Exercise Training as Therapy

High and moderate intensities in strength training in multiple sclerosis patients

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Introduction: Previous studies showed positive effects of moderate strength training (intensity of 40% of one repetition maximum – ORM) in multiple sclerosis patients. The aim of this study was to compare the effects caused by a moderate intensity and high intensity strength training.

Methods: During a 4–6-week rehabilitation period, group 1 (75 patients, aged 49 ± 11 years) and group 2 (12 patients, aged 47 ± 11 years) underwent dynamic strength training of the weaker leg extensor muscles on the leg press. Both training groups trained 2–3 times per week. Group 1 trained with 40% of ORM (3 sets per unit, 20–30 repetitions per set), group 2 with 70% of ORM (3 sets per unit, 8–12 repetitions per set) and a control group (7 patients, aged 51 ± 9 years) did not attend strength training. At the beginning and end of the training period the bilateral and unilateral strength levels were evaluated with the ORM test on the leg press.

Results: Both training groups showed significant increases of bilateral strength (group 1: from 110 ± 39 kp to 119 ± 43 kp, p < 0.001; group 2: from 94 ± 27 kp to 110 ± 36 kp, p < 0.01), in unilateral strength of the weaker leg (group 1: from 42 ± 16 kp to 50 ± 21 kp, p < 0.001; group 2: from 41 ± 16 kp to 50 ± 22 kp, p < 0.01), only group 1 in unilateral strength of the stronger leg (from 60 ± 21 kp to 64 ± 24 kp, p < 0.001), but there was no significant increase in the stronger leg in group 2 (from 59 ± 18 kp to 60 ± 16 kp, n.s.). The control group showed no significant increases. In comparison of the two training groups we found no significant differences in the results but significant differences in increase of bilateral strength between both training groups (group 1: 10 ± 15%, p < 0.01; group 2: 16 ± 13%, p < 0.01) and the control group (−5 ± 17%) were established.

Discussion: Unilateral strength training of the weaker leg in multiple sclerosis patients is possible with 40% of ORM and with 70% of ORM too, without important advantages of any method. It is impossible to equalize the strength of the weaker and the stronger leg in this training period of 4–6 weeks. No training leads also to no benefits.

Conclusion: The training with moderate intensity of 40% of ORM is not more effective than high intensity training but there is a lower risk of exhaustion.
Cross transfer effects: Approach to identify training parameters for rehabilitation

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Introduction: Partial and total immobilisation of muscles after injury or surgery are known to delay the rehabilitation process by hypothrophy. To optimise the muscle activity (e.g.: strength, endurance, coordination) during such a rehabilitation phase, “cross effect training” is an appropriate method to delay or minimize hypothrophy [2]. Several strategies of transfer are known: asymmetric-diagonal-contra-lateral-transfer, homo-lateral-transfer, agonist-antagonist-transfer and contra-lateral-transfer [3]. However, training parameters for an optimal training effect are not described in detail and were partially unknown. Meta-analysis of studies show no comparable results. Thus, the purpose of this project is to determine appropriate training intensity to evoke co-innervation of muscles during rehabilitation.

Methods: Three different isometric and dynamic muscular strength tests of 50%, 75%, and 100%, respectively 30%, 60% and 90% of the maximum voluntary contraction (MVC) of a single-joint-movement and a multi-joint-movement were performed in total 199 healthy young subjects on an (isokinetic) dynamometer. Surface EMG activity (IEMG) of the contralateral, ispilateral and antagonistic side were recorded during the isometric and dynamic tests (best of 3 repetitions). The EMG activity was expressed by a percentage of the MVC-EMG activity. This ratio yields to the overflow parameter.

<table>
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<th>Table 1</th>
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<td>Effect sizes of maximal overflow under different conditions</td>
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<td>Static contraction</td>
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<td>Single-joint movement</td>
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<td>Multi-joint movement</td>
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<td>Effect sizes between 0.46 and 1.45</td>
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Results: Effect size analysis of all transfer strategies have shown that in isometric single-joint-movement contractions more than 50% of MVC evoke maximal overflow activity (see Table 1). Generally higher muscles activities yields higher overflow ratios. Especially contra-lateral transfer is more effective than other strategies of cross-innervation.

Discussion: There were significant differences between single- and multi-joint-movement as well as between static and dynamic trials. Crossing direction is also a determinant fact of the overflow ratio. Therefore different adaptions in strengths properties are possible. Furthermore the results show that an overflow ratio of more than 20% of the MVC is known to facilitate a positive effect on physiological and morphological changes of the muscle [1]. An advanced training method for therapy as well for sport exercise like cross effect training has to be refined and applied to show the increase of strengths properties.

Conclusion: Kind of muscle, single- or multi-joint-movement and crossing direction as well as isometric or dynamic action has to be consider in a special way. In future RCTs has to be done to estimate the increase of strength by special crossing training programs.

References
Evaluation of sport therapy by patients with neuromuscular diseases

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Introduction: The evaluation and validation of sport therapy and medical training therapy indicates practical, educational and psychological hints for the configuration and implementation of therapy content for patients with neuromuscular diseases [1]. The aim of this paper is to review and to discuss some effects such as individual strain for further improvements of the quality of sport therapy.

Methods: On the prospective cross and longitudinal section study, male and female patients with neuromuscular diseases participated (spinales muscleatrophy, fazio-skapulo-humerale dystrophy, limb-trunk-dystrophy, myotone dystrophy and centronuclear myopathy). Heart rate, lactic acid concentration, rating of perceived exertion (RPE) (Borg-scale 20) as well as gait ability (Rivermead Visual Gait Assessment, “Stand-up and Go-Test”, dynamic Foot-Pressure-Measurement) were observed. Training sessions (45 min) were divided into a warm-up- (15 min), flexibility- (10 min), strength- (15 min) and cool-down phase (5 min). All exercises were realized in the same way and monitored by therapists.

Results: Peak heart rate (120 bpm) was seen in the warm-up-phase. During the flexibility-, strength- and cool-down-phase the heart rate was reduced on an average by 100 bpm (see Fig. 1). Blood lactate kinetic increased during the warm-up-phase (rest: $1.03 \pm 0.1$ mmol/l, warm-up: $1.20 \pm 0.18$ mmol/l) and remained constant during the others. The complete session was completed in an aerobic range ($< 1.22 \pm 0.16$ mmol/l). The rating of perceived exertion was assessed by “somewhat hard” (13–14). The paramount value was in the warm up- (max. 14) and in the strength-training-phase (max. 16). In the cool-down-phase the medial RPE was 7.3. No changes in the scores of gait abilities (see limb position, trunk position at stance and swing phase positions) as well changes in ground reaction forces were detected.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{heart_rate_curve.png}
\caption{Heart rate curve over 45 minutes in an exemplary training setting.}
\end{figure}
Discussion and Conclusion: The strain in the patients with neuromuscular diseases (cf. heart rate and lactic) was in a moderate way in all training settings. The rating of perceived exertion has been found to be a reasonable method for quantifying the intensity of aerobic and resistance training [2]. Improvements of technical (gait) skills could not be shown; longer intervals of technique training are necessary to optimize motor patterns [3]. Evaluation of sport therapy and medical training therapy is necessary. Further persons (e.g. specialists in sports, medical doctors, physical education teachers) must be sensitized for the problems of patients with neuromuscular diseases.

References


School sports and osteoporosis prevention: A meta-analysis

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Introduction: Physical exercise during youth has been shown to enhance bone mineral density, thus reducing the risk of osteoporosis. The purpose of this study was to find an optimal means for teachers to help young people to prevent osteoporosis. This was conducted through the analysis of previously published studies addressing osteoporosis prevention through physical activity and sports. Many studies have shown that high-impact sports result in greater benefit than low- or non-impact sports. Most of these studies focused on particular sports and compare results between active athletes and non-athletes in a single country. Since there are many factors that enhance bone mass, such as nutrition or exposure to sun (to increase and convert vitamin D), these studies cannot be compared easily. It is even more difficult to single out the most effective sport from a mere comparison between the results of these studies.

Methods: In order to overcome these difficulties a meta-analysis was conducted. Relevant studies were divided into four groups, namely “gymnasts”, “endurance runners”, “swimmers” and “ball sports”. The difference in percent of the bone mineral density between athletes and their control groups (non-athletes) was taken and added up over all studies. Results from various measuring points were compared. In a next step weighted means and ± SD were calculated. By comparing the resulting effect sizes (ES) the contribution from each sport to enhanced PBM (peak bone mass) can be revealed.

Results: Except for the WT (wards triangle) and LS (lumbar spine), which is higher for athletes in the gymnastics group, all other means were highest in the group consisting of ball games. The TB (total body density) from gymnasts, swimmers, and endurance runners were not higher than those of their control groups. When measuring the FN (femoral neck), the WT and T (Trochanter) for the gymnasts where higher than the values for runners; however, when calculated for the legs (BMD = BMC/total area), the means were reversed.

Conclusion: In physical education activity classes, teachers can best prevent osteoporosis by playing various types of ball games.
Benefits of performance-specific parameters after a one year ambulant cardiac rehabilitation (Phase III)

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**Introduction:** The World Health Organization is defining cardiac rehabilitation as “the sum of sanctions, we need to get the best physical, mental and social status, for coming back in a normal active life and getting their normal place in the society again” [1]. Life style modification is beside of the pharmacological therapy a very important part in the secondary prevention of cardiovascular diseases. Therefore, the most important cardiac and sports medicine (physical activity) associations [2] as well as many popular studies [3] advise physical fitness with moderate intensity. The aim of the study is to show the progress of the performance from 60 persons after a one year ambulant rehabilitation program, including a 30 minutes endurance cycling training (daum electronic; ergo control 250) and a 25 minutes moderate physical training (strength training and coordination training), twice a week. A symptom limited incremental cycle ergometer test was done at the beginning of the therapy (e1), after 6 month (e2) and after 12 month (e3). The intensity of the training was established individually with either 75–85% of the heart rate threshold or the HR according to 50–70% of maximal power output (Pmax). In addition they got the instruction to make further endurance training for two or three times a week.

**Methods:** 57 male patients (age: 60 ± 10 years, height: 175 ± 8 cm, weight: 81 ± 11 kg) attend a one year ambulant cardiac rehabilitation program, including a 30 minutes endurance cycling training (daum electronic; ergo control 250) and a 25 minutes moderate physical training (strength training and coordination training), twice a week. A symptom limited incremental cycle ergometer test was done at the beginning of the therapy (e1), after 6 month (e2) and after 12 month (e3). The intensity of the training was established individually with either 75–85% of the heart rate (HR) of the heart rate threshold or the HR according to 50–70% of maximal power output (Pmax). In addition they got the instruction to make further endurance training for two or three times a week.

**Results:** The average presence was 70 ± 33%. Medication could be changed according to the individual decision of the physician, but was fairly identical. All subjects showed a consistent increase in maximal power output from 144 ± 47 W (e1) to 165 ± 47 W (e2) \((p \leq 0.001)\) and 175 ± 49 W (e3) \((p \leq 0.001)\) respectively, which was 18 ± 19% and 25 ± 23% respectively. The average HR at 100 W changed from 111 ± 16 beats per minutes (bpm) (e1) to 107 ± 19 bpm (e2) \((p \leq 0.01)\) respectively 103 ± 14 bpm (e3) \((p \leq 0.001)\) respectively. The weight changed significantly from 81 ± 11 kg (e1) to 83 ± 10 kg (e3) \((p \leq 0.001)\); BMI 26 ± 3 to 27 ± 3 \((p \leq 0.001)\); resting HR was 74 ± 12 bpm (e1) and 70 ± 12 bpm (e3) \((p \leq 0.05)\); HR\(_{max}\) changed from 134 ± 25 bpm (e1) to 140 ± 20 bpm (e3) \((p \leq 0.05)\); resting systolic blood pressure changed from 116 ± 16 mmHg (e1) to 117 ± 16 mm Hg (e3) \((p > 0.5)\) and maximal systolic blood pressure changed from 173 ± 29 mmHg (e1) to 180 ± 28 mmHg (e3) \((p \leq 0.05)\).
Discussion: There is a huge amount of evidence based studies [2,3] suggesting physical training 4–7 days per week. In this investigation we can show that there is also a benefit in fewer training sessions if the patients are in a poor physical condition. Moreover we can see on the strength of weight, that for some parameters it would be necessary to train more.

Conclusion: In Austria the ambulant cardiac rehabilitation, based on the ÖKG guidelines [4], consists of a physical training twice a week. Even though in this group of patients good progress in performance parameters can be achieved, the goal should be to reach a weekly energy consumption of additional 1700–3000 kcal. This means that it is getting more and more important to make the patients aware of the fact that they should do further exercises in addition to the regular training units.

References


Influences of an ergotropic task on vigilance

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Introduction: Especially in the past years a lot of studies deal with the positive effects of aerobic fitness on the heart rate variability (HRV), a prognostic tool to describe the sympathovagal balance. Aerobic physical fitness is doubtless beneficial in overcoming mental stress situations. In this study it was attempted to demonstrate that a combination of ergotropic and concentrative tasks cause an improvement of vigilance.

Methods: 36 male healthy well trained subjects participated in a vigilance test (KLT-R) both at rest and under ergotropic conditions. During the ergotropic period the work load of the bicycle ergometer was varied in order to hold heart rate on a constant level of 150 bpm. During the whole test heart rate was continuously recorded and
controlled using AR12 recorder (TOM medical). Between the two vigilance tests (two parallel versions of the KLT-R: version A and B) the volunteers had a period of rest.

Results: The parameters “total power” (TP) and “correctly calculated items” (CC) showed a significant increase during the bicycle ergometry ($p < 0.01$). Concerning the number of falsely calculated items the decrease was not significant.

Discussion: The results of this study demonstrate that a combination of an ergotropic activity with a mental task results in an increase of the vigilance. To put it differently, both the quantity and the quality of the performance of the concentration show a higher level at a combined task. So it can be assumed that both the activation of the autonomic nervous system and the reduction of the stress metabolites cause the high vigilance performance.

Conclusion: From the results of this study it can be concluded that a mental task in combination with physical activity causes a high performance of vigilance. It can be assumed that the described combination of a mental task with a physical activity could be the basis of a therapy for patients that suffer from weakness of memory, vigilance or concentration.

References

Effects of a moderate unilateral strength training in patients with different continuous course of multiple sclerosis

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\textbf{Introduction:} Patients with multiple sclerosis (MS) show a restriction in mobility, such as walking and stair-climbing, which is a correlated with lower limb strength [1,2]. The aim of the non-randomized prospective study was to evaluate the effect of an unilateral dynamic strength training in a closed system for the lower leg extensors of patients with different continuous course of multiple sclerosis.

\textbf{Methods:} 36 multiple sclerosis patients with chronic progressive (C-MS; age: 51.6 \pm 10.7 years, BMI 25.3 \pm 3.3) and 35 patients with relapsing (R-MS; age: 45.2 \pm 11 years, BMI 23.5 \pm 3.5) continuous course were selected to strength her leg muscles on the leg press. During a 4-week stay in a rehabilitation clinic the strength levels were evaluated with a One Repetition Maximum Test (ORM) on the training equipment. They absolved twice a week (3 sets per unit, 20–30 repetitions per set) a low intensity dynamic strength training with a resistance of 40\% of the ORM with the weak leg. It was possible to train the patients in accordance with principles of training known from sport science.

\begin{figure}[h]
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\includegraphics[width=\textwidth]{image}
\caption{Results of the ORM-Test.}
\end{figure}

\textbf{Results:} The unilateral strength training significantly increased the maximum muscle strength of the leg extensor muscles. We also can show, that there are positive effects on the outcome of both legs and a significant ($p < 0.01$) increase of the untrained leg in R-MS (Fig. 1). We can find a significant ($p < 0.01$) reduction in the side difference in C-MS (pre: 17.77 \pm 12 kg; post: 13.05 \pm 10.4 kg). The R-MS patients showed no decrease in side difference. There were no significant difference in the outcome between the C-MS and the R-MS group.

\textbf{Conclusions:} The results of the investigation indicate that low intensity (40\% ORM) dynamic unilateral strength training is a useful and well tolerable method to increase muscle strength. The C-MS group benefits as well as the patients with relapsing MS from the training.
References


Cost-utility of water- and land-based exercise therapies in fibromyalgia

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Introduction: The purpose was to compare the cost-utility of three alternatives to treat persons with fibromyalgia.

