somersault is one of the most important elements in trampoline gymnastics, in which gymnasts complete a 360° backwards rotation around the transverse body axis during the flight phase (Heinen et al., 2012; Frohlich, 1980). The performance of a somersault should include an opening phase, i. e. the legs are fully extended pointing vertically at 180° called "kick-out" (FIG, 2017). After that, gymnasts keep a straight position. Gaze behavior is essential for a perfect landing and orientation during the flight phase but the research is still limited (Luis & Tremblay, 2008; Davlin et al., 2004; Heinen, 2011).
Gymnasts supposedly use the trampoline bed as orientation and differences in gaze behavior can be expected, depending on how a somersault is performed. The hypothesis of the present study is that by decelerating their rotation speed with the "kick-out", gymnasts will see the bed earlier and thus have more time to prepare for a good landing.
Therefore, this study examines the influence of the "kick-out" on gaze behavior in trampolining. Gaze behavior is measured using a portable and wireless eye-tracking device. Twelve experienced gymnasts perform 20 back-tuck somersaults (time of flight 1.4 s) with and without the "kick-out". The preliminary results are supporting the hypothesis, as with the "kick-out" the trampoline bed is focused earlier.
We expect that the results can help the coaches to better understand the gymnasts general gaze behavior and the benefits of the "kick-out".

Art du Deplacement (ADD)/Parkour therapy for people with Parkinson's disease? Applying an extreme sport into rehabilitation training to increase physical and mental wellbeing

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The purpose of this study was to transfer ADD training methods into safe training paradigm for people with PD, and coping strategies for mood management through integrating the ADD therapy via the Esprit Concrete Method and neuroprotective training protocol (NEP) through neurowerkstatt-training-center. A growing number of PD exercise studies show, that exercise is beneficial for physical function, and cardinal symptoms in PD. ADD improves physical fitness, and can be considered as a safe activity when practiced under expert supervision, combined with emotional wellbeing informed interventions. We propose that ADD therapy is a potentially useful rehabilitation program for PD. Qualitative guided interviews were used with the main topics expectations, emotions, and training. 4 PDP (3 m/1 f) H&YI–II were included. 4 (45 min) training sessions program combined physical and psychological wellbeing areas of focus through a one-day intensive workshop. The guided interviews gave varied insights. There was a huge range between more and less exercise. Acceptance of body impairment was reflected as having changed in the daily livings reported. PDP seemed more agility and reduced pain was reported. PDP underlined the fun factor in doing serious training, reported feeling safe while training, gaining insight into their coping styles and how to better manage these. This pilot study preliminarily suggests, that ADD therapy is an exercise possibility for people with mild PD. It has potential to physically improve symptoms and it might optimize reduction in disease progression. It further suggests the potential to psychologically improve mental wellbeing. Further research is needed.

Neuroprotective Exercise Protocol (NEP) improves Parkinson's disease (PD) mobility: transferring evidence into practice

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This retrospective cohort study examined the effects of a neuroprotective exercise protocol (NEP) for people with PD. Animal models and human studies both with PD suggest that exercise may be neuroprotective and neurorestaurative, and hence slow down disease progression. Mobility (e. g. gait) seems to be a substantial factor that regulates disease progression.

Nineteen people with PD (age = 68,5 ± 8,12; H&Y I–III) were included. The NEP-group participated in a personal training condition in the neurowerkstatt-training-center between 2015 and 2017. The training method is based on Schwed 2015. Assessments were done at the beginning and at the end of 10 sessions. The sessions were structured in a 2-phase-goal (1) restore gait, and (2) progress gait. PD-focused coordination training (e. g. randomized whole-body-vibration, gait-variability, external-cueing) were used in the first part; endurance-training (e. g. treadmill, walking, running) in the second part. Attendant, PD-subjects were educated within 8 modules (e. g. comfort-zone, gain through exercise, motivation-volition methods) to increase self-efficacy. To our knowledge this is the first study that aims optimal and neuroprotective exercise training strategies combined with education for self-efficacy for people with PD. Clinical parameters of mobility, gait and balance were measured: Timed-up-and-go-test (TUG), Berg-Balance-Scale (BBS), step length (sl) and gait-velocity (v) through 10-meter-walk-test (10MWT), and 6-minute-walk-test (6MWT). TUG, sl, v, and 6MWT showed statistically significant improvements ($p = 0.015$, $p = 0,028$, $p = 0,006$, $p = 0,031$), BBS showed a statistical trend ($p = 0,063$) after NEP.

We conclude that the NEP is an effective exercise strategy to improve mobility, and hence to improve gait abilities and disease symptoms, and maybe slow down disease progression as animal models suggest.

Isolated lumbar extension resistance exercise for the rehabilitation of patients with chronic low back pain and degenerative spine conditions–A case series of 445 consecutive patients

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Isolated lumbar extension resistance exercise (ILEX) is a promising treatment tool for unspecific low back pain. No study has investigated its potential for patients with advanced stages of spine and disc degeneration.

In this case series 445 consecutive patients (172 women, 273 men; mean age 51, range 17–83) with low back pain and/or radiating pain underwent a 9-week rehabilitation program (2 × per week, 1 set ILEX). Based on the diagnosed structural changes, patients were divided into 4 groups: (A) unspecific ($n = 88$); (B) bulging discs ($n = 104$); (C) degenerative disorders ($n = 77$); (D) multiple conditions from B and C ($n = 159$). Before and after the study isometric lumbar extension strength was tested and Visual Analogue Scales (VAS) were used to measure pain, satisfaction rates and percentage of achieved rehabilitation.

Overall, pain relief was achieved in 401/445 (90.1%) of patients (A: 96.6%; B: 90.4%; C: 92.2%; D: 82.9%). For most outcome measures group (A) showed superior results than (B–D) ($p < 0.01$) and group (B) had better results than (C) and (D) ($p < 0.05$). Overall, the effectiveness of ILEX decreased with the degree of degenerative features, higher pain levels, longer pain duration and increasing age. Furthermore, there was a tendency of higher strength increase leading to better results.

ILEX exercise can successfully be applied to all kinds of back pain conditions, in particular for unspecific low back pain and bulging discs. Spine degeneration limits the outcome. Thus, ILEX shall be applied early enough to maintain and regain spinal health.

Influence of whole-body-electromyostimulation on posture and trunk muscle force

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For the prevention and treatment of posture weakness, physical training is recommended. Whole-body-electromyostimulation (WB-EMS) is a new training method with the idea of simultaneously stimulating a large number of muscles while actively performing exercises. Therefore, the aim of this study was to examine possible beneficial or unfavorable effects of WB-EMS training with different stimulation frequencies on posture parameters (fleche cervicale and lombaire, trunk inclination) and isometric trunk extensor and flexor forces.

47 untrained and healthy participants (23.9 ± 4.2 years, 72.4 ± 16.6 kg, 174.2 ± 9.0 cm) were randomly divided into two training groups (20 Hz and 85 Hz stimulation frequency) and a control group. Posture parameters were measured with the Paromed 3D-Scanner, trunk forces with the BackCheck-system before and after the training intervention. The WB-EMS-training program was applied 15 times in 10 weeks and consisted of 9 exercises for 10 muscle groups. Repeated measures ANOVA and post hoc Fisher tests were used for statistical analysis.

The results showed no significant differences in the posture parameters between the groups, aside from trunk inclination that improved in all groups including the control group, probably due to a familiarization process. Both trunk flexor (group*repetition: $F = 4.24$, $p = 0.02$) and extensor (group*repetition: $F = 4.21$, $p = 0.02$) forces increased significantly in the 85-Hz-stimulation group, meanwhile the ratio between extension and flexion remained constant in all groups.

