TREINAMENTO DESPORTIVO
V. 3(3) 05-16, 1998

ESPECIAL

NEW TENDENCIES IN TRAINING SCIENCE

Prof. Dr. Andreas Hohmann
Institute of Sport Science
Otto-von-Guericke-University of Magdeburg
Alemanha

Performance, training and competition

Training science in the european countries has emerged from two main sources: the *sports medicine* and the *methodology of training.* But already within the next ten years, the discipline grew more and more independent, so that in the Soviet Union training science was soon accepted as the core of sports science. Soviet training scientists started to determine the state of the art in that new scientific discipline. East Germany tried to keep up with that development and installed in 1956 the first chair for training science at the German High School for Physical Culture in Leipzig. In West Germany until far into the 1970s (and I think in the english speaking countries until today) training science remained closely related to its two sources, so that you could speak of training science on one hand as something as the applied biology or work physiology of training and on the other hand of something as methodology of elite training.

The close relation of training science to *elite sport*, especially on the field of scientific research, was caused by the struggle of the two political blocks of East and West. This situation led to two consequences: the importance and therefore also the federal support of the discipline grew in the same way as the importance of elite sport for the national representation gained weight. This can be seen obviously by the fact, that the east german High School for Physical Culture in Leipzig in the 1970s narrowed its focus on the education of elite coaches, only. At the same time it improved its work very fast, so that it became one of the most famous (and in combination with the closely related Research Institute for Physical Culture and Sports (FKS)) and most successful institutions for the support of elite sports in the world.

In comparison to that, in West Germany training science was not better substituted than any other discipline of the sport science. In fact, it had - on the contrary to the east german situation - to cope with the blames, that it were the slave of elite sports only, and that the common benefit from this discipline for the whole society remained still unclear.

The unequal standing of training science in the two political systems led to a different *scientific focus* and *way of research*: Training science in the free societies spread its interest beneath the elite sports on various fields of sports (fitness sport, school sport, health sport, age sport, sport in the rehabilitation) with the aim to collect, develop, expand and implement basic knowledge. Training science in the communist countries concentrated on solving the problems of elite sports. Therefore, especially in East Germany, sport science focussed its work on applied aspects. In that context, a lot of studies are based on action research priciples.

The close cooperation of the training scientists with the athletes and coaches in the field of elite sports led to a better understanding of the *process of training* itself. This can be seen in the works of Djatschkow (1974), Zaciorskij (1972), Matwejew (1974, 1981), Kusnezov (1972), Harre (1974), Verchoshanskij (1988, 1992, 1995), Fuchs & Reiss (1990), Deiss & Pfeifffer (1991).

Training science in the english speaking and the other european countries concentrated primarily on the *sport performance*. In West Germany, there were three pathways of research, concerning the *structure of performance* (Ballreich 1969; Willimczik 1972; Letzelter 1975, 1979, 1983; Bös & Mechling 1983; Hohmann & Brack 1983), the *general abilities*, that underlie performance in sports (Grosser 1976; Bührle & Schmidtbleicher 1981; Roth 1982) and the *conditions of performance* (Kindermann & Keul 1977; Liesen & Hollmann 1981; Schmidtbleicher 1980; Gollhofer 1987),

By the process of internationalization of science and research and especially by the turn in the scientific relations between the former east and west block (which can be seen best within the germany scientific community), it became clear, that the research of training science must concentrate on all three perspectives: the performance in sports, the training in sports and the competition in sports (see Fig. 1).

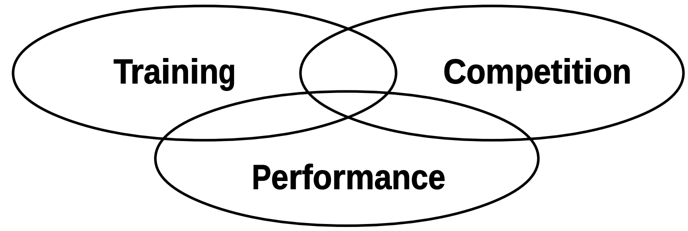


Figura 1 – The three categories of training science.

1 – Research on performance: From the analysis of general abilities to the analysis of competitive performances

In the beginning the research on the performance in sport concentrated on the general structure and then on the main motor abilities, that determine performance on certain levels. In respect to the first task, today we have arrived at a „common sense"-model of the **general structure of performance** (Fig. 2), that fits for most of all sports disciplines. It is capable to integrate most of the scientific findings.

This is not the case, concerning the general abilities. Traitoriented dimensional analysis of the **general structure of motor abilities** have shown a great variety of results. In fact, one can say, that almost every study led to a different picture of the investigated ability. The structure of motor *coordination* for example is empirically determined by a variety from eight (Hirtz, 1964) over four (Schnabel, 1976) down to two dimensions (Roth, 1982; see Fig. 3).

The same situation exists in the field of *endurance*: None of the studies, that tried to analyze the endurance on the basis of the motor output, led to a consistent structure (see Fig. 4). Consistent findings exist only, if the endurance is investigated on a physiological level, that disregards the motor output.