Methods: Eighty-four women with fibromyalgia (mean age 49, SD 10) were distributed to a land-based exercise program \((n = 30)\), waist-high water-based program \((n = 17)\) and conventional treatment used as control group \((n = 37)\). Both exercise training were similar and consisted of 3 one-hour sessions per week. The outcomes were measured at baseline and three months later. The main outcomes were the index of Fibromyalgia Impact Questionnaire (FIQ), the number of Quality of Life Adjusted Years (QALY) obtained by the Area Under Curve technique using the time trade-off elicitation technique from the health states of EQ-5D and the intake of specific drugs. The QALYs were adjusted to baseline differences by multiple regressions. The analyses were modelled for groups of 20 persons in year 2005 € from two perspectives: public health system and societal. Sensitivity analyses for variations in the number of women attending sessions and time spent because of the distance from waist-high pool were performed.

Results: The drugs intake remained unchanged. The incremental cost of land-based versus control per QALY gained was 1206 € from health system view and 1635 € from social perspective. This of aquatic training was 1091 and 2037 € respectively. The incremental cost of aquatic training versus land-based was 950 and 2534 €. Compared to the updated threshold of sanitary efficiency for Spain \([1]\) both therapies were efficient but specially the aquatic training in groups enrolling 5 to 20 persons. But the analysis of sensitivity revealed that aquatic training was not efficient for individuals who need to drive a car more than 60 minutes (30 minutes far) from an adequate pool.

Conclusion: Both therapies are efficient. Aquatic training is more efficient than land-based for women with fibromyalgia living close to facilities with waist-high warm water. In contrast, land-based exercise is suitable to spread the benefits of physical therapy to a high number of persons with fibromyalgia.

Reference


Benefit of blood lactate determination during ergometer training in cardiac rehabilitation

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Introduction: The safety and efficacy of exercise training in patients have been reported in a large number of scientific studies \([1,2]\). Training intensity must overreach a certain threshold, but training effect is higher with
increasing intensity. On the other hand, too high effort can be hazardous and must be avoided. Therefore, defining the optimal exercise intensity remains a difficult task. Furthermore, progression of training intensity during a several months lasting training program is necessary to force adaptive processes. Aim of the study was to proof lactate steady state tests as a method for the validation the training intensity during cycle ergometer training in CHD patients [3].

Methods: Before starting the training program 105 patients (100 male, 5 female; age: 58 ± 11 years; height: 174 ± 7 cm; weight: 83 ± 11 kg) performed a symptom limited incremental cycle ergometer test to find the individual training intensity. The intensity of the training was established individually with either 75–85% of the heart rate (HR) at the heart rate threshold or the HR according to 50–70% of maximal power output (P_max). The training intensity was adapted according ratings of perceived exertion within several weeks. To control the intensity a lactate steady state (LSS) [3] test (daum electronic; ergo control 250) for each patient was done. Within the 30 minutes endurance training (5 minutes warm – step by step up to the individual intensity, 25 minutes at target intensity), capillary blood was collected prior to exercise (La1), in the 5th min (La2), 15th min (La3), 25th min (La4), and at the end of the test (La5). Each sample was analysed immediately, using an enzymatic lactate analyser (BIOSEN C_line sport, Germany).

Results: 72 out of 105 patients presented a lactate steady state (La_{stst}) between La3 and La5 (changes in La <0.5 mmol.l^{-1}). 21 presented a significant decrease (La_{decr}) between La3 and La5 (change >0.5 mmol.l^{-1}; p = 0.001), and 12 patients showed a significant increase (La_{incr}) between La3 and La5 greater than 0.5 mmol.l^{-1} (p = 0.001) (Fig. 1). The maximal La concentration at the end of exercise (La_{decr}: 2.4 ± 1.0; La_{stst}: 2.5 ± 1.2) was significantly higher in the La_{incr} patients reaching 5.0 ± 2.0 mmol.l^{-1}. The intensity of training load was not significantly different between groups (La_{stst}: 59.4 ± 10.8% P_{max}; La_{incr}: 65.5 ± 8.3% P_{max}; La_{decr}: 60.9 ± 9.41% P_{max}). Average heart rate during training load was not significantly different between groups (La_{stst}: 76.2 ± 9.2% HR_{max}; La_{incr}: 79.3 ± 7.9% HR_{max}; La_{decr}: 77.7 ± 8% HR_{max}). Based on the time course of La (Fig. 1) target training intensity was individually adapted by an increase, decrease or no change in power output where appropriate.

Discussion: Physical exercise is one of the most important cornerstones in cardiac rehabilitation [1,2]. A very important task is to prescribe and to control the intensity of the exercise. Guidelines for exercise training intensity prescription have a wide range which makes it difficult to choose an individual target training intensity. As we have shown, even with an individual determination of training intensity an overexertion seems to be possible during training. Moreover, for the adaptation of the intensity during a long lasting training process, often a new symptom limited incremental cycle ergometer test is necessary.

Conclusion: With the LSS during exercise training the actual training intensity can be easily validated and the intensity can be arranged. This can be useful to avoid overexertion and for adaptation of the training intensity over time. Therefore, the control of exercise intensity by means of La measures may be recommended on basis of these results.
Effects of early cardiac rehabilitation exercise training in old patients after heart surgery

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Introduction: Recovery of functional capacity after heart surgery is important for a successful reintegration in daily living. Exercise intervention was shown to improve exercise performance and quality of life in coronary heart disease patients (CHD). Aim of the study was to prove the effects of additional walking or cycle ergometer training on exercise performance compared to a standard rehabilitation program after heart surgery in older male and female patients.

Methods: This trial enrolled 60 (32 male, 28 female) patients (mean age 73.1 ± 4.7 years). Subjects were randomly assigned in three groups (two intervention groups and one control group). Subjects performed a symptom-limited ergospirometry on cycle ergometer (Marquette, USA), which comprised measures of power output, gas exchange variables (Cortex Metamax, Cortex Biophysik, Leipzig), and blood lactate concentration (La) (EBIOplus, Eppendorf, Germany). 12 lead ECG was measured throughout the ergometer test and during recovery. Patients completed a 6-minute walk test (6MWT), additionally. A standard questionnaire (MacNew) was used to assess quality of life. All tests were performed before and after four weeks of cardiac rehabilitation in a cardiac rehabilitation center.

Control group patients (Co) underwent a standard training program (non structured, supervised walking + gymnastics). Intervention groups, walking group (W) and cycle ergometer group (C), completed the standard training program with additional structured and regulated walking (W) or cycle ergometer (C) training.

Results: At baseline no significant differences were detected between all groups for maximal oxygen uptake (VO\textsubscript{2max}) (W: 13.5 ± 2.5 ml/kg/min\textsuperscript{-1}; C: 13.3 ± 1.9 ml/kg/min\textsuperscript{-1}; Co: 12.4 ± 2.4 ml/kg/min\textsuperscript{-1}), maximal power output (P\textsubscript{max}) (W: 45.8 ± 13.2 W; C: 45.6 ± 15.8 W; Co: 40.2 ± 12.3 W), maximal heart rate (HR\textsubscript{max}) (W: 103 ± 17 bpm; C: 102 ± 13 bpm; Co: 104 ± 16 bpm), maximal lactate concentration (L\textsubscript{max}) (W: 2.7 ± 1 mmol/l; C: 2.8 ± 0.8 mmol/l; Co: 2.8 ± 1 mmol/l), rating of perceived exertion at maximum workload (RPE\textsubscript{max}) (W: 14.5 ± 1.8; C: 14.6 ± 1.7; Co: 14.5 ± 1.2), distance covered in the 6-MWT (W: 321 ± 82 m; C: 335 ± 73 m; Co: 304 ± 80 m) and global QOL score (W: 5.8; C: 5.5; Co: 5.3).

After the training intervention these variables improved significantly within all three groups (VO\textsubscript{2max}: +25–27%; P\textsubscript{max}: +34–38%; HR\textsubscript{max}: +6–15%; L\textsubscript{max}: +31–39%; RPE\textsubscript{max}: +15–16%; 6-MWT: +24–30%; QOL global: +12–16%). No significant differences between groups were only found post training except for P\textsubscript{max} in C compared with Co (*P < 0.05).

Discussion: The effective all-inclusive influence of cardiac rehabilitation contributed to an improvement of VO\textsubscript{2max} mean +25.7%. The results are similar to other investigations [1] which reported a 19–29% increase of VO\textsubscript{2max} only in CABG patients. Minimal exercise program (Co-group) allowed more recovery time [2], which is an important reason besides a low pretraining VO\textsubscript{2max} [1] for possible spontaneous improvements [1,3]. The tendency of increasing aerobic capacity in intervention groups is probably due to amount and specificity [4] of exercise training.

Conclusions: The cardiac rehabilitation program improved significantly exercise performance and QOL in old patients after heart surgery. Extensive training caused no significant additional benefits except for P\textsubscript{max}. However, a trend was shown for a functional adaptation dependent on specificity of movement and amount of time spent in exercise training.
Glutathione Peroxidase (GPx)

Endurance test (45% VO\(_{\text{max}}\))

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**Introduction:** Several authors reported that exercise increases oxidative stress [1], which has inspired athletes for intake of antioxidant supplements. Wealth of data exist, often conflicting, concerning the production of reactive oxygen and nitrogen species (RONS) during exercise, their effects on cellular antioxidant systems, cellular components and the effects of exogenous antioxidant intervention on exercise performance and exercise induced damage [2–4]. In the present study the influence of 15 days antioxidant supplementation on glutathione peroxidase (GPx) activity and glutathione (GSH) in erythrocytes at rest, during and after exercise was investigated.

**Methods:** Seven male, healthy and trained (55 ± 5 mL kg\(^{-1}\) min\(^{-1}\) VO\(_{2\text{max}}\)) subjects, mean age 29 ± 3 years, non smokers, undertook two endurance tests on a mechanically braked cycle ergometer for 90 minutes at 45% of VO\(_{2\text{max}}\) and another one for 30 minutes at 80% of VO\(_{2\text{max}}\). One week before the first endurance test was performed VO\(_{2\text{max}}\) was evaluated via step test to exhaustion. All tests were performed twice: once without (placebo) and once with antioxidant supplementation (vitamin C 450 mg/d, vitamin E 72 mg/d, β-carotene 36 mg/d, selenium 100 μg/d) for 15 days. Before, during, 30 minutes and 60 minutes after exercise blood was collected and analysed for vitamin C and E, β-carotene (plasma), GPx and GSH (erythrocytes). Total protein was calculated at each time.

**References**

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point to exclude blood volume artefacts. Subject nutrition was documented and analyzed during the investigation period by software. Statistics: ANOVA and covariance with repeated measurements; \( p < 0.05 \).

**Results:** Vitamin C: The levels measured in the samples prior, during and after exercise were not different between the two groups. No significant influence of exercise (neither intensity nor duration) was found. Vitamin E and \( \beta \)-Carotene: Supplementation caused an increase of both vitamins over the whole observed time. Exercise had no influence on vitamin C and E concentrations. GPx: The mean values in the supplemented group were at all time points found to be lower than in the control group. No effect of exercise was observable on GPx. GSH. There was no difference between supplemented and placebo group. No influence of exercise on GSH was found. Nutritional behaviour was similar beyond the subjects.

**Discussion:** Vitamin supplementation only resulted in a significant increase of plasma vitamin E and \( \beta \)-carotene values over the whole time curve. GSH concentrations showed no clear picture, similar to other investigators [5]. The GSH pool seems to be unaffected by short time antioxidant supplementation as well as by the types of exercises performed in this study. GPx time courses were found to be lower in the supplemented group. We suggest that vitamin supplementation led to a kind of “enzyme-saving” due to the offer of exogenous antioxidants. Obviously selenium supplementation for 15 days did not increase GPx activities.

**Conclusion:** Increase of antioxidant vitamin concentration in plasma might not cause automatically a better antioxidant defense against oxidative stress if GPx concentrations decrease in erythrocytes over the same time period. Supplementation with exogenous antioxidants probably can impair the endogenous antioxidant enzyme systems as shown by GPx values in this study.

**References**


**Neuroendocrine and autocrine effects of crh system on skeletal muscles**

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**Introduction:** The characterization of corticotrophin-releasing hormone (CRH) and CRH receptors and the development of specific CRH receptor antagonists selective for the CRH receptor subtypes have led to the understanding of the biochemical coding of several physiologic and pathophysiologic mechanisms. Aim of this study is to describe the neuroendocrine and autocrine effects of CRH system on skeletal muscles.

**Materials and Methods:** This non-systematic review presents the author’s selection of studies related to the CRH family of neuropeptides. Two databases were searched using basic search terms.

**Results:** Corticotrophin releasing hormone 2 receptor (CRH2R) is expressed in skeletal muscle. Also, Urocortin II mRNA is widely expressed in a variety of peripheral tissues, but was found to be most highly expressed in the skin and skeletal muscle tissues. CRH2R protein is abundant in neural tissues in skeletal muscle, including large nerve fibers and bundles, neural tissue associated with mechanoreceptors, muscle spindles, and the Golgi tendon organ. CRH2R protein is also abundant in blood vessels in skeletal muscle. CRH2R protein is also observed, although with less abundance, in the endo/perimysial regions in skeletal muscle. The exact function of this receptor in skeletal muscle is at present unknown. For this reason, CRH2R agonists were evaluated on normal and denervated muscle mass in rats. CRH2R agonists reduce the denervation-induced loss of rat skeletal muscle mass and force and increase non-atrophying skeletal muscle mass and force. In a similar way, Urocortin II treatment reduces skeletal...
muscle mass and function loss during atrophy and increases nonatrophying skeletal muscle mass and function. These peripheral actions demonstrate that CRF2R-selective agonists may find utility in the treatment of skeletal muscle wasting diseases including age-related muscle loss or sarcopenia. Also, CRH2R-selective agonists were also used to modulate nerve damage and corticosteroid- and disuse-induced skeletal muscle atrophy in mice. These analyses demonstrated that activation of the CRH2R decreased nerve damage and corticosteroid- and disuse-induced skeletal muscle mass and function loss. In addition, experimental data proved a direct autocrine effect of CRH in stimulating thermogenesis in skeletal muscle. In contrast, experimental models with repeated exercise training showed an increase in basal pituitary-adrenal activity associated with decreases in glucocorticoid mRNA expression in brain.

Discussion: The CRH system characterization may be promising for significant advances in our understanding of skeletal muscle disorders and will contribute to the development of novel and more effective prophylactic and/or therapeutic approach.

Conclusion: The axon brain-hypophysis-adrenals does not explain all the possible actions of CRH system on skeletal muscles. The peripheral, autocrine effects of CRH system establish a complementary way and a multimodal basis for the physiology and pathophysiology of muscular tissues.

References

Adrenomedullin and volume regulation in humans under extreme conditions

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Introduction: Diuresis and natriuresis are well-known responses to acute hypoxic exposure, e.g. high altitude (HA) sojourn. Adrenomedullin (AM) is a recently discovered diuretic/natriuretic peptide. The kidney is supposed to be a major site of AM production, and specific receptors are found in renal arteries and glomeruli. Hypoxia is known to be one of the strongest stimulators for AM release. The kidney is amongst the organs most sensitive to hypoxia, and renal AM production is increased under hypoxic conditions. This may cause a protective effect against renal hypoxic injury. As strenuous exercise is also associated with renal hypoxia, AM could be involved in the fluid and electrolyte regulation especially in endurance sports. Aim of the presented study was to examine whether the hypoxic diuretic response (HDR) is affected by AM rather than by other volume regulating hormones.

Methods: After a baseline examination at low altitude (LA), 33 subjects (16 f, 19–65 yrs) underwent investigations on the 3rd day (acute HA exposure, HA-1, 3440 m) and on the 14th day (long-term HA exposure, HA-2, 5050 m) of HA sojourn. At each time, a nocturnal 9-h-urine collection was performed and blood samples were drawn, immediately centrifuged and deep-frozen. The plasma concentrations of AM (AM[p]), VP, PRA, Aldo and ANP were determined and the absolute urinary AM excretion was measured (AM[u]).

Results: As expected, 9-h-nocturnal diuresis rose from 511 ± 47 to 690 ± 80 mL at HA-1 and to 1018 ± 72 mL at HA-2 (p <0.005). In this period, absolute natriuresis (Na⁺[u]) was similar at LA and HA-1 (49.6 ± 4.9 vs. 45.9 ± 4.2 mM), but increased to 84.6 ± 5.9 mM at HA-2 (p <0.005). As shown in Table 1, AM[u] showed the same course at LA and HA-1 and an increase at HA-2. AM[p] rose at HA-1 vs. HA-1 and stayed at the same level at
Table 1

<table>
<thead>
<tr>
<th></th>
<th>AM[u] (pM)</th>
<th>AM[p] (fM/mL)</th>
<th>VP (pg/mL)</th>
<th>PRA (ng/mL/h)</th>
<th>Aldo (pg/mL)</th>
<th>ANP (pg/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>7.9 ± 0.6</td>
<td>16.6 ± 0.4</td>
<td>1.4 ± 0.2</td>
<td>2.4 ± 0.2</td>
<td>191.4 ± 19.7</td>
<td>10.0 ± 0.8</td>
</tr>
<tr>
<td>HA-1</td>
<td>7.6 ± 0.6</td>
<td>20.8 ± 1.0**</td>
<td>0.7 ± 0.1**</td>
<td>1.2 ± 0.1**</td>
<td>132.4 ± 7.1</td>
<td>14.7 ± 1.1**</td>
</tr>
<tr>
<td>HA-2</td>
<td>10.7 ± 0.7*</td>
<td>19.5 ± 0.6**</td>
<td>0.4 ± 0.1**</td>
<td>1.0 ± 0.1**</td>
<td>144.9 ± 15.4</td>
<td>18.0 ± 1.9**</td>
</tr>
</tbody>
</table>

*p < 0.05; **p < 0.005.