Unspecific WB-EMS training with 85 Hz stimulation frequency may improve trunk muscle forces in an adult pain-free population but does not influence posture parameters.

The impact of digitalization in exercise sciences and sports medicine

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We are currently witnessing a digital transformation and progressing coalescence of our daily life and health technologies, with the use of various digital features carried into exercise and medical applications. Some of these innovations will potentially change existing structures in such a great extent that they are already referred to as disruptive technologies.

This presentation is meant to provide an overview of possibilities and pitfalls of digital features in various areas of exercise sciences and sports medicine.

This includes fields like mobile applications, wearables and smart devices in personal and team training use but also physiotherapeutic rehabilitation, telemedical approaches for an altered access to health coaching and therapies, the growing meaning of social media for sports, but also the use of the gained "big data" and artificial intelligence solutions.

However, it will be important not only to focus on digital innovations, but also on an adaptation of security and ethical standards. The challenge will be to integrate these new digital possibilities intelligently and wisely into the daily work of physicians, physiotherapists and their athletes and patients.

Abstracts

Equipment effects on team-handball specific throwing skills in childhood

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The acquisition of throwing skills is influenced by the used equipment. If the ball is too large children are not able to grab the ball and the throw resembles a shot-put movement. Whereas several investigations have been focusing the effect of equipment on skill acquisition (Buszard et al., 2016), research is missing how weight, size and grip of a ball influence the throwing velocity in children handball. 116 experienced participants (13 f, 103 m, age M = 9.47, SD = 1.10) conducted a throwing test (velocity measured by radar), with three different hand-balls (size 0, size 00, street handball). The used ball had a significant effect on throwing velocity (kph) (0: M = 52.87, CI [51.68, 54.04]; 00: M = 56.33, CI [55.01, 57.66]; street handball: M = 61.29, CI [59.83, 62.75]), $p < 0.001$, part. eta-square = 0.68. The differences between the 0- and the 00-ball could be explained by discrepancies in size and weight of the balls, which is in line with recent research (Burton et al., 1992). Furthermore, there is an effect of the grip, since the street handball has the same size and weight as the 00-ball.

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Fully remote coaching method for bicycle pedaling skills using advice from subjects' videos and pedaling force monitor

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Recently, cyclists in Japan have commenced to assist their training with power and motion analysis devices such as SRM or PowerTap. However, most cyclists apply their individual pedaling style. From a practical point of view it is difficult to monitor and judge optimal technique without feedback also because few cycling coaches exist in Japan. New methodology allows to accurately measure pedaling force vector and the efficiency index from the tangential force profile using a pedaling monitor (Pioneer Corporation, Kawasaki, Japan). In this preliminary observation, we aimed to coach cyclists to improve their pedaling action using visual feedback through video and the pedaling force monitor.

Five amateur cyclists (age 44.4 ± 6.0) participated in the experiment. Within an intervention period of more than 2 months the participants were requested to train basic workout (like squat or plank exercises) about 15–30 min almost every day, in addition to pedaling training. The participants were also required to transmit their pedaling monitor data and training videos of pedaling and workout via SNS (Social Network Service) or e-mail. The coach then provided appropriate advice based on the video and data, and provided feedback about improvement of pedaling motion regularly. Through visual feedback and data monitoring the pedaling action improved the force peak area in the force profile was widened. The improvement by this pedaling action means leg muscles interaction became more coordinated. Furthermore, this result shows that squat and plank exercises contribute to improving the pedaling action.

Flexibility—Effects of static stretching in comparison to foam rolling

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Foam rolling has gained its popularity in recent years, not only regarding athletes, but recreational sportsmen as well. There are some studies, comparing the effects of different flexibility training methods regarding flexibility but there are no long-term studies so far. Thus, the main aim of this study was, to compare the effects of two different methods of flexibility training, foam rolling and static stretching and to get an answer to the question, whether one of these methods is superior to the other, regarding the changes in flexibility.

16 adult participants were recruited for the study. These were randomly assigned to either a group of static stretching or a group of foam rolling, so that each group consisted of 8 participants. To evaluate the participants shoulder and hip flexibility, each performed a prone shoulder flexion test, a sit and reach test and a functional movement screen. They performed the specific exercise program three times a week, for eight weeks in total. For statistical analyses were used a two-way ANOVA with repetition to evaluate the differences between groups.

Both groups significantly increased in hip and shoulder flexibility and were able to improve their functional movement scores. Moreover, there was no significant difference in the increases between the test results of both groups.

Both methods are useful methods to increase flexibility in adults. In conclusion there was no method superior.

Suitability and reliability of neurophysiological/ neuropsychological parameters as biomarkers for exercise and recovery

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The current study aims to analyze the suitability and reliability of selected psychometric, cardiovascular, biochemical, and subjective markers as potential biomarkers of exercise and recovery.

Sixty-two subjects (age 19–43) performed two identical 60-minutes continuous running field tests (RFT) intermitted by a recovery period of four weeks. Before, immediately after (IA), three hours after (3 h), and 24 h after (24 h) the completion we assessed Stroop Color and Word Test (SCWT), heart rate variability (HRV), Brain-derived neurotrophic factor (BDNF), and the sensation of pain, based on the Short-Form McGill Pain Questionnaire (SF-MPQ). For statistical analysis, two-way ANOVA, Bonferroni post hoc analysis and intraclass correlation coefficient (ICC) were applied. For BDNF (F(3) = 97.24, $p < 0.05$), SCWT (F(3) = 21.80, $p < 0.05$) and HRV (F(3) = 72.32, $p < 0.05$) significant changes were found IA and 3 h ($p < 0.05$). In contrast, SF-MPQ showed only alterations IA (F(3) = 9.50, $p < 0.05$). Reliability was highest for the HRV parameters, such as average RR-interval (ICC = 0.72, 95% confidence interval (CI) 0,577–0,824), followed by a moderate reliability for the SF-MPQ (ICC = 0.56). Poor reliability was found for BDNF (ICC < 0.50) and SCWT (ICC < 0.50).

All neurophysiological/neuropsychological parameters display changes over time. However, highest reliability was found for selected HRV parameters, implicating their suitability as a biomarker for diagnostics of fatigue and recovery.

Keywords
fatigue
regeneration
stress-recovery cycle
monitoring exercise training

Step Frequency and Step Length during Sprinting of Novices

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Sprinting velocity (v) is determined by step frequency (sf) and step length (sl). Increasing one of these factors leads to an increasing velocity as long as the other factor does not decrease in a comparable magnitude. Results regarding the relationship between sf and sl show inconsistent findings

(Hunter et al., 2004; Mero et al., 1992). Furthermore, less research focuses on step characteristics in novice athletes. The aim of this study was to analyze the influence of sf and sl on v in novices. 30 m sprinting performance of 73 physical-education students (41w, 21,9 ± 1,9 years; 32 m, 23,5 ± 2,1) was analyzed. Sf, sl and v were determined using the OptojumpNext© System at 1 kHz. Pearson correlations between step parameters as well as paired t-tests between groups with fast and low v were calculated. Sf and sl are negatively correlated across both sexes (w: r = -.723; m: r = -.786) followed by a significant correlation of sf and v (w: r = .416; m: r = .632). Faster men (v = 8,8 ± 0,3 m/s) showed higher sf (4.5 ± 0.23 Hz) compared to slower men (v = 8,1 ± 0,2 m/s; sf = 4.0 ± 0.26 Hz). Results also show these differences for female athletes (7,6 ± 0,3 m/s; 4.0 ± 0.25 Hz vs. 7,1 ± 0,2 m/s; 3.8 ± 0.23 Hz). The correlation between sf and sl is in line with other studies while correlations between v and sf and sl show contrary results (Hunter et al., 2004). Results indicate that higher velocities of novices are primarily obtained by increasing sf. Therefore, novice sprint training should focus primarily on step frequency enhancement.