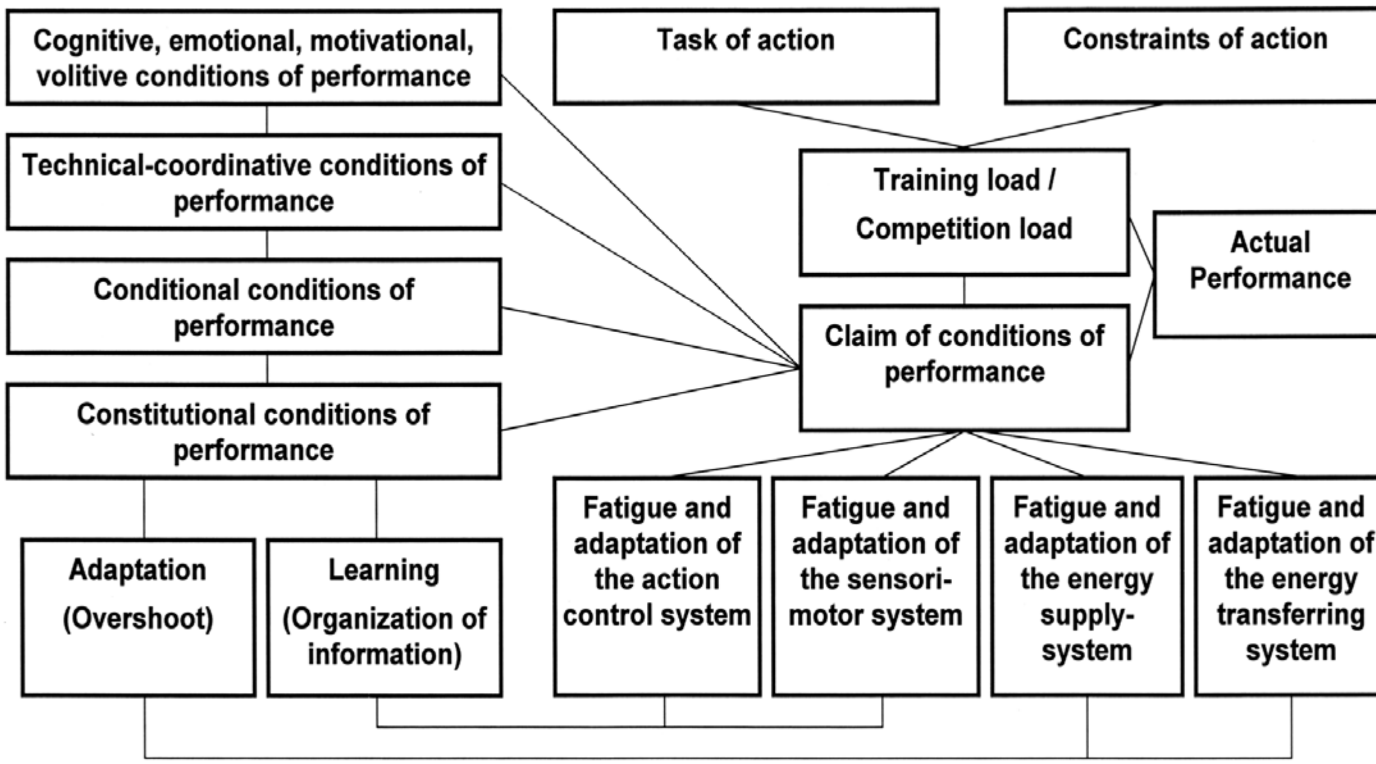


Figura 2 – The general structure of performance in sport (from Schnabel, 1994).

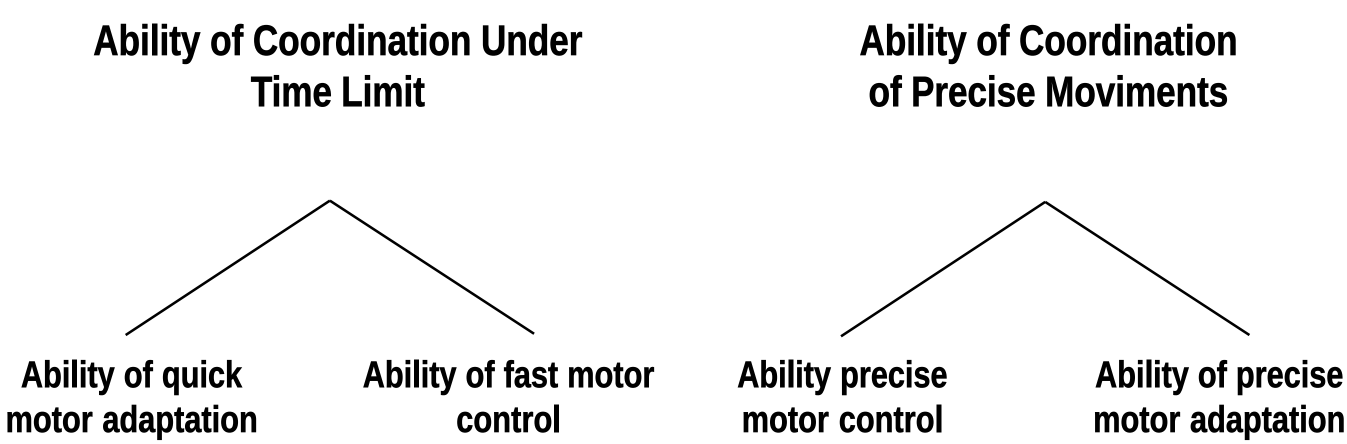


Figura 3 – Different structures of motor coordination (from Roth, 1982).