HA-2. VP and PRA decreased and ANP increased continuously over the time. Compared to LA, Aldo was reduced at HA-1 and stayed at the same level at HA-2. Whereas VP showed only a weak relationship to diuresis (R = -0.20; p < 0.05) and PRA to Na⁺[u] (R = -0.21; p < 0.05), AM[u] correlated strongly to diuresis (R = 0.72; p < 0.005) and to Na⁺[u] (R = 0.57; p < 0.005). No link was found between AM[p], Aldo and ANP and diuresis and/or natriuresis or between AM[p] and AM[u].

**Conclusion:** We believe to be first to report indication that the diuretic and natriuretic effect of AM is mediated by locally produced AM[u] rather than by systemic action of AM[p]. This investigation suggests an essential role of increased renal AM production in the pathophysiology of fluid and sodium loss under hypoxic conditions. AM might be a “missing link” within fluid regulatory adaptive factors under extreme conditions, driving diuresis and natriuresis in concert with already known volume regulating hormones.

**Acknowledgement:** This study was supported by the government of Styria and the city of Graz, by a grant of the Friedrich Schmiedl Foundation and a grant of the Lanyar Foundation.

Heart rate performance curve and Gly389 Arg β1-adrenoceptor polymorphism

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**Introduction:** In 1982 Conconi et al. described the determination of the anaerobic threshold by means of heart rate deflection analysis. However, the Heart Rate Performance Curve (HRPC) was described to be neither linear nor uniform in young healthy male subjects [5] and the method has been critically discussed. Recently, it was shown, that differences in β1-adrenoceptor (AR) sensitivity were described to explain the different response patterns of the HRPC in young healthy male subjects [4]. As the pattern of the HRPC is relatively stable, genetic differences in the β1-AR between subjects with different HRPC and β1-AR antagonist treatment response may be expected. The purpose of the study was to investigate if the Gly389 Arg β1-adrenoceptor polymorphism [2] is related to these described differences in the HRPC.

**Methods:** 164 young healthy male sports students (age 23 ± 4 yrs) participated in the study. Incremental cycle ergometer exercise (40 W start, 20 W/min increase) was performed in all subjects to obtain the HRPC. The different HR patterns were described by the degree and the direction of deflection (k_{HR}) of the HRPC [5]. The β1-adrenoceptor Gly389 Arg polymorphism was determined from venous blood samples according to published standards [3]. ANOVA was calculated to describe differences of k_{HR} between the three genetic variants.

**Results:** The number of subjects presenting different variants was 83 (AA), 73 (AG) and 8 (GG). k_{HR} was found at 0.29 ± 0.34 (AA), 0.37 ± 0.36 (AG) and 0.37 ± 0.37 (GG) (Fig. 1). No significant difference was found for k_{HR} between the different polymorphisms, however a trend to lower values in the homozygous Arg389 (AA) variant was seen.

**Discussion:** As described by Büscher et al. [3] the Arg389 Gly polymorphism was not significantly related to functional differences in the study group. However, comparable to these authors a non significant lower HR response...
Variants

Fig. 1. Relationship between the degree and the direction of the Heart Rate Performance Curve ($k_{HR}$) and the Arg$^{389}$ Gly $\beta_1$-adrenoceptor polymorphism variants.

indicated by a lower $k_{HR}$ value was found in the Arg$^{389}$ variant (Fig. 1). Contrary to Mason et al. [6] who found a significant relationship in the in-vitro function of the Arg$^{389}$ Gly polymorphism, our data do not support this findings.

Conclusion: As previously described the Arg$^{389}$ Gly $\beta_1$-AR polymorphism had no significant functional relationship with HR response to incremental cycle ergometer exercise in young healthy male subjects. Our data suggest that the polymorphism at codon 389 of the $\beta_1$-AR is not of major physiological importance in terms of exercise and $\beta_1$-AR activation in vivo.

References


Obesity and Co-Morbidities

Determining the multidisciplinary approach in morbid obesity therapies

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Introduction: Obesity is a common problem for doctors and patients, while it consists a bad prognostic factor for major operations in general surgery. Bariatric surgery, dealing with really fat people with Body Mass Index >35, is a team depending case with lethal prognosis if certain rules are not followed.

Methods: This non systematic review describes various aspects of Ethics and Legislation for Bariatric surgery and analyses the moral dilemmas that appear.

Results: Too obese people consist a vulnerable group of patients, having psychological problems that include depression, anxiety disorders, mood disorders and problems related to sexuality. Bariatric surgery, represented in
society with the popular Gastring Banding procedure, is a fast growing reality in obesity therapies and recently appears even in small Hospitals, without suitable facilities and trained personnel. Health Legislation is mostly general and does not refer to certain fields and aspects of Medicine. The law-gaps existing in most Health Legislation Systems of Europe, make Bariatric surgery even more attractive and available to general surgeons. Medical marketing has worked well for bariatric surgery, but lack of special training of surgeons on one hand and quality control problems in Health Systems on the other raise mortality and morbidity in a great degree in certain cases. Pre-surgical psychiatric assessment of obese patients is not systematically applied although patients that are willing to be operated for obesity are frequently psychotic or suffer from severe depression. Comparing mortality and morbidity from numerous Hospitals in Europe and USA we conclude that only in Bariatric Surgery Centers, we see percentages similar with medium-risk operations. Talking for the future, mandatory certification of general surgeons for special operations will spread gradually in every Hospital and every country of Europe. Especially for bariatric surgery, an endocrinologist and a psychiatrist are needed to contribute in the team dealing with morbid obesity, and this team cannot work sufficiently in any Hospital. The 303/2002 Law that was voted in France in 2002, determines the Hospital responsibility as an Institute, referring to building, managerial and facility problems and expands the quality control beyond doctors and nurses to the final product of health services.

Conclusion: Health promotion mechanisms will outline the future in obesity therapies, thanks to certification-demanding legislation. Prevention and psychosocial assessment of obesity will become the first step in obesity therapies when moral rules become a law for Hospitals.

References


The mass index MI considers the relative leg length which is ignored by the BMI: Results with tall athletes

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Introduction: The most often used measure to define relative body weight is the Body Mass Index (BMI): $\text{BMI} = \frac{m}{h^2}$ [kg/m²]. Recently, a measure for relative body weight has been introduced [1,2]: the Mass Index (MI): $\text{MI} = 0.28 \frac{m}{s^2}$ [kg/m²] which distinguishes between persons with different body proportions (in terms of sitting height s). Longer legs yield a higher MI compared to the BMI, and vice versa for shorter legs. If the MI is used instead of the BMI, it may be expected that tall persons have an increased MI (compared to BMI) due to their usually unproportional longer legs [3].

Methods: In several field studies high-level volleyball and basketball players as a group of tall athletes (TA) have been compared with a reference group (RG). Height (h), sitting height (s) and weight (m) have been measured according to [4]. Overall, 531 persons, all of them over 18 years old and male, have been investigated. Data of the reference group (men) has been collected in the summer of 2005 in the hot spring bathes of Waltersdorf and Kölflach ($N = 492$). Data of the athletes has been collected during training sessions in Klagenfurt, Kapfenberg and Graz in 2004 ($N = 39$).

Results: The mean height of the RG was 1.761 m with a SD of 0.074 m. We defined “tall” as a body height outside of 1 standard deviation, so that we included only persons with a height over 1.835 m in the group of tall athletes: the mean height of this TA group was 1.962 m (SD 0.083 m).
Fig. 1. Tall athletes: The MI substantially increases with increasing body height h when compared to the BMI.

The mean *BMI* of the RG was 26.37 kg/m$^2$ (SD 3.60), the mean *MI* was 26.80 kg/m$^2$ (SD 3.73). The TA group had a mean *BMI* of 24.33 kg/m$^2$ (SD 3.06) and a mean *MI* of 25.82 (SD 3.45).

When the *MI* was used instead of the *BMI* in the RG the value of the relative body weight changed with a mean difference of +0.43. The mean difference in the TA group was +1.49 (Fig. 1).

**Discussion and Conclusion:** The slightly increased value of the RG (+0.43) is due to a lower mean s/h ratio in the investigated group (0.525 vs. 0.53 which was used for the definition of the *MI*). The higher increase in the TA group mirrors the pronounced effect of individual leg length on relative body weight. The *MI* considers the individual leg length which the *BMI* does not. The WHO is aware of the problems resulting from this inadequacy of the *BMI* when applied to small or tall persons or to different ethnic groups: “Care should therefore be taken in groups and individuals with unusual leg length to avoid classifying them inappropriately as thin or overweight” [5].

**References**


**Vibration Training in Health and Disease**

**Influence of the grade of knee flexion on mechanical and electromiographical impact during the whole body vibration exercise**

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Introduction: The magnitude of acceleration produced by Whole Body Vibration Exercise (WBV) with small vertical oscillations could be osteogenic but one of the most used WBV device by clinics produces oscillations by means of the rocking of a platform on an axle, pointing out a foot of each side of the axle (WBVa). The body posture is a major determinant of the mechanical impact transmitted from vibrating platform throughout body. The purpose was to compare the received three-dimensional acceleration in the lumbar zone and the electric activation of the muscles selected during a WBVa in three 3 different angles of flexion of the knees.

Methods: Thirty women (mean age 22, SD 2) performed 3 repetitions of WBVa (Galileo 900, Novotec, Germany) at 25 Hz and 4 mm of amplitude oscillatory during 30 seconds within 5 minutes of rest between them. The repetitions were performed with 15, 45 and 90° of flexion of knees. The acceleration was recorded by a tri-axial accelerometer (Biopac, USA) attached on the skin at L3 level and the EMG was registered by surface active electrodes (Biopac, USA) on the extensors and flexors of knee and low-trunk. The EMG recorded was expressed as the percentage of these obtained during maximal isometric knee flexo-extension at 45° (Biodex, USA) and trunk flexo-extension during Ito-Shirado Test. It was proceeded the analysis of the variance for repeated measures.

Results: The median of lateral acceleration was 3 times superior ($p<0.001$) to the vertical line one in the 3 angles of measured flexion, and the vertical line was the double ($p<0.001$) of the anterior-posterior line. The maximum accelerations: lateral (11–13 g) and vertical line (6–7 g) had increased when reducing the angles of flexion of the knees, such as the median of the accelerations at the lumbar level. The muscles of the trunk had been stimulated 60–70% and the Internal Vast muscle increases significantly its electric activity as knee flexion increased.

Discussion: Both, lateral and vertical accelerations were clearly superior to the osteogenic threshold previously described by Rubin et al. [1].

Conclusion: The machine used in WBVa transmitted higher mechanical lateral impacts than vertical ones. However, an osteogenic stimulus could be expected in both axes. The machine was especially useful to stimulate internal vastus and low back muscles.

Reference

Injuries: Management and Prevention

Rehabilitation of trauma victims in Greece

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Introduction: Rehabilitation of trauma is a long standing problem and costs more than any other health problem in Greece. The national health system in Greece does not serve rehabilitation needs in special institutes, but these patients are treated for long in General Hospitals, as patients with hernias and cholelithiasis.

Methods: This non systematic review describes the matter of trauma rehabilitation in Greece. Information was taken from the Ministry of Health, the Public Health School, the National School of Public Services Management and Hellenic medical bibliography.

Results: Except from KAT Hospital in Athens, public hospitals are still the expensive solution for rehabilitation in Greece. Interestingly, private rehabilitation institutes have recently appeared and offer rehabilitation services,
attractive for Greek families with relatively high income. Inside Hospitals, the main problem that appears – except from high costs – is nosocomial infections that are fatal in cases of old, diabetic or neutropenic patients. Also, the social health cost is rising since 2 or 3 members of the family spend time and money as they have to help inside the hospital. As co-operation of private and public health organisms is the future commitment of Government with the scope to find economic resources for Public Health, we could say that Greek society has reached to the critical point for the promotion of public health.

Quality control for rehabilitation of trauma victims has not been performed in Greek general hospitals so far. Also, nurses and physical therapists are too few to serve the existing needs. Young residents in practice take on the responsibility of physical therapy and nursing for trauma victims. As far as the private rehabilitation institutes are concerned, it is a usual phenomenon to meet there hypo-trained physicians who haven’t found a position in Hospital for residency yet. Quality control mechanisms have started to be applied systematically in Business, and in private health organisms and it is a matter of time for mandatory and law-supervised quality control in General Hospitals. Centers of Rehabilitation are in paper for many years. It would not be an exaggeration to determine as a political matter the responsibility for establishing future rehabilitation organisms. The future rehabilitation team will cost too, consisted of traumatologists, physical therapists, neurologists, psychiatrists and nurses. Finally, well-informed Greek patients have recently made their own evolution via the establishment of patient associations.

Discussion:
Talking for other countries in Europe, we find that Rehabilitation problem has been better served in West Europe, but not still solved. The American model of Trauma services is also more impressing but has been recently dis-promoted by TV real scenarios of tragedy and disappointing efficiency.

Conclusion:
If money of a country is a basis for rehabilitation, political concern and health government organisms are building the rest of needs. Greece is stepping forward a new period on quality of health services.

Changed function of cervical spine by rock climbing?

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Introduction: Freeclimbing has developed explosively in the last years. The area of shoulder girdle and cervical spine can be overused by the unfavourable posture during climbing and particularly by the monotone strain during belaying. So two different types of stress have to be analysed. During climbing the demand is more dynamic with many movements of the head into reclination and cervical extension, often combined with rotation. In order to react appropriately to dangerous situations, however, the belayer must permanently focus on the climber above. Here static loading of the cervical spine occurs due to maximal end-range extension and reclination of the head. As functional changes always precede structural adaptations our study focussed on measurement and analysis of cervical motions.

Methods: For the intervention group (IG) active climbers were chosen who regularly take part in climbing contests and climbed from 8\textsuperscript{th} up to 10\textsuperscript{th} level (UIAA scale). Students of the University of Potsdam formed the control group (CG). The sporting activities of these students involve minimum strain of the cervical spine. Cyclical cervical rotations were measured using an ultrasonic motion analysis system CMS70 (Zebris, Germany). To detect acute changes the climbers were tested before and direct after a defined belaying stress. Depending on the data, groups were compared by the Mann-Whitney-test or Wilcoxon-test.

Results: The comparison between the IG and the CG showed reduction of mobility in all movement directions for the IG (Fig. 1). After defined belaying the cervical mobility of the climbers was reduced acute (averaged: Flexion/Extension: $-14^\circ \ p = 0.007$; Rotation: $-7^\circ \ p < 0.001$; Lateral Bending: $-6^\circ \ p = 0.004$). Furthermore, significant differences in variability of reverse point (in IG the variability is increased) and speed parameters (parameter for acceleration and deceleration) between IG and CG were detected.

Discussion: The intention of this study was to assess, if the high cervical-cranial stresses of rock climbing affect the function of the cervical spine. Thereby acute and long-termed changings are detectable. As short-termed
Table 1: Characteristics of intervention group – climbers (IG) and control group – non-climbers (CG)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Age (yrs) (Mean ± SD)</th>
<th>Climbing time hrs/wk (Mean ± SD)</th>
<th>Climbing training yrs (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IG – Total</td>
<td>24</td>
<td>26.0 ± 7.2</td>
<td>5.4 ± 2.0</td>
<td>5.9 ± 2.7</td>
</tr>
<tr>
<td>Women</td>
<td>7</td>
<td>23.2 ± 4.5</td>
<td>4.8 ± 2.1</td>
<td>5.6 ± 2.6</td>
</tr>
<tr>
<td>Men</td>
<td>17</td>
<td>26.3 ± 7.5</td>
<td>5.6 ± 1.8</td>
<td>6.1 ± 2.8</td>
</tr>
<tr>
<td>CG – Total</td>
<td>52</td>
<td>23.6 ± 2.2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Women</td>
<td>35</td>
<td>22.7 ± 1.7</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Men</td>
<td>17</td>
<td>25.1 ± 2.2</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Fig. 1. Cervical Range of motion (*p ≤ 0.05; **p ≤ 0.01).

modifications can be announced by altered activities of mechanical receptors and nociceptors of passive and active parts in cervical spine (interlocked facet joints and muscular tonicity), long-termed structural changes are possible.