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Innovative Methods in Strength Training

Does blood flow restriction alter the motor unit recruitment of the muscles at the knee?

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Blood flow restriction (BFR) training is a promising tool for conditioning purposes in uninjured cohorts as well as rehabilitation settings. Training with low-load intensities under BFR is believed to recruit the fast-twitch muscle fibers. Thus, this pilot experiment was designed to identify and compare the characteristics of motor units under free flow (FF) and BFR conditions.

A 22-year-old male athlete volunteered to participate. To standardize the occlusion pressure at the proximal thigh, a vascular Doppler probe was used. Two isometric contractions (FF, BFR) at 30% of the participant's maximum voluntary contraction (MVC) were performed for 33 s. For the BFR condition, the cuff was inflated to 80% of the athlete's resting arterial occlusion pressure and left for four minutes before measurement started. Activity of the vastus medialis (VM) and vastus lateralis (VL) muscles was recorded continuously with five-pin surface arrays (Delsys, sampling rate: 20 kHz) at the dominant side. The signals were decomposed into individual action potentials of motor units (MU) using automated algorithms (EMGworks). The MU identified were divided into tertiles.

Both conditions enabled analyses of a minimum of 41 (VM) or 30 (VL) MU. For the latter, BFR led to recruitment shift of the initial recruitment threshold from 3 to 15%MVC. Additionally, the later recruited, higher-threshold MU revealed a 31% increase of the MU size.

The BFR altered the recruitment of the VL in a more prominent fashion than VM. This might be due to the different muscle fiber conduction velocities of both muscles.

Effects of acute strength training with blood flow restriction on arterial stiffness

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In the following study arterial stiffness has been measured during light and moderate resistance training with blood flow restriction (BFR). 10 male subjects with experience in resistance training (age 24,4 ± 2,63 years, BMI 23,96 ± 1,13, 1RM 302,1 ± 83,11 kg) did 3 conditions randomized on 3 days (30% 1RM without (K30), 30% with BFR (BFR30), 50% 1RM without BFR (BFR50), BFR was without controlled pressure) 5 sets with 15 repetitions (60 s rest) on a leg press. Blood Pressure (BPsys, BPdia) and pulse wave velocity (PWV) were measured resting, immediately (NBL1) and 15 min after the last set. Significant differences between conditions were tested by dependent t-test (α = 5%). BP [mm/Hg] displayed no significant differences ($p > 0.05$) between conditions for NBL1 (K30: 128/82 ± 17,98/9,14 vs BFR30: 132/82 ± 14,32/7,45, BFR30: 132/82 ± 14,32/7,45 vs BFR50: 173/82 ± 9,78/8,75) and NBL15 (K30: 123/78 ± 13,25/4,91 vs BFR30: 122/81 ± 10,48/9,73, BFR30: 122/81 ± 10,48/9,73 vs BFR50: 123/80 ± 10,96/5,45). PWV [m/s] showed no significant differences ($p > 0.05$) between conditions for NBL1 (K30: 5,32 ± 0,60 vs BFR30: 5,50 ± 0,57, BFR30: 5,50 ± 0,57 vs BFR50: 5,47 ± 0,27) and NBL15 (K30: 5,12 ± 0,37 vs BFR30: 5,20 ± 0,48, BFR30: 5,20 ± 0,48 vs BFR50: 5,07 ± 0,36). Results indicate that acute resistance training with low and moderate loads with BFR does not trigger significant differences of arterial stiffness. Values solely tended to be elevated at NBL1.

Effects of Whole Body Electromyostimulation (WB-EMS) vs. Whole Body Vibration (WBV) in patients with chronic nonspecific low back pain

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Recent evidence suggests beneficial effects of WBV in patients with low back pain (LBP) (del Pozo-Cruz et al., 2011). Comparative investigations on WB-EMS are lacking. Thus, the purpose of this study was to assess the effects of WB-EMS on symptomatology and strength indices in patients with chronic, nonspecific LBP. Twenty-one patients were randomly assigned either to a WB-EMS intervention ($n = 11$; age: 53.5 (SD: 7.8) years; body mass: 75.8 (11.0) kg) or a WBV intervention group ($n = 10$; age: 53.0 (7.3) years; body mass: 81.9 (17.2) kg). Both training intervention programs were performed over 12 weeks. Before (PRE) and after the intervention (POST), pain intensity was recorded using a 4-week pain diary. Maximal isometric voluntary trunk strength was assessed on the BackCheck machine for trunk extension and flexion.

A large time effect was observed for mean pain intensity in both groups ($p = 0.001$; $\eta p^2 = 0.78$) with a reduction in LBP (WB-EMS: –42% (95%CI: –29 to –70); WBV: –45% (95%CI: –33 to –71)). For maximum isometric trunk strength, significant time effects were observed for trunk extension ($p = 0.001$; $\eta p^2 = 0.46$) and flexion ($p = 0.001$; $\eta p^2 = 0.45$) with an increase in both, maximal trunk extension and flexion (WB-EMS: +19% (95%CI: 7 to 53) and +16% (95%CI: 8 to 49); WBV: +10% (95%CI: –3 to 36) and +16% (95%CI: 8 to 36)). However, no significant interaction effects were observed for mean LBP and isometric strength parameters. These findings indicate that WB-EMS is a promising training means in order to induce similar effects in pain reductions and strength improvements compared to WBV.

[YIA] The Hatfield-System versus the Weekly Undulating Periodized Resistance Training in trained males

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The purpose of this study was to compare training adaptations attained during 9 weeks of using the Hatfield-System (HAT) the weekly undulating periodization (WUP) strength training. Twenty-six recreationally strength trained men were randomly assigned to either a HAT group ($n = 13$; age = 26.8 ± 7.2 years) or a WUP group ($n = 13$; age = 29.2 ± 9.0 years). Anthropometric measures and strength testing were performed before (PRE) after 6 weeks (POST1) and after 9 weeks (POST2) of training. To subjectively quantify the individual's perception of the physical de-

mands of the intensity of resistance training, a category-ratio scale (CR10) was used by the subjects after each training session. The participants of both groups trained twice a week for 9 weeks. The HAT and WUP programs used the same exercises, the same total training volume and the same total intensity in these six weeks. The difference between the two programs was in the distribution within each training phase. The HAT and WUP groups trained using a periodized strength programs with all programs variables controlled (e. g., volume and intensity). The HAT group used a linear not varying intensity, whereas the WUP group had a varied intensity. The results show that both the HAT and WUP groups made significant ($p \leq 0.05$) increases in strength and power. Thus, HAT and WUP are similarly effective over a nine-week training period, and the decision to use HAT or WUP depends on the preferences of the individual athlete.

[YIA] Periodization of plyometrics: is there an optimal overload principle?