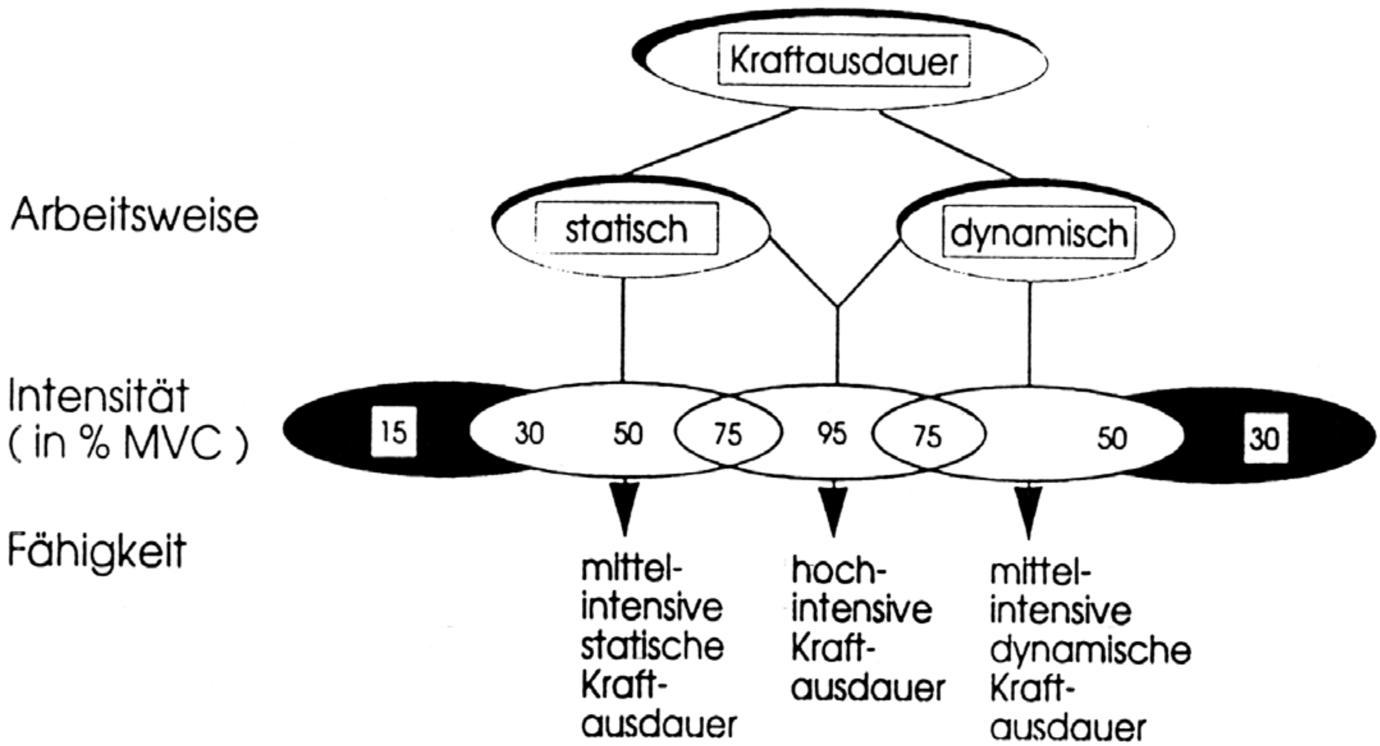


Figura 4 – Different structures of strength-endurance (nach Pach, 1990).

But besides the problem to create a plausible theoretical hypothesis for general motor abilities, there is still another reason for the different findings: each single performance in competition and in training creates a specific and single mixture of external load. This complex of demands is furthermore complicated by the variety of internal conditions of the athlete. Thus, in every single athlete an individual structure of conditions of a certain performance is created. Last but not at least, the interindividual structure of conditions and influences of performance vary within the individuals themselves from day to day. As a consequence, it does not seem to make sense any longer, to use a traitoriented paradigma and to analyze general abilities as conditions of performance.

But if not by general abilities, how then conditions can be defined, that have to be developed by training to reach a certain level of performance in sport? Deiss & Pfeiffer (1991) suggest a specific approach (see Fig. 5). They propose the analysis of the so-called *power-technique-complex.* It shows the relations between the specific abilities, which build the basis of a certain movement in a sports discipline. The model also contents the suitable aims of the training for each factor.

The power-technique-complex describes a set of external factors, which constitute a certain, in most cases a peak performance. The corresponding model, that describes the specific and aequevalent complex of internal biological conditions, is the so-called *functional movement-system,* which is described by Boiko (1990). The functional movement-system is a highly specific, but instable

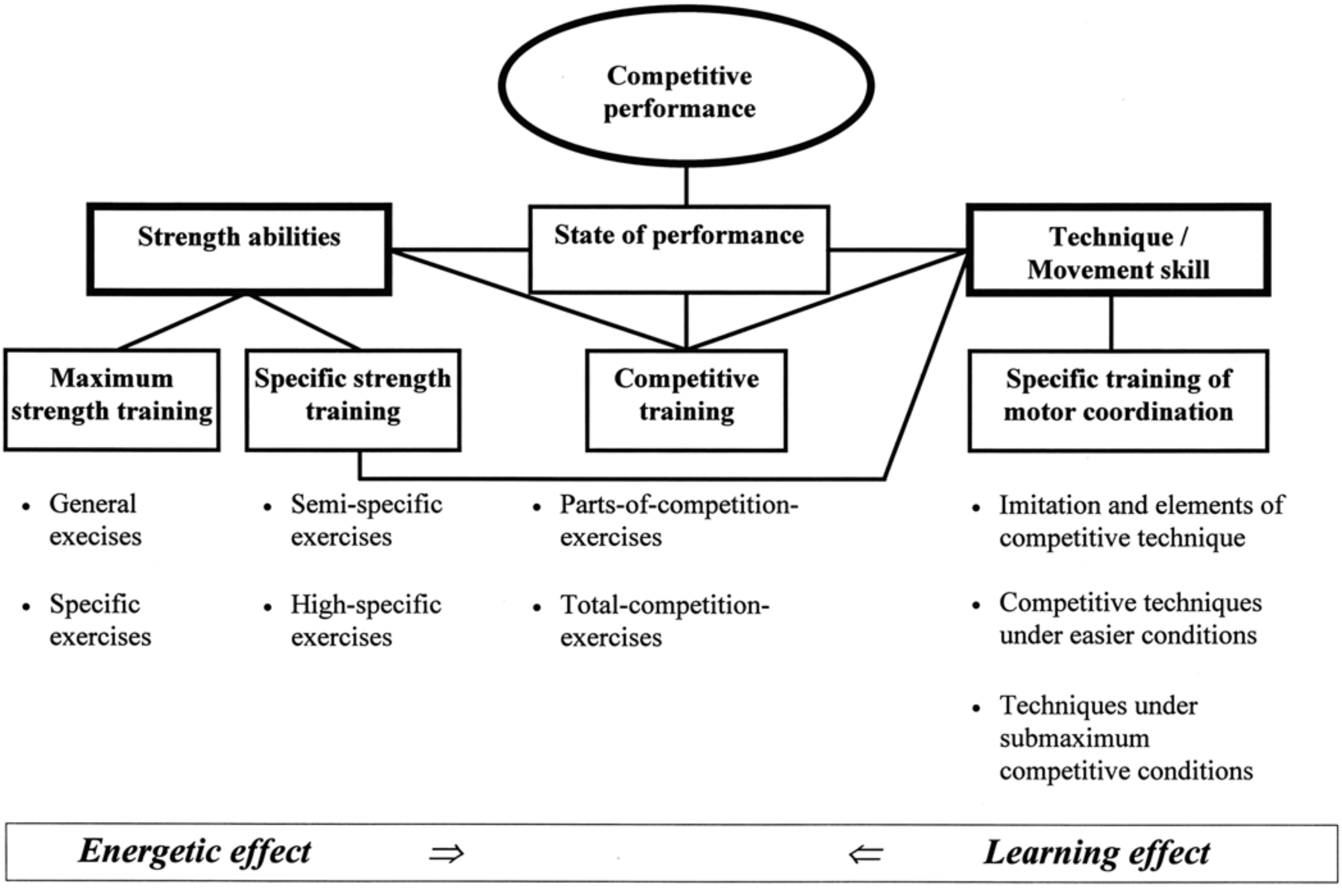
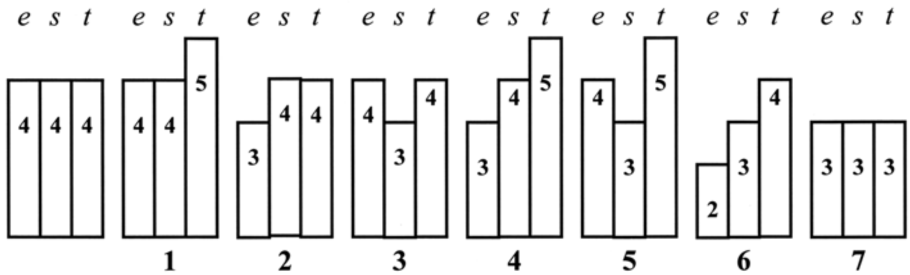