Conclusion: The high stress of rock climbing on the cervical spine has an influence on its movement patterns. Here, acute changes in function must be distinguished from permanent alterations. In long-term muscular dysbalances can develop. Climbing as well as belaying goes along with a high stress of the neck. Additional stress can be avoided by deciding for a certain kind of belaying. The authors advise belaying with an eight descender or AirTrafficControl.

References


EES-induced knee joint moments in paraplegics with long term denervated muscles

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Introduction: Functional electrical stimulation (FES) is applied to reverse degeneration of leg muscles in paraplegics with long term denervated muscles (FES-training). To evaluate the contractile capacity of these muscles, FES-induced joint torque as well as elastic and viscous joint moments are determined. The objective of this study
was to characterize the morphological changes (depletion of contractile proteins in muscle fibres, disarrangement of sarcomers and degeneration of the excitation-contraction coupling apparatus) before the beginning of a FES-training.

Methods: The pendulum test was applied to evaluate the FES induced joint moments in \( n = 10 \) subjects. Therefore a manipulandum was connected to the knee joint and programmed to elicit gravity induced leg oscillations. The FES-induced output torque \( (T_{\text{out}}) \) was compensated before in order to keep the leg in a mean vertical position (knee angle 90°). A second order dynamical model was applied to extract the elastic (C) and viscous (D) moments from the recorded leg oscillations. The test was repeated at the 0% (relaxed), 20%, 40%, 60%, 80% and 100% stimulation level.

Results: In the non-stimulated leg C was \( 15.3 \pm 2.37 \) Nm/rad and D was \( 0.41 \pm 0.21 \) Nms/rad. At a lower stimulation level of 40%, three of ten subject responded with increases in C and D, but only one subject produced a weak output torque \( (T_{\text{out}} = 0.3 \) Nm). At the highest stimulation level (100%) just five of ten subjects produced some output torque while all of them showed viscoelastic increases, see Fig. 1. The mean values of the FES-induced increases were \( C = 29.4 \pm 28.5 \) Nm/rad and \( D = 1.53 \pm 1.03 \) Nms/rad.

Discussion: From these results it is concluded that long term denervated muscles rather became stiffened then produce tension related length changes. Two explanations, FES-induced co-contraction and disarrangement of sarcomers are currently in discussion. Co-contraction comes from the long duration (typically 20 ms) and high stimulation currents (up to 0.5 A) needed to elicit tonic contractions in the quadriceps muscle group. As in this case large transcutaneous electrodes are needed also the hamstring muscle group will become contracted. Electron microscopy from muscle biopsies further shows arrangement of sarcomers in different directions and not along the fiber axis. As sarcomers are the elementary force generators such disarrangement rather will cause tissue stiffening than shortening of fibres with output torque.

Conclusion: Two effects have been presented that may account for the FES-induced increases of joint viscoelasticity in long term denervated muscles. The first effect, co-contraction, rather will appear at higher stimulation levels. The second effect, disarrangement of sarcomers, is thought to be independent from the stimulation level. After the FES-training, when sarcomers rearrange along the fibers axis, the second effect then should disappear.

References
Rehabilitation – Gait Analysis

Clinical gait analysis in female patients with knee osteoarthritis before and after unilateral total knee arthroplasty

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Introduction: Knee osteoarthritis, causing pain and restriction of joint motion, is a frequent reason for development of disability in elderly people. In elderly suffering from osteoarthritis, in addition to gait changes occurring with ageing the gait changes due to joint disease occur. Total knee arthroplasty has been widely used in end stage of osteoarthritis in elderly patients for relieving pain and restoring the joint function [1]. The aim of the study was evaluate changes in gait cycle that arise due to knee osteoarthritis and estimate changes in gait cycle after total knee arthroplasty.

Methods: Gait of 14 female patients (mean age 70.4 ± 4.9 years) suffering from unilateral knee osteoarthritis (III–IV stage after Kellegren-Lawrence) was investigated before and 3 months after total knee arthroplasty. The subjects were asked to walk at self-selected speed across the Footscan pressure plate (RsScan International, Belgia, 2 m × 0.4 m, 4 sensors/cm² [2]). 10 consecutive trials were performed and following gait parameters registered: step time, gait cycle time, single support time, double support time, stance time, step length, stride length, walking velocity.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Comparison of gait cycle parameters before and after total knee arthroplasty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unoperated leg</td>
</tr>
<tr>
<td>Gait cycle parameter</td>
<td>Before surgery</td>
</tr>
<tr>
<td>Step time (ms)</td>
<td>640.6 (median)</td>
</tr>
<tr>
<td>Gait cycle (ms)</td>
<td>1225.1 (median)</td>
</tr>
<tr>
<td>Single support (ms)</td>
<td>383.6 (median)</td>
</tr>
<tr>
<td>Double support (ms)</td>
<td>486.9 (median)</td>
</tr>
<tr>
<td>Stance time (ms)</td>
<td>903.6 (median)</td>
</tr>
<tr>
<td>Step length (cm)</td>
<td>44.7 (median)</td>
</tr>
<tr>
<td>Stride length (cm)</td>
<td>86.1 (median)</td>
</tr>
<tr>
<td>Velocity (m/s)</td>
<td>Before surgery</td>
</tr>
</tbody>
</table>

Results: Affected legs step time, single support time and stance time was shortened before surgery. The difference between affected and unaffected leg step length was not statistically relevant. Three months after total knee arthroplastic surgery single support time prolonged, double support time shortened, step and stride length increased on operated leg (Table 1). Although the single support time was still shortened on operated leg compared to unoperated leg, the difference didn’t reach the statistical relevance. On unaffected leg double support and stance time shortened, step length increased. Walking velocity improved considerably three months after surgery.
**Discussion:** Certain adaptations in gait pattern take place in patients with unilateral knee osteoarthritis. Shortened single support time and lengthened double support time on affected side are probably adaptations for unloading of affected leg and thus relieving pain [2]. Three months after surgery the asymmetry of gait still persisted although walking ability improved considerably. Measurements of free walking speed are suggested for clinical evaluation after surgical interventions in patients with knee osteoarthritis [3]. However the latter doesn’t reflect asymmetry of gait and thus should be supplemented by gait cycle phase analysis.

**Conclusion:** Considerable gait cycle phases asymmetry was found in female patients suffering from unilateral III–IV stage knee osteoarthritis. Gait cycle analysis in clinical setting using footscan pressure plate allows objective assessment of changes in walking ability due to knee joint osteoarthritis and recovery of gait after total knee replacement surgery. Gait analysis allows individual approach to each patient and individually planned rehabilitative measure according to patients needs.

**References**


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**Dynamic laser induced leg axis control system – a new method for controlling and stabilizing the dynamic axis of the leg**

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**Introduction:** The positioning of the knee is to a large extent the result of the quality of muscle coordination. This newly invented tool presented here allows the therapist as well as the patient himself to detect a pathological pattern of movement of the leg. By means of this little device both sides are able to correct certain movements and to stabilize the knee joint.

**Methods:** A laser pointer adapted on a knee brace draws a light track in front of the patient and make movements of the patients knee visible. It works as a feedback system. Furthermore it offers both patient and therapist the possibility to analyse and to correct the actual pattern of movement in swing and stance phase.

**Results:** In the typical pattern of a pathological deviation of the dynamic leg axis the drawing of the light point shows a very extended track. After using the feedback modus in all five patients the extension of the light track became much more narrow.

Also, all patients show a better result after the initial contact in loading response and therefore a decreasing of the internal rotation of the femur and even an increase in knee stabilization. An improvement of the swing phase can also be shown: the increased external rotation in mid and terminal swing was significantly corrected.

All patients involved in the test phase emphasized the easy way of using the device. They were very pleased by getting the chance of correcting their gait patterns by a feedback system which offers them a maximum of self-responsibility and information about their own movement and gait patterns.

**Conclusion:** The newly developed therapy tool enables both, the patient and the therapist to analyse, correct and train certain movements of the knee, especially in the frontal plane. The spatial position of the knee joint is influenced by the orientation of the femurs and the tibia and its relative positioning towards each other. The positioning of the knee is to a large extent the result of the quality of muscle coordination. There is also a remarkable influence of all relevant involved joints.
Controlling the knee motion by means of the new laser device opens a way to train the whole limb (muscles of knee, hip and ankle at the same time). The result shows the correction of the knee position, additionally it optimizes the internal and external rotation of the femur.

The decisive profit of this new therapy tool is the easy application, the measuring during the dynamic process and the feedback modus.

The most remarkable result of this pilot study was that all patients were able to analyse and to control their movements by themselves. They realized that their motions were incorrect and had to be changed. The five documented cases show the success of the new method which is used in daily practice.

Biomechanical analysis of gait adaptability

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Introduction: Efficient rehabilitation is widely based on the knowledge of the parameters that influence motor disturbances. In multiple nerve diseases and traumata like Parkinson disease, stroke or brain-trauma gait impairments are evident. However, although gait impairments are obvious in daily life clinical analyses frequently fail to identify pathological parameters. This might be explainable by the fact that physiological gait is characterised – among other things – by the ability to adapt to fluctuating external conditions, quickly. In contrary most clinical analyses enable the patient to choose gait parameters (e.g. velocity, acceleration) freely and consequently adaptability requirements are low in this test procedure. The aim of this study was therefore to develop a gait analysis method which measures adaptability performance. This idea is guided by the results of postural control tests e.g. static vs. dynamic [1]. As low inter-test correlations were found it was concluded that postural control can not be regarded as a single, homogenous motor control component. Therefore getting valid and reliable information about the status of rehabilitation, reconvalescence or motor safety requires a multivariate postural control test battery.

Methods: Developing the test procedure is based on some preconditions: a) The test procedure should be usable in clinical infrastructures where space and human resources are limited, b) test results have to be accessible quickly, c) test reliability should be high and d) high patient safety is necessary. Consequently we decided to use an apparative supported gait test. A treadmill guarantees low space requirements, high reliability and high patient safety. However treadmill walking implements an artificial coordinative component to some extent. Total time of the test is 5 minutes 20 seconds. In order to prove gait adaptability the treadmill’s velocity is modified each 8 seconds. The type of modification (amount of acceleration or deceleration) is standardised but can not be anticipated by the patient. The range of speed varies between 1.5 and 3.0 km/h. Patients were asked to keep a constant position on the treadmill. An incremental encoder with a cable-belt-system is used to measure patient’s position.
**Results:** As an example the figures below show test results of highly and lowly impaired Parkinson’s disease patients. The highly impaired patient is unable to adapt to velocity changes (upper trace) adequately which results in a highly variable position curve (lower trace). In contrary the same speed modification leads to a nearly flat position curve in the lowly impaired patient which characterises a good adaptability.

**Discussion:** Currently 60 Parkinson’s disease patients and age matched controls were measured. However, statistical analyses are not completed and therefore we can not hypothesize about significance of data and especially about correlations between test data amount of falls or the degree of freezing. However, we are the opinion that the principal of proving adaptability provides potential to assess motor control from an important biomechanical and neurophysiological point of view.

**Reference**


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**Exercise Training in Health and Disease**

**An acceptable fitness test battery for patients with chronic renal failure treated with dialysis**

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**Introduction:** Patients with end-stage renal disease (ESRD), treated with dialysis, are often polymorbid and in consequence of own disease and different complications, that are accompanying to long-term dialysis therapy, they are characterised by sever functional limitations. Their functional capacity is limited on 50% of normal population, their muscle strength is decreased and it leads to reduced physical activity and sedentary lifestyle preferences. Further, they suffer from functional disturbances of the moving system. Owing to hypokinesis and inactivity, these individuals lose their physical fitness, which in turn results in loss of self-sufficiency and self-reliance. Gradually, they develop dependence on other persons’ assistance. According to a literature, an acceptable choice of regular exercise activity together with another treatment methods is the best way of non-pharmacological character, that offers to the patient an opportunity to achieve an optimal functioning and psychosocial level for each one almost equal to premorbid state. An essential part of an each exercise program is an acceptable fitness test battery, which should target such components of motoric performance, whose certain rate is necessary for self-sufficiency keeping and for independent daily living.

**Methods:** We observed the group of 23 patients (15 males and 8 females; mean age \(= 60.9 \pm 14.7\) years). Patients were selected for the study on the basis of medical recommendation. For evaluation of the functional condition we used the “Senior Fitness Test Manual” [4]. The input results of the Senior Fitness Tests (SFT) we compared with the population standard specification. In addition, for assessment of the functional condition, we used the questionnaire focused on estimation of actual exercise skills, then on level of the overall exercise activity before and during the regular dialysis treatment.

**Results:** The input results of the SFT showed that ESRD patients in comparison with the population standard specification have reached subnormal and risk performances, especially in tests that requiring for its implementation muscular strength of lower extremities and physical efficiency. Normal and above normal performances we noted in
patients that were physical active before and as well during regular dialysis treatment and in tests that requiring for its implementation muscular strength of upper extremities and sufficient coxal and shoulder joint mobility. We noted that the joint moving limitation of the upper and lower body was not such wide, how we could suppose in chronic ill patients. After evaluation of the feasible negative influence of own disease and its affiliated complications on the exercise condition, we noted that the total amount of exercise activity turned down. The point of exercise activity limitation is going continuously with the disease progression and the total duration of the regular dialysis treatment.

Discussion: In summary, with the results of individual performances in SFT that requiring for its implementation muscular strength of lower extremities, we can confirm that decreased muscular strength and quickly impending muscular fatigue in physical activity in renal dialysis patients is mostly concentrated into the lower extremities area, where can be noted 50–70% decrease of the muscular mass. Here is the muscular fatigue noted as first of all.

Since age structure of our investigated group was wide and there were 11 patients younger than sixty years, it could be suppose that better performances in SFT will be above all noted in these individuals. But our results did not confirm it.

Conclusion: The fitness tests battery SFT is focused on evaluation of those components of the motor performance, whose keeping is necessary for self-sufficiency and for practise the routine activities of daily living. The independence from the help of the others is eligible in all individuals, particularly in older adults, which are prevailing in dialysis centres of the Czech Republic. Following the result valuation, we consider select fitness tests battery SFT [4] as an acceptable choice for motor skills testing in renal dialysed patients.

Key words: End-stage renal disease, hypokinesis, fitness tests, exercise activity.

References

Influence of cardioselective beta-blockade to the occurrence of exercise induced arterial hypoxemia

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Introduction: Exercise induced arterial hypoxemia (EIAH) is recognized to occur in a significant number of subjects of various activity-levels, both sexes and any age. The aim of this study was to compare the effect of a single dose of the highly $\beta_1$-selective adrenoceptor antagonist bisoprolol with those of placebo on the incidence of an EIAH.

Methods: Sixteen healthy male subjects (mean $\pm$ SD age: 23.5 $\pm$ 4 years; height: 183 $\pm$ 6 cm; weight: 78 $\pm$ 8 kg) randomly received oral placebo or bisoprolol (5 mg) six to ten hours before the test using a double-blind cross-over design. The individuals performed an incremental cycle ergometer test until exhaustion to determine heart rate (HR), blood lactate concentration, oxygen consumption (VO2), carbon dioxide production (VCO2), minute ventilation (VE), respiratory exchange ratio (RER), oxygen pulse (VO2/HR), oxygen partial pressure (PO2), carbon dioxide partial pressure (PCO2), oxygen saturation (SaO2) and pH at rest, at every workload step and at maximum performance as well as after three minutes of rest. Furthermore, the aerobic threshold (LTP1) and the anaerobic threshold (LTP2) were determined.
Results: Bisoprolol significantly reduced HR at rest, LTP1, LTP2 and at maximum power output. No differences between bisoprolol and placebo were found for maximum values of any of the respiratory gas exchange measures, blood lactate concentration or performance. Seven of the sixteen subjects sustained signs of an EIAH: a reduction in oxygen partial pressure of more than 10 mmHg compared to resting values occurred in one person taking placebo and in two persons under beta-blockade. A drop of SaO2 of more than 3% compared to resting values is referred as another definition of EIAH and occurred in two subjects taking bisoprolol. Two other individuals achieved both of these two criteria of EIAH when using drugs.

Discussion: Under beta-blockade more individuals sustained signs of EIAH than after taking bisoprolol. SaO2 and PO2 were reduced primarily at 200 W under bisoprolol, which is in agreement with other investigations where EIAH particularly occurred at submaximal performance. At this workload beta-blockade was associated with a decrease of VE and pH, which are signs of hypoventilation. A relative hypoventilation for a certain workload is referred as possible aetiology for EIAH.