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This study investigated the acute and chronic effects of three plyometric training (PT) programs with equal training loads (intensity × volume × frequency) on speed, agility and jumping performance. Forty-four male recreational team sport athletes were either assigned to a program that (1) increased training volume with exercises of mixed intensity (Mix), (2) kept training volume equal and increased exercise intensity (LowHi), (3) increased training volume and kept exercise intensity low (Low) or to a (4) control group (Control). Subjects trained twice a week for 8 weeks and were tested for 5 m (5 m) and 10 m sprint (10 m), 5 × 10 m shuttle run (5 × 10 m), squat jump (SJ), countermovement jump without (CMJ) and with arm swing (CMJa) and standing broad jump (SBJ). The change in 5 m, 10 m, 5 × 10 m and SJ performance did not significantly ($p > 0.05$) differ between groups. Sprinting and agility did not change after 8 weeks of PT ($p > 0.05$). The CMJ, CMJa and SBJ increased in the PT groups compared to the control group ($p < 0.05$). There was no difference ($p > 0.05$) between PT groups. Additionally, it was shown that a training session of high intensity was more likely to diminish performance the following days. To conclude, PT programs following a different overload pattern, i. e. different combination of volume and intensity, but equal training load showed similar performance effects in recreationally trained men. However, prior to competition, a PT of low intensity is preferred over a PT of high intensity in order to avoid a decline in performance.

Monitoring with Wearable Technology

The use of higher dimensional analyses to visualize the training process

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Quantifying the training load imposed onto team sports athletes is complex given the concurrent multi-modal training programs that these athletes undertake. Consequently, in the age of technology, a wealth of data representing different aspects of the training process are collected. To prevent data overload, optimizing how this data travels from collection to presentation to coaches is crucial to embed data into decision making. Using training and competition load data collected over three seasons, this presentation will provide an overview of how we have embedded higher dimensional analyses in professional rugby league practice to visualize and communicate the relationship between multiple variables relating to the training process and its outcomes (e. g. injury, performance). In particular, the use of principal component analysis to visualize the differences in external and internal training intensities of technical-tactical training drills. Also, the use of partial least squares correlation analysis to visualize the relationship between contextualized player motion (e. g. speed when defending within own half) and technical-tactical performances during competition.

Heart rate variability guided endurance training in recreational runners

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The aim was to investigate whether heart rate variability (HRV) guided exercise prescription yields comparable results on 5000 m running performance and key components of endurance performance in recreational runners. Thirty-one recreational runners were systematically parallelized to one of two groups performing a 4-wk mesocycle with similar training intensity distribution (100%TRIMP) followed by a 3-wk mesocycle with 50% increased TRIMP compared to the first 4-wk mesocycle, and one-wk tapering. Both groups used similar individualized training plans with the HRV group having their training adjusted based on a 6-minute HRV test by Polar Electro Oy each morning during the second mesocycle. VO2peak and running economy were assessed at baseline (T0), after four (T1), seven (T2), and eight weeks (T3).
HRV trained less sessions and with a lower mean intensity as CONTROL. The 5000 m time decreased in CONTROL from T0 to T2 and T3, and from T0 to T3 and T1 to T3 in HRV. VO2peak increased from T1 to T2 ($p = 0.02$) with HRV and from T0 to T3 ($p = 0.006$) with control. Running economy improved only from T0 to T3 and from T2 to T3 ($p < 0.01$) with HRV. An individual mean response analysis indicated a high number of responders ($n = 8$ of 16) in CON and in HRV ($n = 9/13$).
Despite less training time HRV guided training showed comparable improvements in 5000 m running performance. HRV guided training may be a potential method to adjust exercise intensity and improve performance in recreational runners.

Automatic Classification of Skating Cross-Country Skiing Sub-Techniques based on a Single Wearable Sensor and Biomechanical Models

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The aim of this study was to design and validate a sub-technique classification algorithm for everyday cross-country trainings, based on a single sensor worn on the upper back and biomechanical models. The sensor (FieldWiz, Advanced Sport Instruments, Switzerland) recorded GNSS data, acceleration, and angular velocity. Using a customized fusion algorithm and a trunk model [1], the athlete's center of mass kinematics were obtained. Cycles were detected based on maxima in trunk inclination and a Gaussian mixture model was used to assign each cycle to its corresponding sub-technique (Gear 2, 3, 4) based on cycle distance, amount of lateral excursion and trunk inclination periodicity. Gaussian mixture parameters were determined from a separate dataset of short roller skiing trials. The algorithm was validated against video recordings with 5 junior level athletes skating on a 2.4 km lap with roller skis at medium intensity. Turns were removed and uphill and flat sections were selected. 925 sec of data remained, and each second was attributed one sub-technique. Gears 2, 3, 4 were skied during 81, 600, 244 s, respectively. 98.4% of all seconds were correctly classified and misclassifications mainly happened during transitions. This approach of model-based sub-technique classification proved extremely efficient, is fully automatic, and can be used during daily trainings. On-snow validity should be assessed in the future and other sub-techniques (e. g. double poling) could be added.

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Monitoring the Recovery-Stress State Using Commercial Wearables using the Vital Monitor as an Example

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The recovery-stress state (rss) is important for optimal training control. Therefore, various, sometimes complex measuring methods for this parameter are available in competitive sports. A new generation of wearables promises consumer-friendly applications, e. g. the Vital Monitor calculates a regeneration and stress index based on HRV values. The aim of the study was to check whether the Vital Monitor represents the effects of a 3-day intensive endurance training comparable to established methods for the determination of performance or the subjective rss.

10 male subjects (25.1 ± 3.3 years) completed after baseline measurement, a Peak Power Output-Test (410.0 ± 48.31 W, 184.2 ± 11.59 HRmax) followed by a 3-day regeneration phase, followed by a 3-day intensive training phase with 6 training sessions. Before each training session the submaximal endurance performance was measured using the Lambert and Lambert submaximal cycling test (LSCT). On all examination days, the rss was measured in the morning using the Acute Recovery Stress Scale (ARSS) and using the Vital Monitor.

The rmAnova shows high significant differences for the LSCT and ARSS dimensions ($p \leq 0.004$) with a large effect strength (η^2 from 0.46 to 0.70), while the regeneration and stress values of the Vital Monitor as well as the HRV values show no significant differences for an average effect strength (η^2 from 0.09 to 0.13). Both the LSCT and the ARSS clearly indicate fatigue during the intervention period, while the parameters of the Vital Monitor show no clear effect but only a tendency.

[YIA] Towards a wearable feedback system for gait training: Inertial sensor based 3D joint kinematics and spatio-temporal parameters

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The aim of this study was to validate the 3D joint kinematics, and spatio-temporal parameters (STP) of an inertial measurement unit (IMU) system designed for gait analysis as well as gait training and mobile feedback. 26 healthy subjects participated in the study. They were instrumented with 7 IMUs and 32 retroreflective markers. IMU joint kinematics was estimated using a sensor-fusion algorithm based on an extended Kalman filter approach. Gait events were detected implementing virtual contact points on the feet and an adaption of a previously described algorithm. STP were calculated based on these events. A marker based optical motion capture system (OMC) provided the reference. Event detection rate was about 99%. The STP showed excellent correspondence with the OMC system. However, the parameters describing the lateral distances between the feet (step width, swing width) showed the highest relative errors (34.34%, 35.20%). The 3D joint kinematics of the lower limb and pelvis revealed a range of motion error for all joints below 3.5°. The present system revealed valid results for an IMU system for movement analysis delivering a wide spectrum of parameters. These findings encourage further development and initial studies combining the current system with feedback options.