Figura 5 – General model of a Power-Technique-Complex in a non-cyclic sports discipline (Deiss & Pfeiffer, 1991, 72).

Table 1 – Classification of specific training drills (Boiko, 1990).

Drilltype 1:	The space- and energy-related model of the competion
Drilltype 2:	The space- and time-related model of the competition
Drilltype 3:	The energy- and time-related model of the competition
Drilltype 4:	The space-related model of the competition
Drilltype 5:	The energy-related model of the competition
Drilltype 6:	The time-related model of the competition

complex of an optimized consistency of the anatomic structures and an optimized level of physiological functions of the organism. It is built up in advance of a specific demand, which is expected in the future. To create an optimal level of the internal functional movement-system, it is necessary to train in a specific way, only. That means, that the *space-, time- and energy-related parameters* of the training load have to correspond closely with the future competition load. Therefore, Boiko (1990, 49-62) derives 7 classes of highly specific training loads, that help to create an optimal functional movement system (see Table 1and Fig. 6).



	The model of the competition
Drilltype 1	The space- and energy-related model of the competion
Drilltype 2	The space- and time-related model of the competition
Drilltype 3	The energy- and time-related model of the competition
Drilltype 4	The space-related model of the competition
Drilltype 5	The energy-related model of the competition
Drilltype 6	The time-related model of the competition
Drilltype 7	The complex model of a detail of the competition

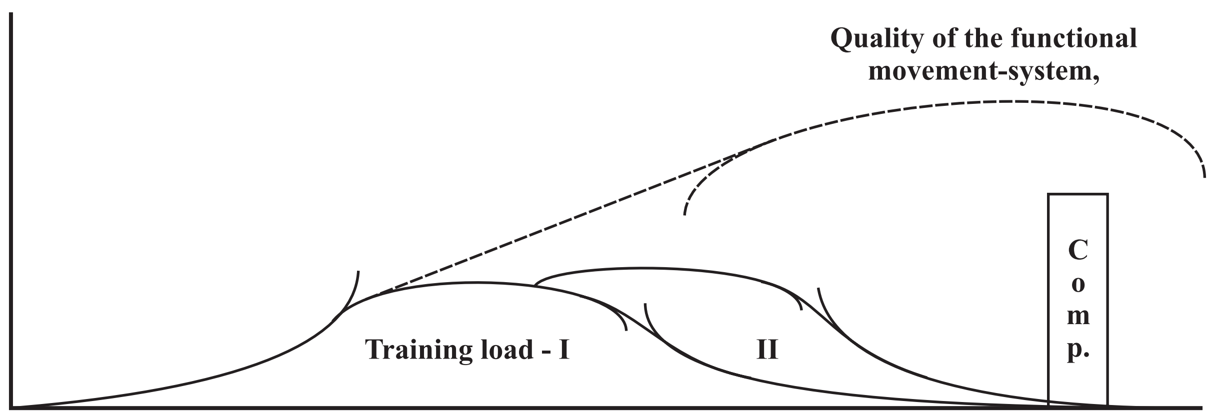


Figura 6 – The development of a prospective functional movement-system (from Boiko, 1990)

As Boiko (1990) suggests, a training process has to consist to a great extent of these seven types of drills and of the competition itself. Non-specific drills should be avoided or cut to a minimum. Thus, the training process will be more specialized and at the same time more intensive. As a consequence, an athlete needs a better basic condition, when he enters the high performance training stage.

2 – Research on training: From pre-post-measurement to serial single case-diagnosis

In order to optimize the training process, soviet training experts began in the 1950s to investigate the structure of training processes scientificly. Matwejew (1974) conducted studies on the structure of the training processes of soviet elite sportsmen and summarized his findings in a first model of the periodization of a training year. But very soon it became clear, that not only the structure of the training process is important for success, but also the results in the motor output of the athlete within the training process (see Fig. 7). The era of motor testing set in. Coaches and, of course, scientists too, wanted to know by pre- and post-tests, how the training load in the different phases of the preparation process of athletes had affected the level of particular abilities and of the competitive performance.