Conclusion: Of the population tested 44% showed symptoms of an EIAH which is in line with reports from other authors. A single dose of the β1-selective adrenoceptor antagonist bisoprolol leads to a higher incidence of EIAH at maximal and particularly submaximal performance. To ascertain why EIAH occurs at this workload, additional investigations are required.

Blood lactate concentrations at the lactate threshold and the respiratory compensation point in comparison to the maximal blood lactate steady-state in patients with different cardio vascular diseases and healthy subjects

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Introduction: Exercise and sports participation of patients with cardiovascular diseases and healthy subjects are desirable entities in rehabilitative and preventive medicine. However, overexertion should be avoided. Valid and reliable performance tests are necessary. The first aim of this investigation was to determine the blood lactate concentration (La) at the lactate threshold (LT) [1], the respiratory compensation point (RCP) [2] and during the maximal lactate steady-state (MLSS) [3] in healthy subjects and patients with cardiovascular diseases of different age, weight, and sex. The second aim of our investigation was an attempt to determine if our results could provide an appropriate La specific difference for our population based on age, weight, and sex as described by Roecker et al. [4], who reported that the La limit of endurance intensity for marathon run was 1.5 mmol.l−1 above the LT.

Methods: 105 subjects participated in the study and were subdivided in 8 female and 9 male groups. All subjects underwent incremental exercise testing (cycle ergometer) to determine the La at the LT and the RCP. Additionally, La at the end of the MLSS was determined by repeated steady-state tests.

Results: Differences in La between LT, RCP and MLSS for all groups are depicted in Table 1. Significant differences (p <0.05) were only found in male subjects between groups for Δ RCP-LT (HS/⩾ 60 yrs, <40 yrs/⩾ 60 yrs, HS/CHD, < 40 yrs/CHD).

Conclusion: Our results suggest that it is not possible to use either independent absolute La or normalized ΔLa values to prescribe exercise intensity above the LT based on pathologies, age, weight, and sex in our study population.

References
A new method for testing motor performance in children

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\textbf{Introduction:} In recent studies about posture problems of schoolchildren we found that up to 40\% of the children also had coordination problems \cite{1}. The basis of these findings were video which we took of posture, spinal movement and some whole body movements, that allowed an insight into the diversity of movement behaviour. In order to evaluate the video in regards to coordination problems, we developed a computer based rating and documenting system that allows us to analyse the main individual movement characteristics.

\textbf{Methods:} In order to perform such an analysis, five movements are filmed: walking, running, jumping on one leg, jumping with both legs and a jumping jack. The children also have to stand on one leg (balance).

In order to carry out the rating the film sequences are transmitted (on or offline) to the computer. There are seven main parameters to evaluate: personality in motion, posture, movement-pattern, quality of movement, coordination, coordinative abilities, and motor-characteristics. Additionally special signs such as a fixated or rotating arm or extra movements are documented.

Each of these main parameters consists of several single parameters that contribute to the rating of the main parameter. For each test-movement, more than 80 characteristics can be rated. The rating takes place on a four point scale.

In order to gather an exact individual analysis, all items that apply to the specific movement should be considered. In most cases it is sufficient to rate up to 10 relevant parameters per test-movement – these are called checkpoints. A weighted sum of all the rated parameters then yields to a quantification of the motor performance itself. The coordination profile documents the intra-individual differences regarding the different test movements and the evaluation of the main parameters as mentioned above.

\textbf{Results:} With the help of this system, a study was done to evaluate the motor performance of 20 Styrian schoolchildren from the ages of six to ten years. Coordination weaknesses were found in 55\% of the children whereas only 25\% showed excellent coordination. Coordination problems were found in only 5\%. As expected, such

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|l|l|l|l|l|l|}
\hline
 & Females & & & & Males & & & \\
 & HS & CHD & AH & <40 yrs & 40–59 yrs & \geq 60 yrs & <65 kg & \geq 65 kg \\
\hline
\hline
$\Delta$ RCP-LT & 2.1±0.7 & 1.8±1.3 & 1.6±1.2 & 2.2±0.8 & 2.0±0.8 & 1.3±1.2 & 2.1±0.8 & 1.8±1.1 \\
 & (0.8–3.8) & (0.6–3.3) & (0.8–3.8) & (0.6–3.4) & (0.6–4.4) & (0.6–3.8) & (0.6–4.4) & \\
\hline
$\Delta$ MLSS-LT & 4.3±1.0 & 3.8±1.8 & 3.5±1.1 & 4.6±0.9 & 3.7±1.2 & 3.8±1.7 & 4.3±0.9 & 3.8±1.5 \\
 & (2.3–6.2) & (0.8–7.6) & (1.7–4.9) & (3.4–6.2) & (1.7–5.8) & (0.8–7.6) & (2.7–5.8) & (1.7–7.6) \\
\hline
$\Delta$ MLSS-RCP & 2.1±1.0 & 1.8±1.0 & 1.7±1.2 & 2.3±1.0 & 1.6±0.9 & 2.0±1.1 & 1.9±0.8 & 1.9±1.0 \\
 & (0.8–4.6) & (0.0–3.2) & (0.4–3.2) & (1.2–4.6) & (–0.4–3.2) & (0.0–3.2) & (0.7–3.4) & (–0.4–3.2) \\
\hline
\end{tabular}
\caption{Differences in blood lactate concentrations (mmol.l$^{-1}$) expressed as mean ± SD (range) between respiratory compensation point and lactate threshold ($\Delta$ RCP-LT), maximal lactate steady-state and lactate threshold ($\Delta$ MLSS-LT) and maximal lactate steady-state and respiratory compensation point ($\Delta$ MLSS-RCP). Healthy subjects (HS), coronary heart disease (CHD), arterial hypertension (AH)}
\end{table}
weaknesses where frequently found in the complex exercises *jumping jack* and *jumping with both legs*. However the highest score was found in running, showing up with 45% of coordination weakness and 25% with severe weakness.

**Discussion:** In a first field-test, this system proved to be an effective tool for the examination and description of motor coordination. The findings (as far as comparable) were in good correlation with data from literature [2]. The interaction of the various parameters will be part of future tests. The creation of a database with case studies is presently underway. Furthermore special exercise programs for children with coordination problems will be developed.

**Conclusion:** With this coordination testing system, it is possible to evaluate individual characteristics as well as the testing of the overall motor performance. Thus, one can take care either of individual weaknesses or support good motor abilities.

**References**


**Interaction of heart rate variability (HRV) with ergotropic and mental tasks**

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**Introduction:** The interaction between psycho-physiological parameters, especially heart rate variability, and psychological phenomena has attracted considerable attention in medicine and psychology during the past years. The study of Schwaberger [1] demonstrated that the aerobic fitness of healthy individuals exerts an influence on the cardiovascular reaction during a mental stress situation (car racing). In the past heart rate (HR) in particular was selected to describe the aerobic physical fitness. The HRV analysis provides a noninvasive tool in order to research both the cardiovascular fitness and the psycho-vegetative balance.

**Methods:** The HRV parameters were measured in 36 male healthy well trained subjects by an ECG-recorder (AR12, TOM medical). The volunteers were investigated during vigilance tests (KLT-R), both at rest and under ergotropic conditions. During the bicycle ergometry (20 min) heart rate (HR) was held at a constant level of 150 bpm. Each condition was followed by a period of rest. The standard parameters of HRV were calculated over periods of five minutes. We demonstrated the correlations between the amount of physical regeneration (HR and RMSSD: period of rest after the ergotropic condition [rest 2] minus period of rest before the ergotropic condition [rest 1]) and the amount of reaction of HR and HRV on a mental task (HR and RMSSD: vigilance test at rest [KLT-R at rest] minus the period of rest before the ergotropic condition [rest 1]).
RMSSD: KLT-R minus period of rest 1 (difference of RMSSD: period of rest 2 minus period of rest 1 correlated highly significantly with the difference of A-8010 Graz, Austria

Task Force of the ESC and NASPE: Circulation

Continuous lactate monitoring during exercise by means of a portable device


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SensLab GmbH, Leipzig, Germany

Results: No significant correlation between the reactions of HR could be found ($r = -0.285; p = 0.097$). The difference of RMSSD: period of rest 2 minus period of rest 1 correlated highly significantly with the difference of RMSSD: KLT-R minus period of rest 1 ($r = 0.779; p < 0.01$).

Discussion: The results of this study demonstrate that HR is not able to describe correlations concerning the difference between before and after an ergotropic period and the amount of reaction on a mental task. The RMSSD seems to be a more specific tool to describe these reactions. It can be assumed that the fact that RMSSD is a HRV parameter that is highly influenced and modulated by the vagotonus causes the high specific reaction.

Conclusion: HRV (especially the parameter RMSSD) seems to be a very specific and precise tool to describe the responsiveness of cardiovascular and autonomic nervous system. Results emphasize the importance of HRV as a reliable prognostic tool in the field of diagnosis of aerobic fitness and psycho-physiology.

References


Continuous lactate monitoring during exercise by means of a portable device


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Introduction: Frequent lactate measurements are usually required to test an athlete’s performance. Typically for such a test the athlete is placed on an ergometer or even has to interrupt activity for a manual lactate measurement. Permanent lactate based intensity feedback during training is not possible. A portable device giving continuous feedback on lactate during training is desirable. In view of such a device we tested possible sites for continuous lactate sampling, adapted an existing glucose monitoring device for lactate and performed first exercise tests.

Methods: To test skin as a site for online metabolite monitoring in comparison to subcutaneous adipose tissue (AT), dermal open-flow microperfusion (OFM) sampling probes (Teflon, OD 0.4 mm) were placed into the dermis of forearm skin and periumbilical AT. Probes were perfused with ion-free, isotonic solution at a flow rate 1 ul/min and effluents collected in 30 min fractions over 6 hrs during an oral glucose tolerance test (OGTT). Effluents were analysed for glucose and lactate as well as for sodium concentrations to serve as a reference. Dermal profiles of the metabolites were determined by sodium calibration (ionic reference technique – IRT) and thereafter calibrated to plasma level at the time of first measurement.

Continuous online lactate measurements were performed in volunteers subjected to ergometer tests up to 3 hrs. To enable online measurements during exercise, a dermal probe in each forearm was connected to a portable monitor fixed to the arm (Fig. 1). The monitors had been developed for glucose monitoring in diabetic patients during EC-Project ‘ADICOL’ and were thereafter adapted for lactate in EC-project ‘CLINICIP’. Containing microfluidics, conductivity sensor (IRT), lactate sensor, data logger and a blue tooth transmitter the monitors transmitted the dermal lactate signal to a hand held computer for display. A lactate-meter (Lactate Scout, SensLab, Leipzig) was used to collect reference values from ear capillary blood every 10 min.

Results: Sodium concentrations in effluents revealed metabolite sampling recoveries of 50–60%. Applying sodium calibration (IRT) to sample glucose yielded dermal glucose levels of ∼70% compared to plasma. Calibration to plasma using first available measurement resulted in profiles equal that of plasma in all dermal probes before, during and after OGTT. This confirmed our guess that the dermis is appropriate for monitoring. Subcutaneous profiles showed more variation but overall also followed plasma well.

During exercise heart rates of 200/min and capillary lactate levels of 10 mmol/l were achieved. Integrated online (conductivity) measurements of dermal effluents for online recoveries compensation by IRT revealed rising sampling recoveries during exercise. After calibration to capillary lactate during steady-state, lactate signals followed the lactate dynamics well over the full range between 1–10 mmol/l.

Discussion: A portable device giving lactate feedback such as used herein may in future allow athletes of various disciplines to control training intensity. To date however a delay of ∼10 min has to be accepted in feedback as fluid is transported to the ex vivo sensor. Another handicap in online lactate measurement is that access to the obviously most appropriate site for lactate monitoring – the well capillarized dermal layer of skin – requires dermal probes which should be developed further for easy implantation.
Conclusion: Online exercise monitoring using continuous skin lactate information is technically feasible and strong relationship of signal to blood is given. Effluents from dermal open-flow microperfusion probes are appropriate for the purpose. In view of a robust device optimization for exercise conditions is required. In future portable lactate monitors should facilitate well directed training by giving the athlete continuous feedback about the actual metabolic state.

Lactate kinetics depend on the on-phase power setting

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Introduction: In recent years our knowledge regarding the lactate metabolism increased significantly. The introduction of the lactate shuttle theory not only suggests that cells “shuttle” lactate to other compartments, but it also implicates that lactate is an easily accessible fuel and carbon reservoir for other molecules [1]. However, in sport diagnostic lactate is an essential parameter to identify the metabolic response to exercise [2]. The aim of this work was to investigate blood lactate kinetics depend on the on-phase power setting.

Methods: For each nine healthy male sports students (age: \(26 \pm 3\) yrs; height: \(178 \pm 6\) cm; weight: \(72 \pm 4\) kg) a step test was used to determine the first (LTP\textsubscript{1}) and the second (LTP\textsubscript{2}) lactate turn point [3]. Based on the obtained data the individual constant workload was calculated below LTP\textsubscript{1}. After sitting for 1 minute on the cycle ergometer, the constant work load was achieved either in 20 watt per minute steps or in one step and was kept constant then for 30 minutes.

Blood samples (20 \(\mu\)l) were obtained from the hyperemized ear lobe at rest, every minute for the first 10 minutes, and every 5\textsuperscript{th} minute until the end of exercise. Blood lactate concentration (La) was measured enzymatically using the EBIO 6666 analyser (Eppendorf).

Results: Figure 1 presents the lactate kinetics of a single load step below the LTP\textsubscript{1}. After 2 minutes the La increases significantly (\(p = 0.015\)) and remains significantly elevated for 18 minutes (\(p = 0.047\)). Different on-phase power settings to achieve the target work load resulted in different blood lactate values as can be seen in Table 1.

Preliminary results with an abrupt (just 5 minutes on-phase with half of final workload) power increase close to LTP\textsubscript{2} resulted in blood lactate values of 8.2–9.6 mmol.l\textsuperscript{−1} in one case and 6.8–7.0 mmol.l\textsuperscript{−1} in another case over a 30 minute period.

Discussion: The mitochondria of muscle cells are able to oxidize lactate in the presence of oxygen [4]. When this pathway is insufficient, an increase in blood lactate accumulation can be observed. Our results indicate that under our laboratory conditions, workouts below LTP\textsubscript{1} already resulted in an initial on-phase lactate response. Furthermore, different on-phase power settings lead to different blood lactate increases. We assume that endurance exercise close to LTP\textsubscript{2} leads to high La due to the on-phase power settings.

Conclusion: The on-phase power setting has a pronounced influence on the blood lactate response and this must be taken into account when performing and creating incremental and constant load exercise tests.
Supplementation with antioxidants has no influence on oxygen uptake and lactate concentrations at a cycle ergometer step test

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Introduction: Several authors reported that exercise increases oxidative stress [1], which has inspired athletes for intake of antioxidant supplements. Wealth of data exists concerning the influence of antioxidant supplementation on oxygen uptake, maximum oxygen consumption capacity (VO\textsubscript{2max}), or lactate kinetics, but analyzes of anaerobic threshold is mainly based on lactate metabolism. In the present study the influence of 15 days antioxidant supplementation on oxygen uptake, VO\textsubscript{2max} and lactate curves due to a Conconi-step test on a cycle ergometer was investigated.

Methods: Seven male, healthy and trained (55 \(\pm\) 5 ml kg\(^{-1}\) min\(^{-1}\)) subjects, mean age 29 \(\pm\) 3 years, non smokers, undertook two Conconi-step tests to exhaustion on a mechanically braked cycle ergometer to estimate oxygen consumption (every 5 min), VO\textsubscript{2max} (Oxycon Alpha, Jaeger, Würzburg) and anaerobic threshold. All tests were performed twice: once without (placebo) and once with antioxidant supplementation (vitamin C 450 mg/d, vitamin E 72 mg/d, \(\beta\)-carotene 36 mg/d, selenium 100 \(\mu\)g/d) for 15 days. Immediately before, each minute during exercise, 3 min, 6 min and 9 min after exercise blood was collected and analyzed for lactate determination (Ebio plus, Eppendorf, Hamburg). Total protein was calculated at the beginning and at the end of exercise to exclude

Fig. 1. On-phase blood lactate kinetics from a single load step below the first lactate turn point.

References

blood volume artefacts. Subject nutrition was documented and analyzed during the investigation period by software. Statistics: ANOVA and covariance with repeated measurements; significance level $p < 0.05$.

**Results:** Oxygen uptake and VO$_2$max: Supplementation had no influence neither on oxygen consumption, measured every 5 minutes, nor on VO$_2$max at the end of the test (left). Lactate: Same result as oxygen parameters: no influence of antioxidant supplementation on each time point as well as on the lactate curve (right).