Workshop: Recovery Management

Recovery Management

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Special Aspects of Training & Testing in Hypoxia & Hyperoxia

Altitude training for performance enhancement: The scientific debate

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Endurance Competitions at Altitude–A Narrative Review on Psychological Aspects

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Altered environmental characteristics at altitude (e. g. hypoxia, temperature) are known to have detrimental effects on exercise performance during endurance competitions. Evidence on the effects of altitude on performance-related physiological parameters is available. However, exercise performance during endurance competitions is influenced by many different aspects out of which also psychological factors are believed to play a large role. To the best of our knowledge, no research is available focusing on psychological aspects in the preparation for or during endurance competitions at altitude. Therefore, a literature search has been performed to identify original articles and reviews on a) reported changes of psychological aspects due to altitude and b) on research addressing psychological aspects in endurance competitions without exposure to altitude. The focus was set on the following situational psychological aspects: cognitive functions including decision making, mood states including perceived exertion, and use of psychological strategies in the preparation for an endurance competition. On the basis of the connection of these findings, research recommendations for an optimal preparation for endurance competitions at altitude in terms of psychological aspects will be demonstrated.

New aspects of hyperoxic training for normoxic performance

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Nutrition & Training

Effect of New Zealand Blackcurrant extract on endurance performance in Yo-Yo Intermittent Recovery Test Level 1

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New Zealand Blackcurrant (NZBC) has a very high content of secondary plant compounds in the form of anthocyanins. Performance improvements under various conditions.

(Perkings et al., 2015; Willems et al., 2016) have demonstrated an ergogenic effect of NZBC extract after a seven-day intake phase. The aim of this study is to examine the in-fluence of NZBC extract on performance in the Yo-Yo Intermittent Recovery Test (Yo-YoIR1).

Participants consumed NZBC extract in capsules (300 mg/day CurraNZ®) or placebo (300 mg/day microcrystalline cellulose) for 7 days in a double-blind, randomized crossover de-sign (washout phase: 14 days). The groups were parallelized after Yo-YoIR1 using the estimated VO2max. Yo-YoIR1 was performed again after each supplementation phase. The subjects documented their nutritional behavior for 7 days before the second Yo-YoIR1 in order to repeat it before the third Yo-YoIR1.

The data acquisition is still in process. Results and interpretation will follow.

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[YIA] The use and dosage of pre-workout supplements amongst recreational athletes

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Consumption of pre-workout supplements (PWS) has increased substantially in recent years. However, dosages of ingredients vary between manufacturers. Therefore, the aim of this study was to analyze ingredients from various products and to survey past and present (4 weeks) consumption behavior.

Analysis of ingredients was performed in 30 products according to manufacturer's specifications. Subsequently, online questionnaire was used to assess reasons for taking, timing and dosing of PWS in 39 recreational athletes (4 females; 35 males; 25.15 ± 3.67 years).

Most prevalent ingredients in PWS were caffeine, beta-alanine, L-citrulline, L-arginine, L-tyrosine, taurine and creatine. Average dosing per serving were 254 mg caffeine (125–410 mg), 2513 mg beta-alanine (500–4000 mg), L-citrulline 3506 mg (500–8000 mg), L-arginine 2726 mg (500–8000 mg), L-tyrosine 1227 mg (150–3000 mg), taurine 1211 mg (90–2500 mg) and creatine 3031 mg (1000–5000 mg). Average values were in (63%) or below (36%) the recommended ergogenic dosage. Major motives for PWS use were improved concentration, increased blood flow and delayed onset of fatigue. Most subjects consumed PWS 1–3 times per month. In most cases consumption took place 15–30 min before training. Manufacturers' recommendations for consumption were generally followed. A large number of subjects (82%) reported minor side effects from PWS consumption (e. g. paresthesia, insomnia, headache).

Based on current research only caffeine, L-citrulline, L-arginine and taurine show relevant direct performance-enhancing effects, while the benefit of beta-alanine, L-tyrosine and creatine in PWS seems highly questionable. Dosages of ingredients were safe, but often too low to increase performance.

[YIA] Evaluation of different sports drinks on endurance performance and energy metabolism

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Aim of the study is to evaluate a newly developed sports drink on endurance performance as well as carbohydrate (CHO) and fat metabolism. Individual substances of the performance drink mix, isolated in three different drinks and a placebo drink were tested.

12 healthy and well-trained endurance athletes of age 20 to 35 years participated in the study in an experimental crossover design. The intervention included four Time Trials (TT) with a pedaling capacity of 80% VO-2peak over 40 min with a subsequent increase of power every minute by 10 watts until exhaustion. In a double-blinded and randomized protocol, four different drinks (A = placebo, B = dextrose, C = B plus nitrate booster and D = C + arginine and L-citrullin) were added to 300 ml water and ingested 60 and 30 min before each TT. There were no differences in maximal performance ($p = 0.818$), peak oxygen uptake ($p = 0.670$), maximum lactate concentration ($p = 0.746$) and maximum heart rate ($p = 0.950$) between the four treatments. During the TT no statistically significant differences in lactate and blood glucose concentration, heart rate, respiratory

gas parameters were found. Significant differences ($p < 0.05$) for glucose concentration were found at rest and in the warm up phase only. The pre-post comparison showed significant differences in the urine pH values between the CHO drinks and the placebo.

Reasons for the lack of effects can include timing and frequency of ingestion as well as the composition of the sports drinks. The additional substances had no effect on performance, carbohydrate and fat metabolism during TT.

[YIA] Utilization-focused monitoring of the hydration- and regeneration-status with national adolescent team-handball athletes

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The knowledge of hydration status and the physical strain of athletes is important to prevent performance deficits and injuries. Easy to conduct and utilization-focused tools to monitor hydration, physical strain and recovery are available, but their applicability have not yet been evaluated in team-handball on elite level so far. A training-camp (7 days) of a male U18 national team ($N = 16$) was used to measure hydration status (thirst rated on a modified RPE-Scale 1–10, weighing before/after training), and to monitor the perceived recovery/physical strain (AEB-questionaire, Hitzschke et al., 2016). The body weight decreased in mean –0.67% (all CI [>–2.58, <0.49]) during the training sessions/matches. Participants also reported low values of perceived thirst after waking up (min. M = 2.11, CI [0.81, 3.41]; max. M = 2.66, CI [1.12, 4.20]). A steady decrease of recovery and a steady increase of physical strain was demonstrated by the AEB-tool. Whereas hydration management works well over the training-camp, the monitoring of recovery/strain provides the possibility of focusing each player individualized and to adapt the training load. The conducted study shows that hydration and perceived physical strain/recovery is easy to measure with the applied tools. Furthermore it is feasible with a manageable amount of time during a training-camp.

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High and average consumption of dietary supplements prevails among male but not female gym users

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Altered environmental characteristics at altitude (e. g. hypoxia, temperature) are known to have detrimental effects on exercise performance during endurance competitions. Evidence on the effects of altitude on performance-related physiological parameters is available. However, exercise performance during endurance competitions is influenced by many different aspects out of which also psychological factors are believed to play a large role. To the best of our knowledge, no research is available focusing on psychological aspects in the preparation for or during endurance competitions at altitude. Therefore, a literature search has been performed to identify original articles and reviews on a) reported changes of psychological aspects due to altitude and b) on research addressing psychological aspects in endurance competitions without exposure to altitude. The focus was set on the following situational psychological aspects: cognitive functions including decision making, mood states including perceived exertion, and use of psychological strategies in the preparation for an endurance competition. On the basis of the connection of these findings, research recommendations for an optimal preparation for endurance competitions at altitude in terms of psychological aspects will be demonstrated.

Team Sport: Training & Testing

Reliability of energetic profiles of intermittent shuttle runs

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To evaluate the reliability of metabolic profiles for intermittent shuttle running using the PCr-LA-O2 method.

