Habilitation

A collection of published papers on the subject of

Physiologically-based performance diagnostics and exercise prescription -

Particular reference to aerobic high-intensity interval exercise

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Summary

Evidence concerning the beneficial effects of exercise training and physical activity is overwhelming and includes improvements in exercise performance, quality of life, and the prevention and treatment of chronic diseases. The obtained *training effects* as well as potential *health risks* during exercise are triggered by the exercise-induced acute physiological responses which depend on the prescription of the particular exercise. Therefore, it is highly relevant to prescribe exercise as individually and accurately as possible, particularly in patients with chronic diseases. However, detailed knowledge regarding the dose-effect relationship between the prescription of exercise and the acute physiological responses is lacking.

A consistent model for exercise diagnostics is the basis of an adequate exercise prescription. Our research team combined performance diagnostics and aerobic exercise prescription to design a methodological approach that is *physiologically based* [**V, VI, VIII, X, XI**]. Our model for exercise performance diagnostics includes the determination of individual and physiologically justifiable *turn points (TP_1, TP_2)* (*thresholds)*. These turn points, which are determined during incremental exercise tests, are based on actual individual physiological data such as blood lactate (La), heart rate (HR), and ventilation (VE) or other gas exchange parameters. The physiological patterns of these parameters are stable across different populations. Therefore, this *"turn point model"* should be the principle for a subsequent prescription of exercise intensities in order to induce exercise stimuli and acute physiological responses that are adequate for individual subjects and homogeneous within a group of subjects. The principles of the turn point concept do not only apply to endurance training, but also to most other areas of training research such as warm-up strategies, regenerative training, sports games, sprint training, and strength endurance training as well as to occupational workloads.

But what is the *optimal intensity and duration* for continuous and intermittent exercise training? The manipulation of one single exercise component may result in markedly different acute physiological responses influencing training effects and health risks. Importantly, the acute responses yielded by particular exercise protocols should be known *before* the exercise begins. They should be prospectively controllable and predictable via the exercise prescription, which, for this reason, needs to be well-designed. This applies for both continuous and interval-type exercise.

In particular, the application of *aerobic high-intensity interval exercise (HIIE)* has become the focus of attention in the last decade since it has been shown to induce similar or even greater improvements in aerobic capacity than continuous exercise (CE) in healthy individuals and patients with chronic diseases. However, the prescription for aerobic HIIE is much more complicated compared to CE and often fails to be individualized and accurate in training practice and scientific studies. For this reason, we established a novel and consistent prescription model for aerobic HIIE which is physiologically based and allows for a prospective regulation and prediction of acute physiological responses [**I, X, XI**]. The single components of HIIE (peak workload (P_{peak}), peak workload duration (t_{peak}), recovery load (P_{rec}), recovery duration (t_{rec}), and the resulting mean load (P_{mean})) are set by means of the following equation: $\mathbf{P_{mean} = (P_{peak} * t_{peak} + P_{rec} * t_{rec}) / (t_{peak} + t_{rec})}$. This methodological approach to HIIE was applied in several studies in health and disease by our working group [**II, III, IV, VII**]. It allows for a customized application of aerobic HIIE in different areas of life including training therapy, competitive and recreational sports, public health, and occupational work.

Beside the scientific developments, it will be increasingly relevant to enhance *public awareness and acceptance* of science and research in general and of sports science in particular. Therefore, it will be an important task for the academic community to convey scientific insights and current research findings to a wider public and to present these insights and findings in an exciting and understandable way.

List of selected papers:

First author:

I. **Tschakert G.** & Hofmann P. High-intensity intermittent exercise - methodological and physiological aspects. *Int J Sports Physiol Perform* 2013, 8: 600-610.

II. **Tschakert G.**, Kroepfl J., Mueller A., Moser O., Groeschl W., Hofmann P. How to regulate the acute physiological response to aerobic high-intensity interval exercise. *J Sports Sci Med* 2015, 14: 29-36.

III. **Tschakert G.**, Kroepfl J.M., Mueller A., Harpf H., Harpf L., Traninger H., Wallner-Liebmann S., Stojakovic T., Scharnagl H., Meinitzer A., Pichlhoefer P., Hofmann P. Acute physiological responses to short- and long-stage high-intensity interval exercise in cardiac rehabilitation: A pilot study. *J Sports Sci Med* 2016a, 15: 80-91 (in press).

IV. Moser O., **Tschakert G. (contributed equally)**, Mueller A., Groeschl W., Pieber T.R., Obermayer-Pietsch B., Koehler G., Hofmann P. Effects of high-intensity interval exercise versus moderate continuous exercise on glucose homeostasis and hormone response in patients with Type 1 Diabetes Mellitus using novel ultra-long-acting insulin. *PLoS One* 2015a, Aug 28; 10(8): e0136489. 17 pages. doi: 10.1371.

Co-author:

V. Hofmann P. & **Tschakert G.** Special needs to prescribe exercise intensity for scientific studies. *Cardiol Res Pract* 2011, Article ID 209302, 10 pages, 2011. doi:10.4061/2011/209302.

VI. Hofmann P. & **Tschakert G.** Exercise training in chronic disease - importance of performance diagnostics. Scientific conference with international participation. June 15-16, 2013, Faculty of Education in Jagodina, University of Kragujevac. *PROCEEDINGS BOOK* 2014*,* 17 (special edition): 19-30.

VII. Wallner D., Simi H., **Tschakert G.**, Hofmann P. Acute physiological response to aerobic short interval training in trained runners. *Int J Sports Physiol Perform* 2014, 9(4): 661-666.

Textbook chapters:

VIII. Hofmann P., Mueller A., **Tschakert G**. Durchführung und Interpretation von Belastungsuntersuchungen - Gütekriterien, Protokolle und Spezial-Ergometrien zur Belastungsuntersuchung. In: Wonisch M., Hofmann P., Pokan R. (Hrsg): *Kompendium der Sportmedizin.* Wien, New York: Springer Verlag GmbH 2016a (in Druck).

IX. Hofmann P., **Tschakert G**., Mueller A. Grundlagen der Trainingslehre - Teil I: Allgemeine Grundlagen, Planung und Organisation des Trainings. In: Wonisch M., Hofmann P., Pokan R. (Hrsg): *Kompendium der Sportmedizin*. Wien, New York: Springer Verlag GmbH 2016b (in Druck).

X. **Tschakert G**., Mueller A., Hofmann P. Grundlagen der Trainingslehre - Teil II: Training der Hauptkomponenten der Leistungsfähigkeit - Trainingsmethoden und Trainingsberatung. In: Wonisch M., Hofmann P., Pokan R. (Hrsg): *Kompendium der Sportmedizin*. Wien, New York: Springer Verlag GmbH 2016b (in Druck).

XI. Hofmann P. & **Tschakert G**. 4. Trainingswissenschaftliche Grundlagen. Kenngrößen des sportlichen Trainings, Kondition, Belastungskomponenten, Leistungsdiagnostik u. Trainingssteuerung. In: Lamprecht M. (Hrsg): *Lehrbuch Sporternährung*. Graz: Clax Fachverlag GmbH 2016 (in Druck).