**Discussion:** High H$^+$ levels in the cell lead to decreased pH. Thus the protons could react with superoxide so that free radical accumulation can occur [2]. NADH acts as carrier for the protons as well as an antioxidant. Consequently antioxidant supplementation could help to reduce H$^+$ levels and lactate concentrations. Some investigators found a correlation between lactate concentrations and oxidized glutathion (GSSG) [3], the antioxidant substrate of glutathione peroxidase (GPs), an influence of antioxidant supplementation on GSSG concentrations but not on lactate values. Other researchers did not find any influence of an antioxidant on lactate kinetics [4]. In the present study also no affection of supplementation on lactate curves or oxygen parameters was found.

**Conclusion:** Despite the significant rise of vitamin E or C concentrations in plasma the used antioxidant supplementation did not influence oxygen uptake, VO$_2$max or lactate values. Obviously muscle acidosis is not relevant enough to lead to a cellular state of oxidative stress. Antioxidant supplementation does not influence lactate and VO$_2$max diagnostics.

**References**


**Antioxidant vitamin intake on postprandial lipemia during exercise and recovery**

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**Introduction:** This study investigated the effect of consuming antioxidant vitamins on post-prandial lipemia in a group of active subjects. Antioxidant vitamins prevent free radical development by scavenging the O$_2$ escaped
from mitochondria and thereby help in stabilization of cell membranes [1,2]. Lipid and lipoprotein metabolism is associated with cell membrane biosynthesis, thus injuries on cell membranes resulting from exercise may affect synthesis or release of lipids into blood plasma. We have thus compared normal dietary vs. antioxidant vitamin intake to realize how antioxidant vitamin supplements modify plasma lipid and lipoprotein levels at two different exercise intensities (i.e. 75% and 50% VO2max) in active subjects.

**Methods:** Six middle-aged healthy male cyclists participated in the study. By taking normal diet subjects exercised at 75% VO2max for 30 min, and after a 3-days interval at 50% VO2max for 90 min on bicycle ergometer. After 7 days rest, they were supplied with antioxidant vitamins consisting of Vit. E, Vit. C, β-carotene, and selenium (vitamin diet) and undertook the same exercise loads as above. Lactate, FFA, TG, TC, HDL, and LDL were assessed at basal rest, at the end of exercise (EE) and at 1 h post-exercise recovery period (PE) by standard laboratory procedures. Plasma volume changes were calculated from changes of total protein level.

**Results:** Comparisons between “normal” with “vitamin” diet showed no differences (p > 0.05) on lipid and lipoprotein concentrations in blood plasma. However, comparisons along the time course of changes in lipid profiles resulted in a trend of similar pattern during the two dietary intakes. Lactate was significantly higher from rest (p < 0.05) at the submaximal (intensive) exercise (75%), while FFA was significantly higher from rest (p < 0.05) at the end and recovery period of the moderate (extensive) exercise intensity (50%) during both dietary intakes (Table 1).

**Discussion:** The observation of similar pattern of changes on lipoprotein profiles during normal and vitamin diet indicates that excess vitamin intake does not modify postprandial lipemia to a greater degree in exercising subjects. However, taking the effect of exercise alone, lipolysis was enhanced as the result of prolonged exercise activity (90 min exercise) than heavier exercises loads (Table 1). Our work, therefore, substantiates the fact that normal diet taken in proper proportion is adequate to supply the vitamin needs of active subjects.

**Conclusion:** 1. Exercise, per se, but not excess vitamin intake modifies postprandial lipemia in exercise. 2. From changes in FFA level, exercise below submaximal intensity enhances lipid oxidation to a greater degree than exercises of heavier intensities.

**References**


---

Table 1

<table>
<thead>
<tr>
<th>Submaximal exercise (75% VO2max, 30 min)</th>
<th>Moderate exercise (50% VO2max, 90 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rest</td>
</tr>
<tr>
<td>TG mg/dl</td>
<td>N = 107 ± 12</td>
</tr>
<tr>
<td>TC mg/dl</td>
<td>N = 170 ± 10</td>
</tr>
<tr>
<td>LDL mg/dl</td>
<td>N = 100 ± 10</td>
</tr>
<tr>
<td>HDL mg/dl</td>
<td>N = 48 ± 1</td>
</tr>
<tr>
<td>FFA mmol/l</td>
<td>N = 0.31 ± 0</td>
</tr>
<tr>
<td>Lactat mmol/l</td>
<td>N = 0.83 ± 0.1</td>
</tr>
</tbody>
</table>

*Rest vs. corresponding rest level p<0.05,*

**Table 1**

Plasma lipid, lipoproteins and lactate concentrations measured during submaximal (75%) and moderate (50%) exercise intensity with normal (N) and following antioxidant vitamin (V) intake. EE (end of exercise), PE (1 h post exercise recovery), * p < 0.05 vs. corresponding rest level.
Measurements of two different positions at the back attachment on Biodex dynamometer

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**Introduction:** The purpose of this study was to investigate isokinetic measurements for lumbar extension and flexion muscles groups at the SCP – Seated Compressed Position (Isolated Lumbar) and SSP – Semi-Standing Position (Functional) and to compare peak torque values (Nm).

**Methods:** Twenty healty subjects participated as a voluntary for this study. There were 18 males and 2 females in this study. The mean age was 22.90 ± 2.67 (range 20–30) years. The mean height for subjects was 174.90 ± 6.94 cm; the mean weight for subjects was 69.30 ± 10.39 kg. The measures were done with the Biodex System 3PRO isokinetic dynamometer at the back attachment system unit. Isokinetic measurements were made at the lumbar extension/flexion pattern at the seated compressed position and semi-standing position concentrically 30, 60, 90, 120, 150 and 180 deg/sec angular velocities, with five repetitions at the each angular velocity. For two positions gravity correction was signed. Tests were done at 60 degrees of range of motion. Before the tests they did warm-up periods and some trial tests repetition. Every measures were repeated one day interval. The results were analysed with the paired t-test. Peak torque values were investigated for the evaluation.

<table>
<thead>
<tr>
<th>Angular Velocity</th>
<th>Extension SCP</th>
<th>Extension SSP</th>
<th>Flexion SCP</th>
<th>Flexion SSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°/s</td>
<td>226.7 ± 49.1</td>
<td>232.3 ± 51.9</td>
<td>180.8 ± 49.6</td>
<td>187.8 ± 57.1</td>
</tr>
<tr>
<td>60°/s</td>
<td>249.6 ± 49.2</td>
<td>247.7 ± 48.7</td>
<td>179.1 ± 39.2</td>
<td>183.7 ± 38.9</td>
</tr>
<tr>
<td>90°/s</td>
<td>259.1 ± 51.3</td>
<td>274.9 ± 53.5</td>
<td>181.5 ± 32.7</td>
<td>188.5 ± 32.6</td>
</tr>
<tr>
<td>120°/s</td>
<td>286.3 ± 63.2</td>
<td>301.5 ± 64.4</td>
<td>197.3 ± 35.9</td>
<td>203.1 ± 31.7</td>
</tr>
<tr>
<td>150°/s</td>
<td>304.5 ± 86.1</td>
<td>315.2 ± 64.1</td>
<td>210.8 ± 30.7</td>
<td>218.8 ± 23.9</td>
</tr>
<tr>
<td>180°/s</td>
<td>317.1 ± 83.4</td>
<td>311.6 ± 59.1</td>
<td>246.3 ± 45.2</td>
<td>240.9 ± 32.6</td>
</tr>
</tbody>
</table>

*p > 0.05

**Results:** Between two positions there was a difference of 0.7–6.1%. Most of the Semi-Standing Position extension and flexion values at angular velocities were higher than Seated Compressed Position peak torque values. However at each angular velocity for two positions there weren’t statistically significant (*p > 0.05*) differences (Fig. 1, Table 1).

![Fig. 1. SCP-Seated Compressed and SSP-Semi-standing Positions.](image)

**Discussion and Conclusion:** There weren’t any different results for two different position used at the Biodex System back attachment unit. The most important reason is that it used the same pivot point and the same trunk...
position for testing. At the semi-standing position and seated compressed position there was a support at the surface thus there wasn’t different for torque values. In spite of the position of upper trunk testing were the same, hip and lower extremities surface supports were different however torque values weren't affected. Two positions can be used with confidence clinically.

References


New aspects for exercise testing on dynamometer

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Introduction: Isokinetic tests are a common method to quantify strength capacity in single and multi joint movements. Especially in high speed movements there are still substantial limitations to reach preset speed, due to the effect of gravity and even more due to the moment of inertia [1,2,4]. Purpose of this study was to investigate the specific effect of compensating the moment of inertia in single and multijoint movements at different speeds.

Methods: \( N = 25 \) healthy male and female subjects (age: \( 27 \pm 4.4 \) years) with different activity levels (no exercise up to daily exercise) participated in the study. After a warm up phase, maximum torque/force measurements (5 repetitions) where executed for four movements: single joint knee extension and flexion (K), multijoint lower limb extension and flexion (L), multijoint trunk extension and flexion (T) and a complex shoulder/arm extension (S) movement, on rotational and linear dynamometers (Con-trex® MJ/LP/TP/WS CMV AG). K and S was measurement at \( 60, 180 \) and \( 360 ^\circ /s \), T at \( 60 \) and \( 120 ^\circ /s \) and L at \( 0.3, 0.6 \) and \( 0.9 \) m/s (linear leg press). Two measurement modi (isokinetic classic: only gravity compensation; isokinetic new: gravity and inertia compensation) were tested concentrically in randomised order proceeding from slow to fast movement speeds. The test order of the four movements was also randomised. Main Outcome measure was the realized maximum velocity at preset speed limit. Data was analysed descriptively with mean and 95% confidence interval.

<table>
<thead>
<tr>
<th>Joint/movement</th>
<th>Preset speed</th>
<th>Ext/Flex</th>
<th>Modus</th>
<th>( N )</th>
<th>Realized max speed (mean) ± 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>( 360 ^\circ /s )</td>
<td>flex</td>
<td>classic</td>
<td>24</td>
<td>346.8 ± 3.0</td>
</tr>
<tr>
<td>K</td>
<td>( 360 ^\circ /s )</td>
<td>flex</td>
<td>new</td>
<td>24</td>
<td>349.1 ± 3.0</td>
</tr>
<tr>
<td>L</td>
<td>0.9 [m/s]</td>
<td>flex</td>
<td>classic</td>
<td>25</td>
<td>0.42 ± 0.02</td>
</tr>
<tr>
<td>L</td>
<td>0.9 [m/s]</td>
<td>flex</td>
<td>new</td>
<td>25</td>
<td>0.68 ± 0.02</td>
</tr>
<tr>
<td>S</td>
<td>( 360 ^\circ /s )</td>
<td>ext</td>
<td>classic</td>
<td>25</td>
<td>144.6 ± 9.6</td>
</tr>
<tr>
<td>S</td>
<td>( 360 ^\circ /s )</td>
<td>ext</td>
<td>new</td>
<td>25</td>
<td>310.7 ± 9.6</td>
</tr>
</tbody>
</table>

Results: In healthy subjects there were no differences at the knee between the classic and the new mode. At the lower limb there were higher realized velocities in the new mode in flexion with increasing speed (difference: \( 0.24 \) m/s at \( 0.9 \) m/s preset speed), but no differences in extension. For the trunk movement were no differences at \( 60 ^\circ /s \) but with preset \( 120 ^\circ /s \), a mean difference of \( 20 ^\circ /s \) was observed (Fig. 1). The realized maximum speed at the shoulder/arm extension (preset \( 360 ^\circ /s \)) was on average \( 170 ^\circ /s \) faster in the new mode (Table 1).
Fig. 1. Realized maximum speed: Trunkflexion at preset 60 and 120°/s in classic and new measurement mode (comparison: no compensation – with compensation of the moment of inertia) [°/s].

Discussion: Desired high speed tests (preset speed) on dynamometer are not always high speed in real [2,3]. With compensation of inertia, healthy subjects are able to reach the preset speed limit as far the range of motion allows.

Conclusion: New measurement modi, which compensate for the moment of inertia, seem to be highly relevant in desired high speed tests. In all movements with large involved body segements absolut high test speeds are only possible with a compensation of both, gravity and moment of inertia. Patients with lower strength levels will probably also benefit at low test speeds and tests (e.g. knee) with small inertia.

References


Strength and Conditioning in High-Level Athletes

Force capacity of elite race car drivers in motor sports

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Introduction: Race car driving provokes cardio circulatory responses that can reach levels of up to 80% of values obtained in maximal graded exercise tests while the fraction of cognitive stress-related increase is unknown [2]. Beside that, high forces for braking sequences of up to 70 kg on the braking pedal and high centrifugal forces require well established strength performance capacity. Data on strength performance capacity of elite race car drivers is not reported in literature. The purpose of this study was therefore to compare strength performance capacity of elite race car drivers with age matched physically active controls.

Methods: Maximum strength performance capacity and muscular endurance of 8 elite race car drivers (RD, age: 26.5 ± 5, height 177 ± 4.4 cm, weight: 68.8 ± 7.8 kg) and 10 physically active (according to ACSM guidelines [1]) controls (CO, age: 26.2 ± 6, height 181 ± 8.0 cm, weight: 72.7 ± 7.5 kg) was tested on Con-trex ® System Modules
Transferability and reproducibility of objective and subjective parameters from exercise testing to training

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Introduction: For the prescription of exercise intensity the \% of maximal oxygen consumption (VO\textsubscript{2max}) – method is highly recommended \cite{1}. Although VO\textsubscript{2max} can be estimated from formulas, the gold standard is to obtain VO\textsubscript{2max}.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|c|c|c|c|c|}
\hline
\multicolumn{8}{|c|}{Table 1: Maximum force capacity and muscular endurance of RD and CO} \\
\hline
\textbf{Test} & \textbf{Lower extremity} & \textbf{Upper extremity} & \\
& max & decline & max & decline & max & decline & endurance \\
\hline
\textbf{Work mode} & \textbf{Unit} & \textbf{[N]} & \textbf{[\%]} & \textbf{[N]} & \textbf{[\%]} & \textbf{[Nm]} & \textbf{[\%]} & \textbf{[Nm]} & \textbf{[\%]} & \textbf{[s]} & \textbf{[s]} \\
\hline
RD & 0.5 m s\textsuperscript{-1} & \textbf{1517} ± 285 & \textbf{32} ± 13 & \textbf{2271} ± 466 & \textbf{16} ± 10 & \textbf{74} ± 10 & \textbf{35} ± 31 & \textbf{84} ± 33 & \textbf{40} ± 26 & \textbf{78} ± 27 \textbf{[192]} \\
CO & 0.5 m s\textsuperscript{-1} & \textbf{1561} ± 161 & \textbf{21} ± 11 & \textbf{2072} ± 478 & \textbf{9} ± 15 & \textbf{68} ± 9 & \textbf{23} ± 30 & \textbf{101} ± 6 & \textbf{44} ± 12 & \textbf{94} ± 26 \textbf{[192]} \\
\hline
\end{tabular}
\end{table}
directly during a cardiopulmonary exercise test (CPX). It is however, not clear if the corresponding heart rate (HR), minute ventilation ($V_E$) and the ratings of perceived exertion (RPE) from the CPX are consistent with the values obtained when using the work load for training. In this sub-analysis from a pharmacology study we compared the data from the CPX with the data from constant load exercise based on this CPX.

Methods: Twelve non-smoking, healthy male and female subjects (28.6 ± 4.9 years, BMI 23.2 ± 2.7 kg/m$^2$) performed a CPX with an initial work load of 20 Watt and 15 Watt increments every minute until exhaustion. HR, $V_E$ and RPE (Borg scale 6–20) were determined every minute. The work load corresponding to 50% of VO$_{2\text{max}}$ was used at 2 following study days where 30 minutes ergometer exercise was performed. Measurements were undertaken before start and at 10, 20 and 30 minutes of exercise. Data for VO$_{2\text{max}}$, HR, $V_E$ and work load (P) are given as mean ± SD, data for RPE are given as median (range). Tests are made as paired tests with t-test for HR and for $V_E$ and Wilcoxon’s Signed Rank test for RPE.

Results: Maximal values of the CPX were as follows: VO$_{2\text{max}}$: 50.3 ± 9.3 ml/min/kg; P$_{\text{max}}$: 251 ± 66 W; HR$_{\text{max}}$: 191 ± 9 beats/min; $V_{E\text{max}}$: 105 ± 31 l/min. The corresponding workload of 50% VO$_{2\text{max}}$ was 111 ± 35 W which was 44 ± 4% of P$_{\text{max}}$. Mean resp. median data from CPX and the two exercise days are shown in Table 1. Data were reproducible with no significant differences between the two dosing days. HR (beats/min) of constant load exercise 1 and 2 were 125 ± 7 and 126 ± 8 after 10min, 129 ± 9 and 127 ± 10 after 20 min and 132 ± 10 and 129 ± 9 after 30 min, respectively. Heart rate during 30 minutes of ergometer training had a tendency to be slightly lower than the heart rate of the corresponding workload during the CPX. No difference was found for RPE, but there seemed to be a higher variation in subjective effort.