$n = 16$ trained team sport players (age: 23 ± 3 yrs, height: 185 ± 7 cm, weight: 85 ± 14 kg) completed two IFT30-15 tests (Buchheit, 2010) in a test-retest setting within 3–7 days. Speed level (SL), time to exhaustion (TTE), oxygen consumption (VO2), blood lactate (blc), and heart rate (HR) values were collected. The metabolic profiles 2 for IFT30–15 were calculated using the adjusted PCr-LA-O2 method (Beneke et al., 2002; Latzel et al., 2018). Reliability was assessed by Bland-Altman limits of agreement (loA) and intraclass correlation coefficients (ICC).

Performance variables SL (loA: -0.28 ± 0.94 km/h, ICC: 0.95) and TTE (loA: -29 ± 78 s, ICC: 0.96) as well as metabolic variables Wtot (-0.156 ± 1.333 kJ/kg, ICC: 0.98), Vo2peak (0.1 ± 4.3 ml/kg/min, ICC: 0.95), Ptot (1.2 ± 1.0 W/kg, ICC: 0.91) and Wblc (0.2 ± 2.0%, ICC: 0.84) showed high to very high agreement, while it was slightly lower for Waer (0.2 ± 9.8%, ICC: 0.78) and Wpcr (0.4 ± 9.9%, ICC: 0.70).

Reliability of performance and metabolic variables for IFT30-15 derived from the PCr-LA-O2 method were acceptable to very high and in line with those of others (Bagger et al., 2003; Buchheit, 2010). This supports the notion that the adjusted PCr-LA-O2 method represents a reliable estimate to quantify energetic profiles of sports involving intermittent shuttle running.

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[YIA] Energetics of intermittent and continuous shuttle runs

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To analyze the metabolic profiles of intermittent and continuous shuttle running.

$n = 16$ state-level Handball players (age: 23 ± 3 yrs, height: 185 ± 7 cm, weight: 85 ± 14 kg) completed an IFT and an IFT without breaks (IFTcont) (Haydar et al., 2011). During the tests, speed level (SL), time to exhaustion (TTE), oxygen consumption (VO2), blood lactate (blc) and heart rate (HR) values were collected. The metabolic profile (Wtot kJ/kg, Ptot Watt/kg, Waer %, Wpcr %, Wblc %) for IFTcont was calculated using the PCr-LA-O2 method (Beneke et al., 2002), while for IFT the adjusted PCr-LA-O2 method (Latzel et al., 2017) was applied. Effect sizes are denoted as Cohen's d.

SL (18.25 ± 1.43 vs. 16.40 ± 1.02 km/h, d = 1.19) and TTE (966 ± 130 vs. 552 ± 61 s, d = 2.10) were considerably longer in IFT compared to IFTcont. Ptot was lower in IFT than in IFTcont (14.2 ± 1.0 vs. 16.8 ± 1.4 W/kg, d = −2.05), while Wtot was higher in IFT than in IFTcont (13.7 ± 2.4 vs. 9.3 ± 1.3 kJ/kg, d = 1.50). Additionally, Waer (67.2 ± 5.2 vs. 85.2 ± 2.5%, d = −4.01) and Wblc (4.4 ± 1.4 vs. 6.2 ± 1.8%, d = −3.57) were lower in IFT, while Δblc (9.2 ± 1.6 vs. 9.0 ± 2.0 mmol/l, d = 0.09) was almost equal. Finally, Wpcr (28.4 ± 4.7 vs. 8.6 ± 2.1%, d = 6.27) was higher in IFT compared to IFTcont. The large differences in energy share during IFT and IFTcont, the divergence between Wblc and Δblc and the substantially higher Wpcr in IFT highlight both the need for specific exercise tests and the importance of calculating metabolic profiles.

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Sprint mechanical properties of elite adult and under 19 year's male handball players

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This study compared power, force, and velocity properties of 14 elite adult (PRO) and 11 under 19 year's (U19) male handball players. Force-velocity and power-velocity relationships, as well as theoretical maximum running velocity (vmax), force (Fmax), and power (Pmax) data were computed from timing gate data of 30 m linear sprints. Therefore, an inverse dynamic approach was applied, which is based on the movement of the center of mass. The approach was optimized for taking the individual starting time into account, which represents a progress in the present research field, when aiming to compute sprint mechanical properties by different methodological approaches under field conditions. While vmax (U19: 8.8 ± 0.4 m/s; PRO: 8.6 ± 0.7 m/s) did not differ between both teams, Fmax (U19: 608 ± 65 N; PRO: 738 ± 91 *N*) and Pmax (U19: 1363 ± 165 W; PRO: 1614 ± 209 W) were lower in U19 players. Moreover, relative to body mass Fmax (U19: 7.5 ± 0.5 N/kg; PRO: 8.1 ± 0.6 N/kg) was also lower in U19, but not Pmax (U19: 16.7 ± 1.4 W/kg; PRO: 17.7 ± 2.1 W/kg). Interestingly, no differences were found in 5 m, 10 m, 20 m, and 30 m sprint times. Overall, the study shows that both absolute and relative sprint mechanical properties differ according to age in elite handball players. More research is required to determine, if sprint mechanical properties are more useful for practical applications (e. g., profiling, training, or talent selection) than traditional sprint time analyses. Generally, the use of mechanical properties may become more important in the future and were not limited to standardized sprint tests.

Leg-dominance effect in elite youth team-handball

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Sport-specific movement profiles promote the development of bilateral strength differences (e. g. leg-dominance effect, LDE). Some studies investigated the LDE of handball-players (Xaverova et al., 2014), but none of them considered the LDE focusing specific movements (stand- and jump-throws). The purpose of the present study was to identify the bilateral differences in isokinetic torque of the knee extension/flexion of youth handball players. Elite youth U19 handball players ($N = 20$; age M = 17.3; SD = 1.1) were tested isokinetically following the methodological procedure of Alt et al. (2018). The results show higher peak torque (Nm/kg) of the non-dominant leg (M = 2.49, SD = 0.32; dominant leg M = 2.36, SD = 0.33), $p < 0.01$, eta = 0.40, and higher differences between concentric and eccentric movements in the non-dominant than in the dominant leg (M = 0.09, SD = 0.15), $p = 0.02$, eta = 0.25. Because there was no eccentric knee extension by the non-dominant leg in throws (except of landing), we suppose that landing- or cutting-movements could have a bigger influence on the specific strength-profile than throwing.

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[YIA] Reactive Agility in Youth Basketball

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The ability to combine a short time reaction on a non-predictable event with a fast action (Reactive Agility) can be considered as an important feature of playing performance in Basketball. Existing tests mostly assess agility but neglect the reaction component or do not adapt to Basketball specificity. A specific sensor-based test for the detection of Reactive Agility has been developed recently. The focus on this study is on the test evaluation with youth basketball players on different levels of expertise.

The Push Step Test simulates a one on one defense situation in basketball and measures lateral movements to the left or right upon an optical signal. The Fitlight®-Systems was used to control test conditions as well as to measure time parameters. 105 male athletes of under 18 years (youth national team, 2., 3. and 4. youth league) were tested. An ANOVA was performed to examine differences between the playing levels.

Overall mean movement times ranged from 1.023 s to 1.467 s with highest values for the national and 2. youth league players. Performance to the right, respectively left side differed slightly (Mean difference 0.012s) ANOVA revealed significant differences ($p = 0.005$, $R^2 = 0.119$) for all parameters only between players on lowest level of expertise and higher skilled players. Results indicate that a reactive agility task on lateral movement discriminates players on a low level of expertise but does not differ with advanced expertise.