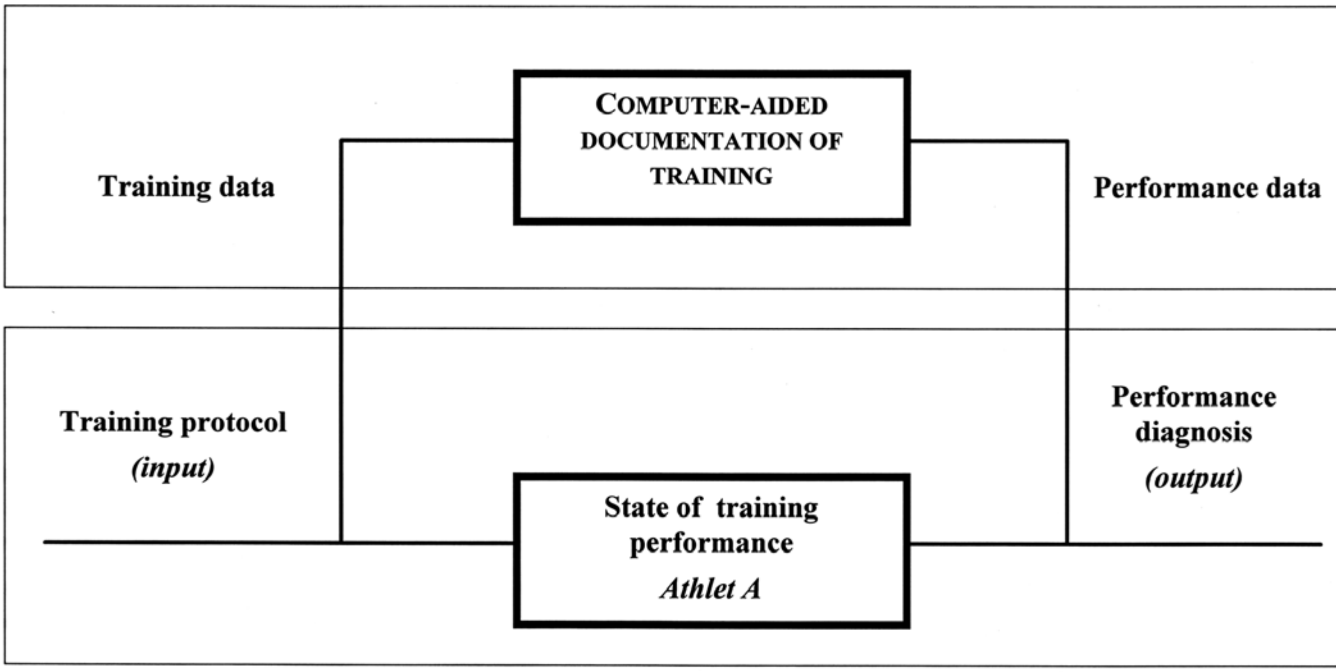


Figura 7 – Training controll as combination of diagnosis of training and diagnosis of performance (from Hohmann, 1994).

Two main difficulties can lower the value of the results: Firstly, in many cases the tests themselves are not reliable, so that progresses in performance can not be detected (Letzelter 1986). This problem gets by far more serious, if not group scores are controlled, but individual data. Secondly, even if highly reliable tests are used, one can not be sure, whether the chosen points in time are adequate (Neumaier & Rieder, 1992; see Fig. 8)

That unsatisfying situation caused two reactions: One was to develop more reliable tests, and to prefer primarily internal valid and more

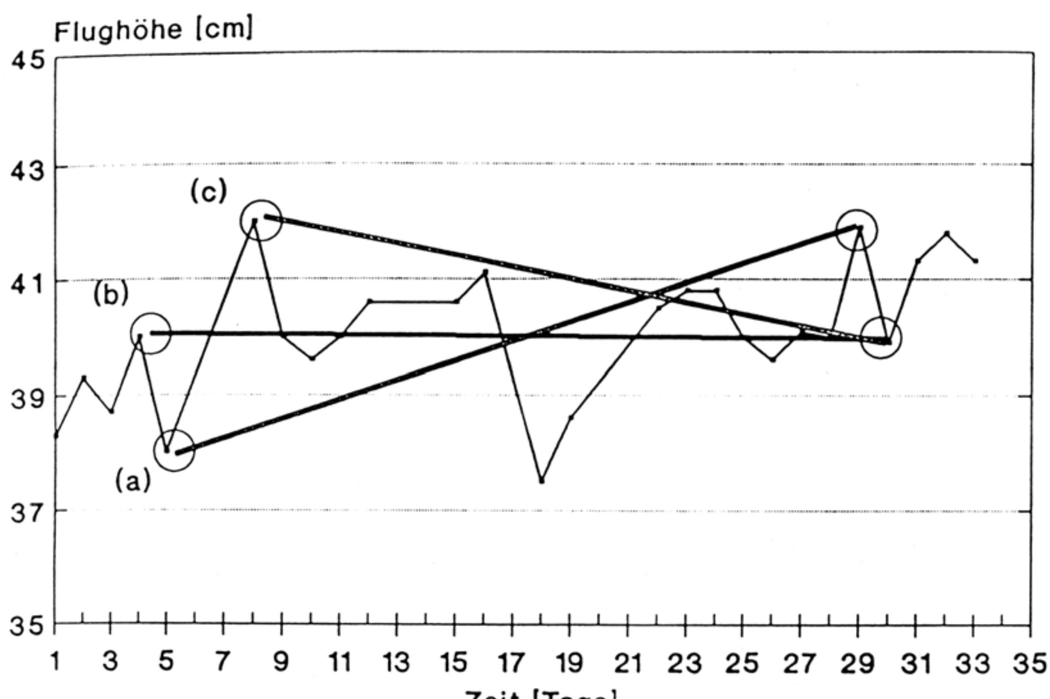
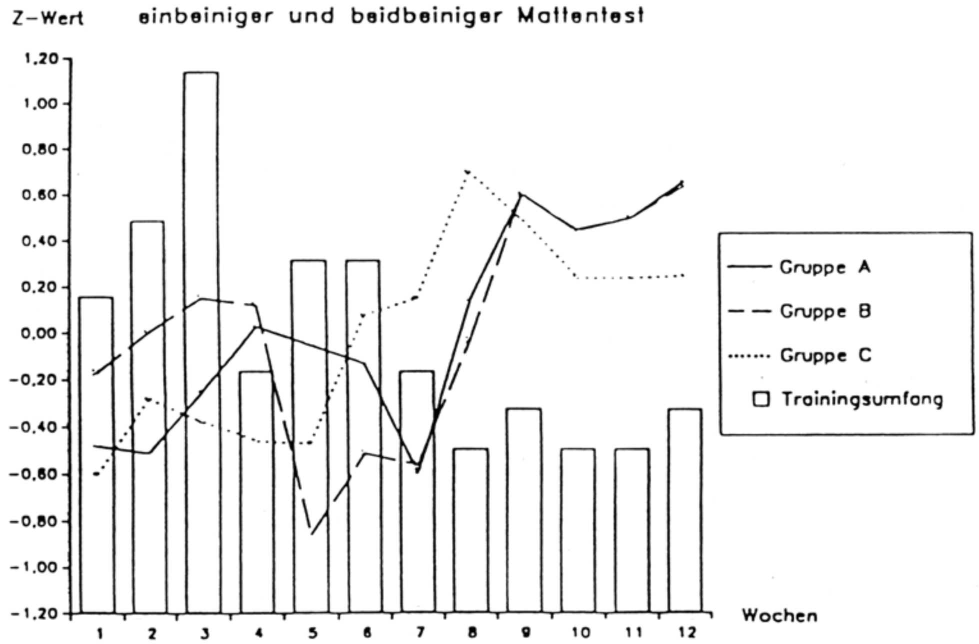


Figura 8 – The problem of pre- and post-testing in training control (Neumaier & Rieder, 1992).