Discussion: Although there seems to be a good transferability of HR and $V_E$ from CPX to constant load exercise, the subjective response was highly variable in these subjects. Even though the BORG-scale is also recommended for training purposes [1], more objective parameters like HR seem to be more accurate.

Conclusion: Whereas there seems to be a higher variability in subjective effort during both, CPX and constant exercise, the more objective value HR is highly transferable and reproducible for training purposes. Therefore, for prescription of exercise intensity objective parameters seems to be more appropriate than subjective parameters.

Reference

Functional adaptations of the locomotor-system due to boxing
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Introduction: Performance-orientated boxing is characterised by high strains on the locomotor-system. In this noncyclical sport enormous torsions between shoulder- and pelvic-girdle must be compensated. Furthermore,
shoulder-girdle and neck can be overused by the fighting posture and standard-techniques, that are often associated with non-physiological patterns. The aim of study is this to examine effects of habitual posture and of function of selected muscles by boxing training.

**Methods:** In a boxing group (BG) of 11 young boxers – C-national junior boxing team (age: 14.6 ± 0.6 years; 7.3 ± 0.6 training units/week) and a control group (CG) of 52 male pupils (age: 15.4 ± 0.4 years) the static of head, shoulder-girdle, and pelvis was detected by somatoscopy. In the BG only, M. pectoralis major et minor, M. levator scapulae, and M. trapezius pars ascendens were tested on shortness by JANDA’s method. All boxers fight in regular position (left hand and leg in front). Depending on the data, groups were compared by the Chi-Quadrat-test or the exact Fisher-test.

**Results:** In comparison to the CG, head and shoulder of the boxers were ventralised more often ($p < 0.01$). Only one boxer but 32 volunteers (43 for shoulder position) showed a balanced posture for head and shoulder in sagittal plane (Fig. 1 left). Furthermore, significant group differences in the symmetry of shoulder height ($p = 0.006$) and iliac crest ($p = 0.002$) were detected in the frontal plane. By 7 of 11 boxers a superscript of left iliac crest was detectable (Fig. 1 right). In CG the balanced position is outweigh.

For tests of shortness adequate tensibility or shortening level 1 were detected. No shortening level 2 was located. In 73% of the boxers a functional shortness of the M. pectoralis minor was detected (M. pectoralis major, M. levator scapulae, M. trapezius pars descendens each with 28%). Two boxers each are shown no shortening muscle or shortening in all tested muscle.

**Discussion:** Our study demonstrated significant differences in the analysed parameters of the posture. Also a muscle dysbalance in shoulder girdle between pectoralis and interscapularis muscles were detected, that are explainable by boxing specific strains, because the boxing fight position stimulate this changes. As none of the junior athlete complained about any strains in musculoskeletal system, the authors think, these changes are sport-specific adaptation and prerequisites of optimal performance.

**Conclusion:** The classification in physiological (sport-specific) or prepathological changes is difficult to assess, as long-term increased burdens for some parts of musculoskeletal system could develop to pathologics. Adequate compensational exercises like erecting of thoracical spine, training the interscapular muscles, stretching and relaxing of neck and pectoralis muscles should be integrated in the training. Thus intervention should be accompanied by measures of physiotherapy.

**References**

The effect of laterality on young athletes in flat water canoeing

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Introduction: Laterality, the dominance of one hemisphere, and the effect of these two phenomena on sports performance capacity have yet to be described in detail.

Methods: During the period from October 1997 to October 2000, 275 kayakers and canoeists between the ages of 11 and 20 were examined twice annually (March and October) using extensive training scientific, kinetic and biomechanical equipment. The athletes were members of a state-wide canoeing club (national junior elite athletes). The main focus of the study was the correlation between (a) force differences arising between the left and right upper extremity and (b) athletic performance under laboratory conditions (canoe counter current system) and field conditions (flat water). The following data was gathered: selected strength capacities (maximum force \([F_{\text{max}}]\), initial and maximum rates of force development [IRFD, MRFD]) of the upper arm flexor at a static strength measurement system, force curves at the measuring paddle during exercise tests using the canoe counter current system and canoeing times in flat water over 250 m (included EMG – signals of the upper arm flexor) and 2,000 m during the course of the year.

![Graph showing difference of maximum force between left and right arms](image)

Fig. 1. Difference of maximum force between left and right arms \((F_{\text{max}} \text{ left (} F(2, 20; 0.05) = 103.682; p \leq 0.000); F_{\text{max}} \text{ right (} F(2, 20; 0.05) = 126.076; p \leq 0.000)\)).

Results: The results of the static maximum force test showed that the difference in maximum force between the left and right arm increases with age. As maximum force increases, the difference in the mean value of maximum force seems to increase as well. The longitudinal study included only right-handed athletes. Thus, in the longitudinal group the assumption seems to be confirmed that right-handers also have greater force in their preferred extremity. However, further longitudinal analyses showed that the higher maximum force achievement changes from the right into the left arm with some test subjects. These results show that it is not always possible to determine which side has greater maximum force solely on the basis of handedness. The EMG signals map the different loads under laboratory...
and field conditions and include individual characteristics. In the EMG curves measured in flat water effects of the field conditions (e.g. flow direction of the water, wave strength, wind direction) can be clearly observed. Under field conditions, strain on the musculature is higher than under laboratory conditions.

Discussion: According to Vagenas and Hoshizaki [2] bilateral differences, which are frequently observed during symmetrical physical activities, may be attributable to the systematic combination of structural and neuromuscular factors. However, there is ongoing controversy about the relationship between preferred extremity (preference dominance) and the extent of force development (achievement dominance). The preferred extremity (e.g. the writing hand) is commonly believed to possess the higher maximum force level.

Conclusion: Results from the longitudinal section indicate that with exclusively right-handed subjects the preferred extremity cannot biuniquely be shown to have a higher force level. This result is confirmed by the cross-sectional findings. Therefore it could be concluded that the morphological (structural) organization of the human locomotor system forms the very basis for locomotor movement symmetries. However, due to diverse factors such as differences in extremity lengths and the attendant force levels, movement asymmetries may arise during cyclic movements such as walking and running. This observation is consistent with Starosta’s [1] theory, which holds that ontogenetically induced upper extremity growth differences lead to different leverage lengths and attendant levels of force. Apart from that, the dominant extremity might be used instinctively for movement guidance e.g. during strength training.

References


Concentric/eccentric strength endurance differences in female alpine ski racers

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Introduction: Due to the high relevance of strength endurance of the hip and knee extensors in alpine skiing, strength endurance tests are utilized to monitor training. Alpine ski racers require high eccentric and concentric force development and have demonstrated high leg strength when compared to other athletes [1]. In Austria, different strength endurance tests for alpine ski racers begin at the age of 12. Various strength endurance tests are used, depending on age and performance level. The Contrex 30 repetition test is part of a test battery used for some training groups in the Austrian Ski Federation.

Methods: The Contrex linear leg press is utilized for closed-chain testing of the lower extremities. It can measure both concentric and eccentric forces up to 6kN and speeds up to 0.6 m/s. Measurements are made unilaterally with the right and left legs separated by a 10 min. pause. For the isokinetic strength endurance test the range of motion is set between knee angles of 85° to 120°. The testing speed is set at 0.2 m/s and 0.4 m/s for the eccentric and the concentric contractions, respectively. These speeds are employed to simulate a ski specific movement pattern. The test consists of 30 maximal concentric/eccentric repetitions preceded by 3 repetitions to evaluate maximal 1RM concentric/eccentric power. All repetitions are used for data analysis and left and right power is summed to give total mean power. The main parameters of interest are the mean absolute and relative power (concentric and eccentric) for every 5 reps over the 30 repetitions. The decrease in power and the starting power (percent of maximum power) are computed. 24 female alpine ski racers from 3 different groups, World Cup (WC, \(n = 8\)) European Cup (EC, \(n = 7\)) Juniors (JUN, \(n = 9\)), were tested in preparation of ski season 04/05. A one way ANOVA and a general linear model with repeated measures compared with a Tuckey-HSD post-hoc-test were carried out to statistically test group differences. Significance level is set at \(p < 0.05\).
Results: WC racers were significantly older than EC and JUN ($p < 0.01$) and EC skiers were significantly older than JUN ($p < 0.05$). WC had the highest and JUN the lowest body weight, with significant differences only between WC and JUN ($p < 0.01$). JUN showed the highest mean in starting power but differences between groups were not significant. When comparing decrease of power there were no significant differences between the 3 groups, but JUN produced the greatest decrease. WC showed significantly higher absolute concentric values than JUN and significantly higher eccentric values than EC and JUN ($p < 0.05$). No significant differences in concentric and eccentric absolute power were observed between EC and JUN. WC had the highest relative power but relative concentric and eccentric power was higher in JUN than EC (see Fig. 1). None of these observations were statistically significant.

Discussion: To evaluate the power decline in this test, the athlete must start with maximal power. The highest observed starting power (JUN) was $68.5\% \pm 8.4$ of maximum power. The relatively low starting power may have psychological origins as the athletes know that the test is very demanding. If starting power is truly maximal, a higher power decline should be observed. This could be seen in JUN, with highest starting power and the greatest power decline. Not surprisingly, WC exhibited the highest absolute and relative power over the entire test. When comparing power over 30 reps, absolute values increased with skill level but relative power was higher in JUN than in EC. It should be noted that WC also had the highest body weights. Strength endurance is very relevant in ski racing so values should increase with performance level.

Conclusion: This strength endurance test enriches performance diagnostics for alpine ski racers. It is a good instrument to monitor the training process but also for individual longitudinal analysis. Over time it can be observed how injuries and other factors influence force imbalances between both legs.

Reference


The effect of different wind forces on heart rate behavior during freestyle windsurfing

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**Introduction:** Previous studies reported measurements of heart rate during sailing or windsurfing [1], Olympic windsurfing competition [2], exhausting isometric exercise on a simulator or at sea [3], and sail pumping in Olympic level windsurfers [4] via ambulatory monitoring. The aim of this investigation was to compare the effect of different wind forces on heart rate behavior during freestyle windsurfing.

**Methods:** Two female and six male freestyle-windsurfers ages from 22 to 32 (25 ± 2.9) completed a windsurfing session that was similar to a competition, composed of 8 different maneuvers (Table 1) and the effect of wind forces measuring 4 to 6 Beaufort (Bft). The HR was recorded beat to beat with a “S810i” heart rate monitor (Polar Electro, Finland). The windsurfing equipment was adapted to the individual conditions of the subjects.

<table>
<thead>
<tr>
<th>Maneuver</th>
<th>4 Bft</th>
<th>5 Bft</th>
<th>6 Bft</th>
</tr>
</thead>
<tbody>
<tr>
<td>jibe</td>
<td>142 ± 5.2</td>
<td>154 ± 9.9</td>
<td>164 ± 6.9</td>
</tr>
<tr>
<td>loop</td>
<td>151 ± 7.7</td>
<td>157 ± 9.1</td>
<td>168 ± 8.7</td>
</tr>
<tr>
<td>heli-tack</td>
<td>146 ± 13.1</td>
<td>158 ± 5</td>
<td>170 ± 12.9</td>
</tr>
<tr>
<td>bodydrag</td>
<td>147 ± 7.4</td>
<td>159 ± 7.6</td>
<td>167 ± 7.6</td>
</tr>
<tr>
<td>duck-tack</td>
<td>142 ± 8.1</td>
<td>160 ± 6.9</td>
<td>167 ± 12.5</td>
</tr>
<tr>
<td>spock 540</td>
<td>144 ± 16.3</td>
<td>157 ± 10.1</td>
<td>172 ± 6.7</td>
</tr>
<tr>
<td>duck-jibe</td>
<td>143 ± 9.1</td>
<td>157 ± 6.9</td>
<td>168 ± 4.4</td>
</tr>
<tr>
<td>volcan</td>
<td>138 ± 15.4</td>
<td>161 ± 11.7</td>
<td>168 ± 5.2</td>
</tr>
</tbody>
</table>

**Results:** Peak HR during the 8 different maneuvers performing in 4–6 Bft are listed in Table 1. Significant differences between maneuvers were only found at 4 Bft. (F (7, 49) = 2.44 p ≤ 0.05; jibe/loop, loop/duck-tack, loop/duck-jibe, loop/volcan, heli-tack/volcan, bodydrag/volcan). While at 5 Bft (F(7, 49) = 0.75 p = 0.632) and 6 Bft (F(7, 49) = 0.58 p = 0.772) no significant differences were found. Significant differences (p <0.05) between wind forces were found during jibe (4Bft/5Bft, 4Bft/6Bft, 5Bft/6Bft), loop (4Bft/6Bft, 5Bft/6Bft), heli-tack (4Bft/5Bft, 4Bft/6Bft, 5Bft/6Bft), bodydrag (4Bft/5Bft, 4Bft/6Bft), duck-tack (4Bft/5Bft, 4Bft/6Bft), spock 540 (4Bft/5Bft, 4Bft/6Bft, 5Bft/6Bft), duck-jibe (4Bft/5Bft, 4Bft/6Bft, 6Bft/6Bft), duck-jibe (4Bft/5Bft, 4Bft/6Bft, 6Bft/6Bft), duck-jibe (4Bft/5Bft, 4Bft/6Bft, 6Bft/6Bft), volcan (4Bft/5Bft, 4Bft/6Bft).

**Discussion:** Our results of freestyle windsurfing of different wind forces consisting of 8 different maneuvers are in agreement with Schöne et al. [3], who have found different but higher HRs at intensity similar to competition. The HR at 6 Bft was comparable to sail pumping (165 ± 12 for men and 175 ± 13 for women) in Olympic level windsurfers [4].

**Conclusion:** The cardiocirculatory response of freestyle windsurfing is predominantly dependent on wind forces and less dependent on the type of maneuver.

**References**

Changes of selected body composition parameters in elite sprint runners during the training year

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Introduction: The determination of body composition by using the methods of bioelectrical impedance (BIA) has become a relatively common part of both clinical examinations for medical purposes and for sports training. Periodic body composition measurement can be used not only to assess the effects of training or diet interventions but also to estimate of maturation or pathologies states, like overtraining.

The aim of this study was to assess changes of selected body composition variables during the training year in high performance athletes – sprint runners.

Methods: We tested 17 male subjects, top trained Czech runners – 400 m and 400 m hurdles (Table 1). We measured the body composition parameters (body fat, fat-free mass and extracellular cell mass: body cell mass ratio – ECM/BCM) four times regularly in the preparatory and the competitive periods of the training (1st winter preparatory period, 2nd winter competitive period, 3rd preparatory period, 4th summer competitive period). In these periods we monitored the anaerobic capacity level by using Kindermann-Schnabel test.

Table 1

<table>
<thead>
<tr>
<th>N</th>
<th>Age [yrs]</th>
<th>Height [cm]</th>
<th>Weight [kg]</th>
<th>Body fat [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>21.0 ± 2.5</td>
<td>182.3 ± 5.8</td>
<td>73.6 ± 5.4</td>
<td>10.3 ± 1.9</td>
</tr>
</tbody>
</table>

The body composition parameters were estimated from whole-body bioimpedance measurement at different frequencies – 1, 5, 50 and 100 kHz (B.I.A. 2000 M, Data Input, Germany). The whole time we monitored the training program in terms of volume: intensity ratio.

![Fig. 1. The character of the training program during the year.](image)

Results: The results of body composition analysis show the small decrease in body weight (1st period 73.6 ± 5.4 kg – 4th period 72.7 ± 5.1 kg). The significant changes have been found neither in the percentage of fat mass (10.3 ± 1.9% in the 1st period and 9.8 ± 1.7% in the 4th period) nor in the fat-free mass (66.0 ± 4.4 kg in the 1st
period and 65.6 ± 4.1 kg in the 4th period). ECM/BCM was significantly changed (0.74 ± 0.07 in the 1st period and 0.70 ± 0.05 in the 4th period).

Discussion: The values of body weight, fat free mass and fat mass were relatively unchanged.

The ECM/BCM ratio can be used as complementary criterion for assessing the predisposition for exercise. The lower the ECM/BCM ratio, the better is the predisposition for exercise [1]. In our project in top trained runners were connected the decreases of ECM/BCM ratio with the changes of the training program character (in terms of decrease of volume: intensity ratio) and with better level of anaerobic capacity.