[YIA] Transfer of specific tactical behavior to pitch and training configuration in small sided games

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To ensure a suitable usage of the 4vs4 Small-sided games (SSGs) in soccer practice for tactical demands, the optimal pitch and drill configurations should correspond to age specific competition demands and thus have to be derived from game analysis. The aim of the present study was to diagnose the pressure level on the player with the ball (PwB) depending on the age group and tactical patterns at the highest youth level in Germany. 6 games in the age groups U15/U17 were tape-recorded, and player's positions were tracked by direct linear transformation (2D-DLT). The pressure on the PwB was determined by the smallest rectangle that includes the PwB plus his nearest 3 teammates and the 4 nearest opponents. We hypothesized and showed that the pressure on the PwB is higher in situations releasing the ball as compared to receiving ($p < 0.05$) (i). Surprisingly, the pressure on the PwB is significantly ($p < 0.05$) higher in U15 compared to U17 games (ii). Thirdly, we hypothesized and found significantly larger size dimension of actions for the U15 in the mid field of pitch area ($p < 0.05$) than in the attack zone ($p < 0.05$), in contrast the result was inverse for the U17 (iii). In context with the results of hypothesis (ii) the U17 seems to follow a more straight forward tactical behavior strategy pronouncing counter attacks.

Our results indicate that the pressure level is a valuable variable that should be considered within the training process depending on tactical game philosophy.

Agility for Exercise-Based Fall Prevention in the Elderly: Conceptual, Cross-Sectional and Longitudinal Findings

Acute and interventional effects of exercise training on postural control in seniors: Applicability of novel training regimes

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Studies indicate that motor imagery (Hallett et al. 1994) and observation of movements (Neuper et al. 2005) activate brain regions that are also active during the actual task performance. Based on these findings it is assumed that activation of (motor) representations is responsible for behavioral adaptations after mental training. With respect to postural control, Hamel & Lajoie (2005) and Tia et al. (2010) reported improved performance after motor imagery and movement observation, respectively. Thus, motor imagery and observational training seem to have the potential to improve postural control. However, no previous study has ever tested whether mental non-physical training can improve posture in an unstable, dynamic environment, where sensory feedback is essential in order to counteract external perturbations that cannot precisely be anticipated. Furthermore, it is not known whether these forms of non-physical training can improve sensorimotor function of the cervical spine that is also considered to rely strongly on sensory feedback. The present talk highlights the potential of motor imagery and observation to improve performance in tasks that strongly rely on afferent feedback and displays brain activity (assessed by fMRI and TMS) associated with mental training of different postural tasks. Furthermore, comparisons between young and elderly subjects are made.

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Agility training to improve intrinsic fall risk factors in the elderly: a randomized controlled parallel group trial

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Training of balance, strength and flexibility is currently recommended for the prevention of falls and frailty that are frequent among the elderly. Integrative multi-component exercise (= agility) training interventions have been called for that train stop-and-go patterns, cutting maneuvers, turns and decision-making. Here, such a program's efficacy is tested in regard to fall risk factors.

Twenty-seven community-dwelling healthy seniors (16♂; 11♀; age: 69.5 ±5.3 y; BMI: 26.4 ±3.7 kg/m2) were trained for 8 weeks in a group setting with 3 sessions per week lasting 45 to 60 min. The agility group (AGI) used the integrative multi-component training and the traditional group performed balance and strength training separately. Outcomes were static and dynamic balance, lower limb and trunk maximum strength (MS) and rate of torque development (RTD) as well as cardio-circulatory capacity (CCC). Group differences in change scores were estimated with linear regression controlled for baseline and gender. Effect sizes (ES) with 90% confidence intervals are reported.

Both groups improved with small ES in CCC (ES $> 0.45[0.24;0.80]$), dorsal extension MS (ES $> 0.23[-0.10;0.84]$) and dynamic balance (ES $> 0.28[-0.02;0.58]$). Only AGI improved notably in plantar flexion MS (ES $> 25[-0.02;0.76]$) and RTD (ES $> 0.72[0.23;1.24]$) as well as trunk

extension RTD (ES = 0.28[0.01;0.55]). Small ES in favor of AGI were found for CCC (ES = 0.22[–0.05;0.50]), plantar flexion MS (ES > 0.21[–0.10;0.94]) and RTD (ES > 0.54[–0.06;1.15]) as well as trunk extension RTD (ES = 0.45[0.09;0.80]).

Agility based exercise training seems at least as efficacious as traditional balance and strength training in affecting fall risk factors among community-dwelling healthy seniors.

Agility Training for the elderly: Study Protocol of a multi-center randomized controlled trial

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Increasing demographic change rates lead to rapidly ageing societies, creating great responsibilities for relatives and high financial burdens for health care systems (WHO, 2015). Exercise training is recommended for elderly people as it counteracts age-related impairments and the occurrence of falls (McPhee et al., 2016). Adding up available training recommendations across all domains (e. g. endurance, balance, strength) results in more than 500 min of weekly exercise for older adults (Nelson et al., 2007). Thus, a multimodal agility training approach has been proposed and is examined in a large multicenter trial.

A one-year two-armed randomized controlled intervention study that functionally combines balance, speed, strength, endurance and cognitive demands will be conducted at two study centers (Cologne and Basel) with 170 healthy community-dwelling seniors. Participants will be allocated to either the intervention- or the control group using the minimization method (Scott et al., 2002) (strata: sex, age, leg strength, 6-min walk distance, dual-task gait speed). Pre- and post-assessment will include neuromuscular (e. g. maximum force, balance, gait speed), cardiovascular (e. g. 6-minute walk, spiroergometry, echocardiography), cognitive (e. g. Eriksen-Flanker task, *N*-Back test) and psychosocial (e. g. depression, perceived stress, quality of life questionnaires) measures. Instructed training sessions will take place twice a week for one hour. The control group will receive minimal training recommendations following the ACSM guidelines (ACSM, 2010). Pre-post change scores in all outcome measures will be calculated including in intention-to-treat vs. as-treated analysis by computing several analyses of covariance adjusting for baseline values.

Training & Testing–Varia 2

Classroom-based 8-minute micro-sessions of functional high-intensity circuit training enhances muscular fitness but not endurance performance in 11-year old students

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The present study assed the impact of 8-minute classroom-based micro-sessions of functional high-intensity circuit training (FunctionalHIIT) on motor performance in students.

35 students (age: 11.5 ± 2) participated, 17 students performed daily and for 4 weeks 8-min FunctionalHIIT (>17 Borg scale) during regular school classes and 18 students served as passive control group (CG). Heart rate (HR) was recorded during and perceived exertion (RPE) was recorded after each session in FunctionalHIIT group.

Mean RPE of FunctionalHIIT was 17.3 ± 2.1 with corresponding mean HR of 186 ± 14 b/min. Performance in lateral jumping test, sit ups, and 20-m sprint revealed significant interaction effects between FunctionalHIIT group and CG. While no significant baseline differences between both groups were detected, FunctionalHIIT group significantly outperformed the control group over time. However, no significant baseline differences and no significant interaction effects were detected for 6-min run, flexibility, push-ups, balance and standing long jump. Classroom-based FunctionalHIIT sessions, performed daily during four weeks did not improve aerobic endurance but enhanced certain parameters of motor performance in untrained pupils. FunctionalHIIT during regular school classes could offer a new perspective for increasing motor performance in young students. For improving endurance in children, training stimulus has to be more intense and session and intervention duration should be longer.