Grupo A: "Techniker"
Grupo B: "Sprinter"
Grupo C: "Allrounder"

Figura 9 – Development of the index of reactivity during a preparational training process at different types of handballplayers (from Brack 1991).

reliable physiological and biomechanical tests - even if they do not clearify much variance of the complex performance in several sports. The other reaction was to interpret the processes of training and performance as time series, and to investigate their interaction by means of a bivariate analysis of the training effects. Therefore, training data (input) and performance data (output) have to be collected frequently. Then they have to be analyzed as single case-data.

Sometimes one can see differences between certain types of athletes only by looking at the graphs of training load and performance (see Fig. 9).

Advanced studies investigate the time of delay in the adaptation of certain types of athletes after a certain amount of training load. We used this strategy during the preparation of the west german national team in waterpolo for the 24th Olympic Games in Seoul, 1988. By means of a regression analysis of the two time series (training load as independent and performance as dependent variable) we found out, that there were different types of players. The two types showed differences in the delay of a cumulative training effect (see Fig. 10).

Conditioning training
Players with an early short-term delay

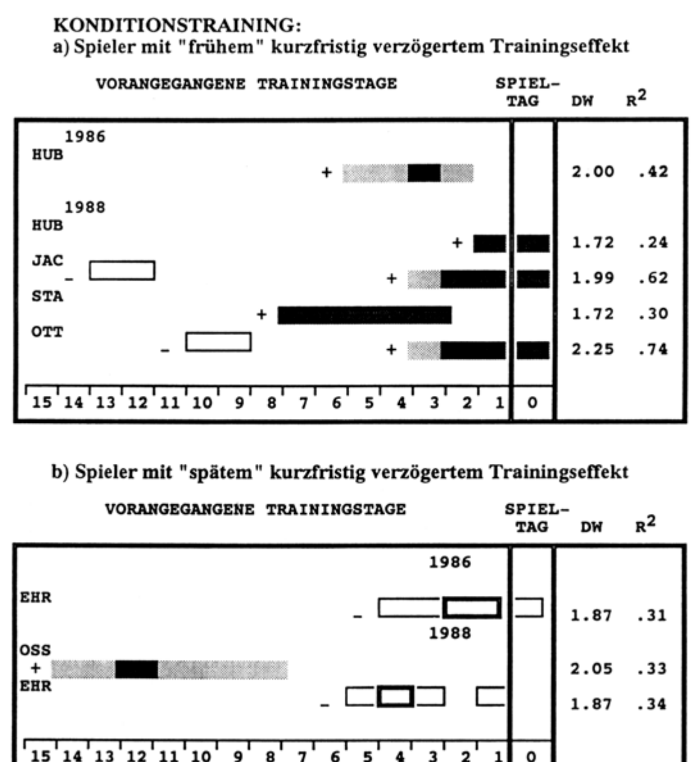


Figura 10 – Individual short-term delays in the development of peak performance depending on the amount of daily training load in elite waterpolo players (Hohmann, 1994).

One of the main problems in elite sports is to get all athletes of a training group in best shape at the same time. If the coach knew the individual characteristics of the delay of the adaptation of his athletes, he would be able, to plan and monitor the training process for each individual more precisely. Thus, there is a better chance to reach peak performance at the right time.

3 –Research on competition: From analyzing the performance to simulating the successful strategy

In many sports disciplines, even at the highest level of performance, a lot of athletes have reached similar peak performances. So, winning does not only depend on the right shape in the right moment, but also on the right tactical strategic behaviour in the right situation.

Especially in fighting sports and in the sports games the right strategy is decisive and superior to all other factors of the performance (compare fig. 2). In order to create a successful strategy and to develop an effective behaviour of the own team, coaches assess selected fights or games in order to find out weak points and strong aspects in the tactical behaviour of the upcoming opponent.

Coaches primarily look at the weaknesses of the opponent, that appear in certain types, areas or phases of the interaction with another team. In opposition to that, training scientists still list the observed items of the behaviour within the fight or game without regarding the stream of interaction ot the parties. The scientific approach is similar to the referees calculation of the result of the fight resp. the game. Very often this poor and simple procedure is already used by the official game observers of the clubs or federations, sometimes even by the press.

	ABA	ABB	FAA	FAB	ZUA	ZUB	ANA	ANB	BLA	BLB	PUA	PUB
AUA		89.2									1.8	9.0
AUB	92.8										7.2	
ABA					94.8		1.3	2.6				1.3
ABB			2.0			91.9	2.0	2.0			2.0	
FAA				2.6	72.7		5.2	3.9				15.6
FAB			3.1			64.6	6.2	7.7	3.1		15.4	
ZUA				0.8			97.7	0.8				0.8
ZUB			0.8				0.8	96.2			2.3	
ANA				25.2						33.1	30.2	11.5
ANB			30.5						48.9		11.3	9.2
BLA			27.1	18.6						1.4	20.0	32.9
BLB			19.1	29.8			2.1				36.2	12.8