Conclusion: From the point of view of long-term body composition monitoring, the character of the sports preparation, while retaining relatively stable values of the body weight, percentage of body fat and fat free mass, will show in the ECM/BCM ratio. This parameter appears to be, in accordance with our results, as an important indicator of the level of the fitness achieved by training in sports preparation.

Keywords: Body composition, extracellular body mass, body cell mass, fat mass

Reference


Heart rate and heart rate variability in a microcycle with different training regimen

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Introduction: Changes in resting heart rate are due to changes in autonomic function. Enhanced vagal activity decelerates heart rate, more sympathetic activity increases heart frequency [2]. Measures of heart rate variability (HRV) give a possibility to evaluate the autonomic input on the heart under different physiological conditions. Aim of the study was to evaluate differences in autonomic control as a result of adaption or maladaptation in two various microcycle training regimens using constant load or constant strain.

Methods: Two different groups of trained men (A: 27 ± 7 yrs. age, 179.8 ± 4.3 cm height, 74.9 ± 3.5 kg weight, constant training load; B: 29 ± 8 yrs. age, 180.8 ± 4.9 cm height, 72.7 ± 6.4 kg weight, daily adapted training load) performed a cycling ramp test until exhaustion for a period of 17 days on a daily basis. After the PRE-phase of 3 days with no training, but daily incremental tests, the following 7 days of training (TEST-phase) an exhaustive ramp test (T1) followed by a 30 min exercise (TU, 87% heart rate maximum from T1) and another second maximal ramp test (T2) were performed every day. The subsequent POST-phase consisted of 7 days without training and one maximal ramp test each day. Parameters of performance and autonomic modulation (spectral analysis with low/high frequency components, Poincaré plot with standard deviation of beat-to-beat RR interval variability SD1 and SD2) were observed in an active orthostatic test [3].

Results: In the recumbent position resting heart rate was significantly higher in A and decreased due to training in both groups. Group A showed an increased LF/HF ratio in TEST and POST phase (p<0.05). During the training period higher values for index SD1, SD2 were obtained in A (p<0.05 in POST). Spectral analysis indicated differences in LF% during POST phase with obviously more sympathetic drive in A. The maximum performance in both groups was significantly different in all phases but in a longitudinal comparison between PRE and POST these parameters kept stable (B) or even increased in A. Maximum heart rate was lower in B and decreased in both groups from PRE to POST.

Discussion: In general specific variables from heart rate variability measures (RRI, SD1, LF%, TSD) showed increasing values, which means a positive adaptation to both training regimen. Higher heart rate values in recumbent position, training induced rises in LF% values as well as LF/HF% ratio showed an enhanced sympathetic drive, an
**Table 1**
Mean values of LF/HF% in all phases

<table>
<thead>
<tr>
<th></th>
<th>LF/HF%</th>
<th>PRE</th>
<th>TEST</th>
<th>POST</th>
</tr>
</thead>
<tbody>
<tr>
<td>group A</td>
<td>100.00%</td>
<td>86.51%</td>
<td>69.18%</td>
<td></td>
</tr>
<tr>
<td>group B</td>
<td>100.00%</td>
<td>97.09%</td>
<td>69.93%</td>
<td>534.22%</td>
</tr>
<tr>
<td>Test</td>
<td>0.093</td>
<td>0.005</td>
<td>0.021</td>
<td>534.22%</td>
</tr>
</tbody>
</table>

**Fig. 1.** Daily RR Intervals in recumbent position.

indication for an intensified cardiovascular stress in group A. The nearly constant exercise performance (Pmax) in both groups and the gradually lower heart rate parameters (HRmax, HRE3) may be seen as the result of a positive adaption to the training load in both groups [1].

**Conclusion:** Heart rate variability data seem to be very individual. Therefore we suggest either to compare intra-individual longitudinal values than cross sectional ones. Without clear signs of overreaching a trend towards overload could be seen in A. Critically we may remark that exercise duration of training session in one microcycle is too short to indicate clear signs of overreaching/overtraining even in moderately trained subjects.

**References**


**The Wingate Test under-estimates maximum power: The Sprint Power Test measures maximum power as a function of load**

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**Introduction:** The maximum power produced by an athlete is – in the context of other determining variables and parameters – a major performance factor in all sports where the body (or an object) is to be accelerated by muscle forces within short time. Therefore it is most interesting to ask how much mechanical energy can be produced by the
athlete within a few seconds and what does the fatigue function look like when maximum power activations occur repetitively over a period [1]. The mechanical power $P$ is the work $W$ (equal to the change in kinetic energy) divided by the time interval $t$:

$$P = \frac{W}{t} = \frac{\vec{F} \cdot \vec{s}}{t} = \vec{F} \cdot \vec{v};$$

SI units: [W], [J], [s], [m/s]. The maximum power obtainable has always to be seen in dependence on the time domain of relevance, the resistance force given, and the velocity of motion. High acceleration phases which last a few seconds only occur in many sports, e.g. in football, ice hockey, shot put, gymnastics, etc.

**Methods:** The *Sprint Power Test* [1] has been designed to measure such short-time muscle power on the bicycle ergometer at loads in the range from 4 to 14% of body weight acting as frictional force on the fly-wheel of a *Monark* weight ergometer (rotosport.com); 874E, 884E, and 894E which allow power measurements up to 2000W were used. Weight accuracy was $\pm 0.1\%$ and the velocity of the flywheel was measured with similar accuracy by means of a hall sensor and an electronic device (power analyzer, bewotech.com) which also allowed determination of the rotational energy of the fly-wheel: 

$$E_{\text{rot}} = I \omega^2 / 2,$$

with $I$ being the moment of inertia of the flywheel.

**Sprint Power Test:** The athlete performs a short sprint at 4% load to obtain maximum power on the bicycle ergometer (action duration of a few seconds only), followed by a pause of 5 minutes, followed by the next load step, etc. (4, 8, 10, 12, 14%), until maximum power decreased for the first time (the power-load function has a maximum).

**Repetitive Sprint Power Test:** Repetitive measurements of maximum power at a given load with intervals typical for a given sport indicate fatigue behaviour.

![Graph](image)

**Results:** The Figure shows the power-load function (left curve; $P$ measured on the fly-wheel) of a young shot put athlete (body height 1.823 m, sitting height 0.970 m, mass 112.6 kg, 17 years; BMI 33.9, MI 33.5 kg/m$^2$). The right curve shows the relative power [W/kg] as a function of pedal frequency (rpm) which can be used as a diagnostic characteristic of the athlete’s muscle contraction velocity at a given load (at 4% load: 197 pedal rotations per minute). Results obtained with 28 male and 22 female finalists of Austrian-wide talent tests (the best young athletes from all kinds of sports):

- **Male:** $P_{\text{max}} = 16.1 \pm 1.6$ W/kg (highest $P_{\text{max}} = 19.1$ W/kg), max. pedal frequency $f_{\text{max}} = 193.7 \pm 9$ rpm (highest $f_{\text{max}} = 203.7$ rpm), age $= 16.2 \pm 0.8$ years, $\text{BMI} = 21.9 \pm 3.1$ kg m$^{-2}$, $\text{MI} = 22.5 \pm 2.9$ kg m$^{-2}$ [2];

- **Female:** $P_{\text{max}} = 12.8 \pm 1.5$ W/kg (highest $P_{\text{max}} = 14.4$ W/kg), max. pedal frequency $f_{\text{max}} = 165.3 \pm 13$ rpm (highest $f_{\text{max}} = 182.3$ rpm), age $= 15.6 \pm 0.9$ years, $\text{BMI} = 20.0 \pm 2.2$ kg m$^{-2}$, $\text{MI} = 21.1 \pm 4.5$ kg m$^{-2}$. In all cases, the maximum power at 7.5% load (peak power according to *Wingate*-terminology) was substantially below the maximum of the sprint power function.

**Discussion and Conclusions:** Maximum obtainable power depends on the load (force), velocity, and also on the time domain of relevance [3]. For sprint tests on a bicycle ergometer the rotational energy of the flywheel has to be measured, otherwise large measurement errors would result due to the angular acceleration. A frictional force of only 7.5% of body weight acting on the fly-wheel of the bicycle ergometer (Wingate protocol) is not sufficient for obtaining the maximum peak power trained athletes can produce. The *Sprint Power Test* focuses on action durations of a few seconds at various loads and results in the power-load graph which allows to precise determination of maximum power in this time domain.
Mode of exercise has a strong influence to the relative intensity of aerobic training recommendations in highly trained triathletes

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Introduction: Training recommendations for aerobic exercise are often given as percentage of maximal heart rate or oxygen consumption for all groups of endurance athletes as well as for prevention and rehabilitation. It is, however, unclear, if these recommendations are valid for all modes of aerobic exercise in highly trained endurance athletes.

Methods: Seven competitive triathletes (age: 27 ± 3 years, weight: 73 ± 10 kg, height: 183 ± 5 cm) were examined on three different days. They performed a maximal test on three different ergometers, i.e. treadmill, cycle ergometer, and crank handle ergometer in randomized order to determine oxygen consumption (VO\textsubscript{2max}), workload (V\textsuperscript{resp. P}), heart rate (HR), and blood lactate concentration (La). The corresponding individual aerobic and anaerobic thresholds were determined using the lactate turn point concept [2,3].

Results: Maximal values were as follows: treadmill: VO\textsubscript{2max}: 68 ± 6 ml/min kg, \( V_{\text{max}} \): 19 ± 1 km/h, HR\textsubscript{max}: 191 ± 7 bpm, \( L_{\text{a}} \text{max} \): 9.5 ± 1.9 mmol/l; cycle ergometer: VO\textsubscript{2max}: 69 ± 7 ml/min kg, P\textsubscript{max}: 416 ± 34 W, HR\textsubscript{max}: 187 ± 7 bpm, \( L_{\text{a}} \text{max} \): 12.6 ± 1.8 mmol/l; crank handle ergometer: VO\textsubscript{2max}: 47 ± 5 ml/min kg, P\textsubscript{max}: 188 ± 24 W, HR\textsubscript{max}: 176 ± 7 bpm, \( L_{\text{a}} \text{max} \): 10.5 ± 2.1 mmol/l. The values at the aerobic threshold for treadmill vs. cycle vs. crank handle ergometer were: VO\textsubscript{2}: 46 ± 2 ml/min kg (68 ± 6%) vs. 35 ± 4 ml/min kg (51 ± 6%) vs. 17 ± 2 ml/min kg (40 ± 3%); HR: 148 ± 8 bpm (78 ± 4%) vs. 127 ± 11 bpm (68 ± 5%) vs. 113 ± 13 bpm (64 ± 7%). The values at the anaerobic threshold for treadmill vs. cycle vs. crank handle ergometer were: VO\textsubscript{2}: 59 ± 3 ml/min kg (87 ± 5%) vs. 54 ± 4 ml/min kg (78 ± 4%) vs. 31 ± 3 ml/min kg (66 ± 7%); HR: 175 ± 5 bpm (91 ± 2%) vs. 163 ± 8 bpm (87 ± 3%) vs. 146 ± 12 bpm (83 ± 6%).

Discussion: The determination of submaximal parameters gives valid information about the metabolic strain during exercise. Especially the anaerobic threshold according to the second lactate turn point has shown to be a valid estimate of the maximal lactate steady state. Therefore, the relative intensity for exercise prescription of aerobic training seems to be strongly coupled to the mode of exercise. For exercises with a higher involvement of active muscles a higher relative percentage of VO\textsubscript{2max} and HR\textsubscript{max} is found at a comparable metabolic strain (i.e. aerobic threshold and anaerobic threshold).

Conclusion: The relative intensity for exercise prescription of aerobic training is strongly coupled to the mode of exercise. To obtain a comparable metabolic strain exercise with more muscles involved need a higher relative percentage of VO\textsubscript{2max} and HR\textsubscript{max} compared to exercise with less muscles involved. These findings should have wide implications for exercise intensity recommendations for all groups of endurance athletes. Furthermore, exercise recommendation for prevention and rehabilitation should also be adapted according to the mode of exercise.
Isokinetic dynamometry in the evaluation of anaerobic capacity in elite futsal players

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Introduction: One of the major characteristics of Futsal is its bouts of high intensity short-term exercises. The muscle strength, together with their anaerobic power and capacity are therefore crucial determinants for athletic performance. There have been few attempts to correlate the isokinetic strength testing variables and anaerobic tests. In this retrospective study, Fatigue Index as given by the Wingate Test (FI\textsubscript{w}) using the bicycle ergometer was compared with several determinations of Fatigue Indexes (FI\textsubscript{i}) obtained by applying the isokinetic equipment.

Methods: This analysis is based on the results of the Isokinetic and Wingate tests, performed on ten elite futsal players. The isokinetic tests were carried on using a Biodex System II dynamometer, in the concentric mode at 180, 60 and 300\textdegree/s, and with 5, 3 and 30 repetitions, respectively. For the estimation of the Fatigue Indexes \textsuperscript{1} (FI\textsubscript{i}), the minimum value was taken as the average of the last five repetitions of the series at 300\textdegree/s.

The Wingate Anaerobic Test was performed with a braking load of 0.75% body weight in a Monark bicycle ergometer.

Possible correlations for the fatigue indexes were analysed using the Spearman statistical test.

Results: With the values of this sample, the comparison of the fatigue indexes obtained with the isokinetic dynamometer in concentric/concentric mode, at 300\textdegree/s, and those obtained with the Wingate did not shown association. The application of the statistical Spearman test shows that the null hypothesis, H\textsubscript{0}: \rho\textsubscript{s} = 0, can not be rejected.

Discussion: The lack of association between the two methods used to estimate the fatigue indices, is attributed to the following facts:

a) the sample is too small and
b) the angular velocity is too high. At such high velocity, the efforts required at each leg probably were not enough to cause exhaustion of the anaerobic lactic pathway.

Conclusion: Because there was no association between the FI\textsubscript{w} and the FI\textsubscript{i}, the fatigue indexes obtained with isokinetic test can not be taken as indicators of the anaerobic lactic pathway. Further studies are need with a new protocol with smaller angular velocities and larger samples.

References


\textsuperscript{1}The fatigue index, by definition, is given by the following ratio: \((\text{Maximum Momentum} – \text{Minimum momentum})/\text{Minimum Momentum}) \times 100.
Comparison of laboratory and on-court endurance testing in 6 to 10 year old children

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\textit{Introduction}: Previous studies investigated cardiorespiratory response during tennis training and competition in adult tennis players \cite{1,2}. The purpose of this investigation was to assess exercise intensities during a specific tennis training session in children.

\textit{Methods}: The coach played the ball to the children once to their forehand side and once to their backhand side with a maximal individual intensity without pausing to allow the children to hit the ball over the net into the tennis field. Nine children performed an incremental treadmill test (TT) measuring heart rate (HR) and respiratory gas exchange measures to determine HR_{\text{max}} and VO_{2\text{max}} as well as HR and VO\textsubscript{2} at the respiratory compensation point (RCP). To ascertain tennis specific exercise intensities, HR and VO\textsubscript{2} were measured also during tennis training field test (FT) for 10 min. Nine children (4 boys and 5 girls) ages 6 to 10 underwent both tests.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{fig1.png}
\caption{A child during the tennis field test.}
\end{figure}

Results: HR at the RCP was 187 \pm 11 bpm compared to FT HR, which was significantly higher ($p < 0.01$) during the first 3 min (161 \pm 9, 173 \pm 11, 177 \pm 10). From the 4\textsuperscript{th} – 9\textsuperscript{th} min, there were no significant differences for the HR (183 \pm 11, 184 \pm 13, 184 \pm 8, 187 \pm 12, 188 \pm 13, 192 \pm 13). However, in the 10\textsuperscript{th} min, there was a significant increase (195 \pm 9, $p < 0.01$) compared to HR at RCP. HR at $P_{\text{max}}$ (203 \pm 10) was significantly higher compared to HR measured throughout the FT ($p < 0.05$). VO\textsubscript{2} at the RCP was (42 \pm 6 ml.kg\textsuperscript{-1}.min\textsuperscript{-1}) compared to FT, which was significantly lower ($p < 0.05$) during the first 3 min (28 \pm 7, 37 \pm 6, 39 \pm 5) and not significantly different from the 4\textsuperscript{th} – 10\textsuperscript{th} min (40 \pm 7, 39 \pm 6, 39 \pm 6, 39 \pm 6, 41 \pm 8, 44 \pm 7). In comparison to VO\textsubscript{2\text{max}} (48 \pm 6), VO\textsubscript{2} during the FT was significantly lower ($p < 0.05$) throughout the test.

\textit{Conclusion}: These results suggest that children subconsciously perform at or above the RCP in a sport specific activity like tennis training with greater technical demands without compromising their technical abilities.

\textbf{References}