Lactate kinetic in isokinetic force loads

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Systematic studies on lactate kinetics are currently unavailable for force loads. The aim of the study was to investigate the lactate kinetics of force loads as a function of load duration (tload) and movement speed (ω). 14 male subjects (age 22.7 ± 2.5 years, BMI 24.9 ± 2.2 kg/m2) performed unilateral isokinetic knee flexion and extensions. In each case, 9 tests with 6, 10, and 14 repetitions at 60°/s, 150°/s, and 240°/s were combined and randomly assigned. Capillary blood samples (20 μl) were taken to determine lactate before, immediately after, and every minute until the 30th minute post loading. To determine the invasion constant K1 and elimination constant K2, the lactate values were adapted to a Bateman function (2 compartment model). The effects of tload and ω on K1 and K2 was performed using ANOVA with repeated measurement (5%). Correlations between K2 and Lamax were tested using the Pearson coefficient. The tload showed a significant effect on K1, K2, and Lamax ($p < 0.0001$, eta2 = 0.59, 0.45, 0.92). ω showed a significant effect in Lamax ($p < 0.0001$, eta2 = 0.85) but not in K1 and K2 ($p > 0.05$). There was no significant interaction between tload and ω ($p > 0, 05$). There was a linear relationship of 0.32 ($p < 0.001$) between K2 and Lamax. The decreasing K1 indicates an increased oxidation with longer duration. K2, on the other hand, showed an increase to buffer the highly elevated Lamax and control the pH.

Heart rate-derived training load quantification following three different running protocols

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Several attempts have been made to quantify internal and external training load in objective and subjective ways to assess fitness/fatigue states as well as the impact on performance to manage the training process optimally. This article reviews existing training impulse (TRIMP) concepts by comparing them based on different running protocols. 14 moderately trained male subjects (24.5 ± 1.4 years) completed a lactate threshold test and performed three different running protocols (I: constant running, 40 mins @75%-HRmax; II: Fartlek, 30 min different intensities; III: HIT, 29 min, 4 ×2 min, @ >90%-HRmax) at different days in a random order, while recording their heartrate. Six literature-based TRIMPs relative to the corresponding exercise duration as well as the protocol's mean heart rates (HRmean) were calculated and (a) analyzed for differences between the protocols (one-way ANOVA) and (b) for relationships between each other separated by protocol (Spearman's rank correlation). Protocols' averaged TRIMPs as well as HRmean are different for I–II and I–III ($p < 0.05$) whereas II–III do not differ reflecting the characteristics of the running protocols. There are significant large ($r > 0.93$, $p < 0.001$) and medium to large ($.34 < r < 0.54$) positive relationships between TRIMPs with different HR-processing (continuous/averaged) and different weighting functions (individualized/standardized) for all protocols, which suggests the use of continuous HR-processing and individualized TRIMPs. Furthermore, relationships are large ($r > 0.89$, $p < 0.001$; $r > 0.66$, $p < 0.01$) between Edwards/Banister-TRIMP and Lucia/i-TRIMP (stepwise/continuous weighting function) for all protocols encouraging the use of both methods, though mathematically implying inaccuracies at step's boundaries.

Evaluation of a group based 8-week outdoor-fitness training on physiological performance in recreational athletes

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Nowadays, lack of time or motivation are the most common reasons for sedentary behavior (Reichart et al. 2007). Different concepts try to lower the barrier to be physical active by offering a highly intensive, time effective and motivating program. One such method is out-door circuit training (otherwise known as bootcamp training). However, the effects of such a training on recreational athletes are not well known and will be evaluated in this study.

Participants (30f,13 m; $33 \pm 7y$, 175 ± 9 cm; 72 ± 12 kg) volunteered for the study. Each participant completed a battery of physical performance tests (functional fitness test, a treadmill based stepwise incremental test and a core stability test) pre and post an 8-week bootcamp intervention. To assess the difference between pre and post, a paired sample t-test was calculated to show the difference in test outcomes (α-level $= 5\%$).

Results show a significant increase in functional and strength exercises. On average, participants perform higher repetitions in the posttest e.g. high knees (Pre:M $= 136 \pm 29{,}4$; Post:M $= 170 \pm 32{,}8$) $t(42) = -10{,}3, p < 0.00$. The isometric core stability increased in all directions, e.g. back extension (pre:M $= 78{,}3 \pm 30{,}3$; post:M $= 111{,}7 \pm 41{,}0$) $t(41) = -6{,}5, p < 0.00$. Participants ran longer in post than in pre (2498 m ± 741 vs. 2236 m ± 599) $t(38) = -6{,}0, p < 0.00$ whereas lactate increased slightly (8,9 mmol $\pm 2{,}2$; 9,6 mmol $\pm 2{,}4$) $t(39) - 1{,}03, p = 0.31$. Average maximum heartrate was lower in post than in pre ($186 \pm 9{,}7$; $188 \pm 11{,}0$) $t(38) = 1{,}36$, $p = 0.18$.

An 8-week outdoor training is useful to improve general core-stability and endurance tasks besides training specific exercises. No changes in lactate accumulation could be due to longer running distances. Lower heartrates in lower steps show that changes in metabolism occur.

Heart-rate recovery at three minutes after exercise outperforms earlier time points in prediction of estimated maximal oxygen uptake

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The heart-rate recovery (HRR) is an important predictor of overall mortality (Cole et al., 2000) and of autonomic function and training status (Daanen et al., 2012). The present study aimed to investigate at which time point (1, 2, or 3 min) HRR best predicts the maximal oxygen uptake (VO2max) in young healthy women. 102 female subjects (age: 23.1 ± 4.5 years, height: 168.8 ± 6.3 cm, mass: 60.6 ± 7.1 kg) performed the 20 m Shuttle Run Test (SRT) and were verbally encouraged to give maximum effort. HRR was defined as the difference between the maximum heart-rate during exercise and the heart-rate at 1, 2, or 3 min during recovery. Each measure was used as a predictor of the VO2max estimated from SRT in separate linear regression models. Results revealed that only HRR at 3 min was able to predict a small amount of the VO2max ($R^2 = 0.06$, $F(1,100) = 5{,}95$, $p = 0.02$). Although HRR is frequently measured at 1 and 2 min after exercise, HRR at 3 min might be supplemental and add to the overall picture of recovery.

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Exergames–an appropriate medium for training in sport?

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Exergames (or active video games, AVG), i.e. digital games including whole-body movements to control gameplay, have been applied to several areas of training, e.g., resistance, aerobic endurance and coordination training. Therefore, the question arises whether and under which conditions exergames are appropriate training tools in sport.

In this presentation, existing studies are reviewed regarding the impact of exergames on resistance, endurance and coordination performance.

On the one hand, the review clearly indicates that exergames have the potential to improve resistance, endurance, and balance performance. However, the effects seem to be limited to low initial levels of performance rather than elite sport. Furthermore, the studies investigate physical training effects as a by-product rather than a result of systematic application of established training regimens.

Therefore, the application of exergames for health training of older adults (i.e., rehabilitation and prevention) may be of some advantage, particularly for balance and resistance training. However, the effects of exergames are usually lower than the effects of traditional training methods warranting the conclusion that exergames are not (yet) an optimum method for training. There is a lack of studies deploying exergames in a systematic way in training. In addition, exergames are missing that have been systematically developed for adopting up-to-date training methods.

Most existing studies suffer from low quality. Particularly, the prescription and monitoring of training load as well as the systematic application of specific training methods is insufficient. Therefore, more high-quality studies in different settings are re-quired to corroborate these preliminary results.

Workshop: Point-of-Care Testing (POCT)

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