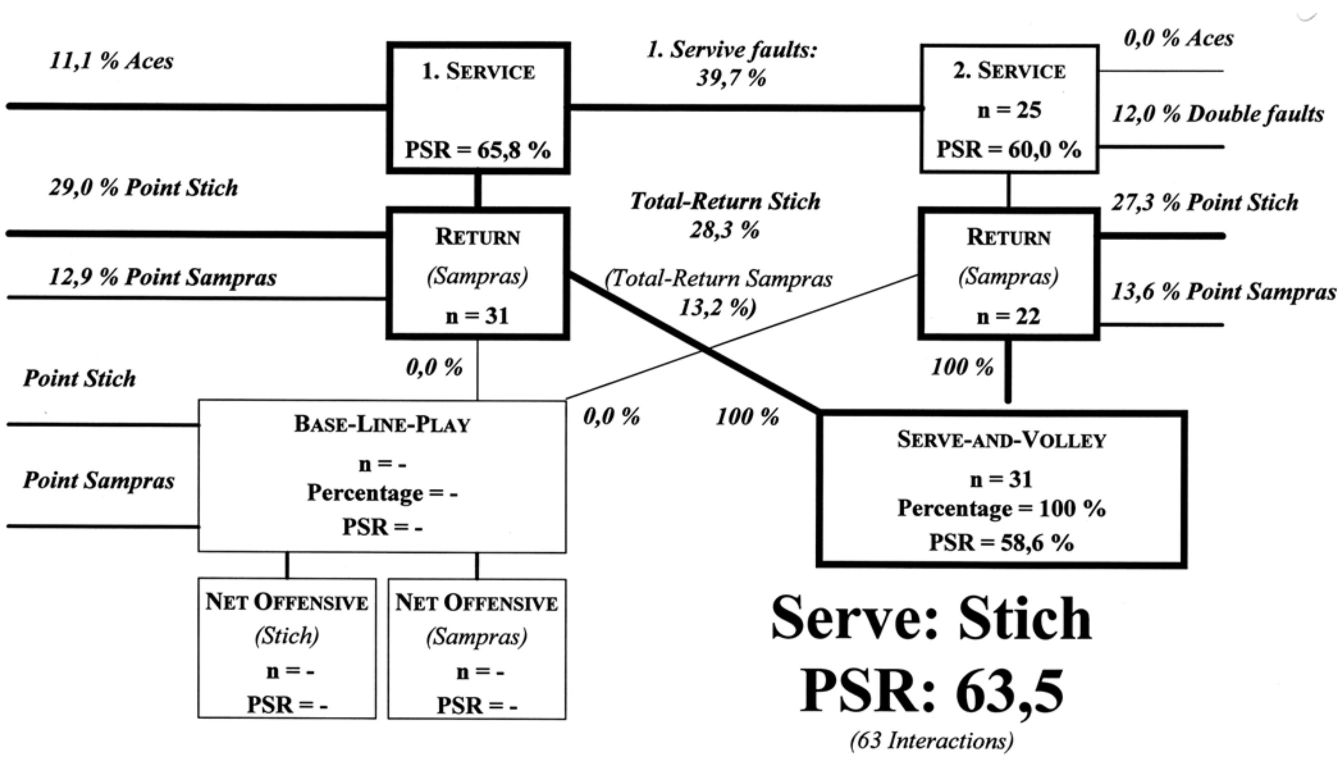
Figura 11 – Probabilities of making the point in a transition matrix of the volleyball match Germany vs Cuba at the Bremen Cup 1995 (Lames & Hohmann, 1997).

For a scientific approach in tactical analysis and game preparation, another system seems to be more adequate. It reflects the behaviour of both parties in the original and oscillating stream of interaction. Lames (1991) describes the stream of interactions in sports games by means of the mathematical model of a Markov-chain. In a first step, the game is devided into certain states. Then the probability of the transitions within the game from one state into the possibly following next states are calculated. This procedure leads at the end to the final probability for the win of the game for both parties, the winner and the looser. Fig. 11 shows the probabilities of the transitions in a volleyball game between the womens national teams of germany and cuba.

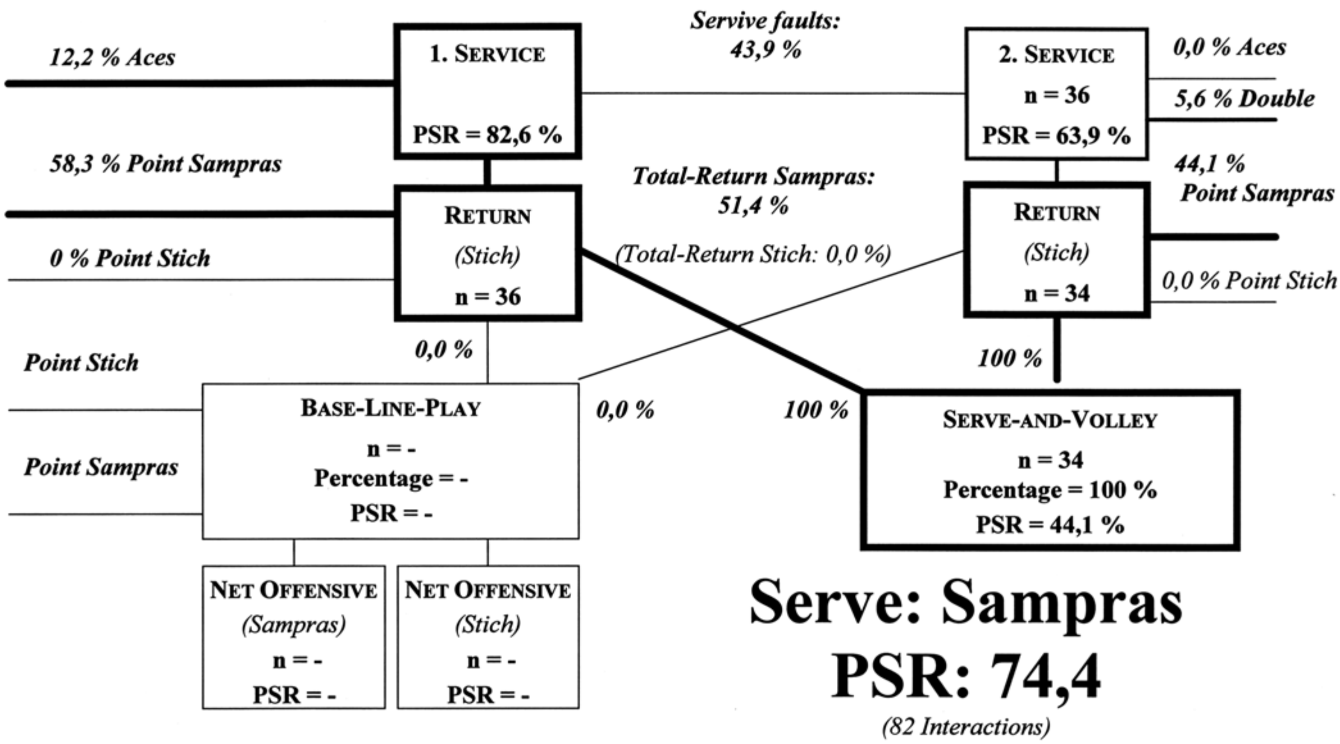
The matrix starts with the serve of team A (AUA), which leads in 89.2 percent of all cases to a reception of team B (ABB). Only 1.8 percent of the serves lead to an ace (PUA), in 9.0 percent team B gets the point (PUB; which means the right to serve). After the reception of team B, 91.9 percent of the balls go to the playmaker of the own team and result in a set (ZUB), only a few lead immediately to an attack of the own (ANB) or the opposite team (ANA). The attack can be followed by a block (BL A/B) or a defensive action in the field (FA A/B).

The main advantage is, that now one can change virtually the probabilities of the transitions between two interesting states. At the same time, the tactical behaviour of the opponent will be regarded by the mathematical model. So the probable influence of each action on the winning probability can be calculated. The simulation of the winning strategy can be based on the variation of the probability of the success of single *actions (states)* or on the variation of the probability of success of single *players*. Both strategies can be applied on the own and also on the opponent team. Fig. 12 shows, how a successful strategy could be developed for a tennis game between Becker and Sampras.

Figura 12 – Transition probabilities between the states of the wimbledon final in tennis between Becker and Sampras (from Lames, 1994).



Continuação da Figura 12.



REFERENCES

BALLREICH, R.: **Weg- und Zeit-Merkmale von Sprintbewegungen**. Berlin: Bartels & Wernitz, 1969.

BERGER, J.; Minow, H.-J.: **Der Mikrozyklus in der Trainingsmethodik**. In: Theorie und Praxis der Körperkultur. 33, 8, 133-140. 1984.

BERGER, J.; Minow, H.-J.: **Der Mesozyklus in der Trainingsmethodik**. In: Theorie und Praxis der Körperkultur. 34, 5, 373-381, 1985.

BERGER, J.; Minow, H.-J.: **Der Makrozyklus in der Trainingsmethodik**. In: Theorie und Praxis der Körperkultur. 36, 1, 50-60, 1987.

BOIKO, V. V.: **Die gezielte Entwicklung der Bewegungsfähigkeit des Sportlers**. Frankfurt/Main: Deutscher Sportbund/ Bundesausschuß Leistungs-sport, 1990.

BÖS, K.; Mechling, H.: **Dimensionen sportmotorischer Leistungen**. Schorndorf: Hofmann, 1983.

BRACK, R.: **Zu Struktur und Wirkung der Vorbereitungeperiode im Handball**. In: Hamsen, G. (Red.): Sport an Hochschulen. Forschung, Lehre, Hochschulsport. Heidelberg: Universität Heidelberg/Institut für Sport und Sportwissenschaft, 6-28, 1991.

BÜHRLE, M.; Schmidtbleicher, D.: **Komponenten der Maximal-und Schnellkraft. Versuch einer Neustrukturierung auf der Basis empirischer Ergebnisse**. In: Sportwissenschaft. 11, 1, 11-27, 1981.

DEISS, D.; Pfeiffer. U.: **Leistungsreserven im Schnellkrafttraining**. Berlin: Sportverlag, 1991.

DJATSCHKOV, W. M.: **Die Steuerung und Optimierung des Trainingsprozesses**. Berlin: Bartels & Wernitz, 1974, 1977².

FUCHS, U.; Reiß, M.: **Höhentraining**. Münster: Philippka,1990.

GOLLHOFER, A.: **Komponenten der Schnellkraftleistung im Dehnungs-Verkürzungs-Zyklus**. Erlensee: Sport Fitness Training, 1987.

GROSSER, M.: **Psychomotorische Schnellkoordination**. Empirische Untersuchungen über Sprintverhalten. Schorndorf: Hofmann, 1976.

HARRE, D.: **Trainingslehre**. Berlin: Sportverlag, 1974, 1979[8].

HIRTZ, P.: **Zur Bewegungseigenschaft Gewandtheit**. In: Theorie und Praxis der Körperkultur. 13, 8, 729-735, 1964.

HOHMANN, A.: **Grundlagen der Trainingssteuerung im Sportspiel**. Hamburg: Edition Czwalina, 1994.

HOHMANN, A.; Brack, R.: **Theoretische Aspekte der Leistungsdiagnostik im Sportspiel**. In: Leistungssport. 13, 2, 5-10, 1983.

LAMES, M.; Hohmann, A.: **Zur Leistungsrelevanz von Spielhandlungen im Volleyball**. In: Koch, P. (Hrsg.): Integrative Aspekte in Theorie und Praxis der Rückschlagspiele. Hamburg: Edition Czwalina, 121-128, 1997.

KINDERMANN, W.; Keul, J.: **Anaerobe Energiebereitstellung im Hochleistungssport**. Die Bedeutung der metabolischen Azidose unter physiologischen und pathologischen Bedingungen. Schorndorf: Hofmann, 1977.

KUSNEZOW, W. W.: **Kraftvorbereitung**. Berlin: Sportverlag, 1972.

LAMES, M.: **Leistungsdiagnostik durch Computersimulation**. Ein Beitrag zur Theorie der Sportspiele am Beispiel Tennis. Frankfurt/M.: Thun, 1991.

LAMES, M.: **Systematische Sielbeobachtung**. Münster: Philippka, 1994.

LETZELTER, M.: **Sprinteigenschaften, Wettkampfverhalten und Ausdauertraining von 200m-Läuferinnen der Weltklasse**. Ahrensburg: Czwalina, 1975.

LETZELTER, M.: **Zur Theorie des 400-m-Laufs**. Niedernhausen: Schors, 1979.

LETZELTER, M: **Leistungsdiagnostik: Beispiel Eisschnellauf.** Niedernhausen: Schors, 1983.

LETZELTER, M.: **Möglchkeiten und Grenzen der sportmethodischen Leistungsdiagnostik**. In: Mechling, H.; Schmidtbleicher, D.; Starischka, S. (Red.): Aspekte der Trainings- und Bewegungswissenschaft. Motorisches Lernen - Leistungsdiagnostik - Trainingssteuerung. dvs- Protokolle Nr. 22. Hamburg: Deutsche Vereinigung für Sportwissenschaft, 143-177, 1986.

LIESEN, H.; Hollmann, W.: **Ausdauersport und Stoffwechsel**. Schorndorf: Hofmann, 1981.

MATWEJEW, L. P.: **Periodisierung des sportlichen Trainings**. Berlin: Bartels & Wernitz, 1974, 1978[3].

MATWEJEW, L. P.: **Grundlagen des sportlichen Trainings**. Berlin: Sportverlag, 1981.

NEUMAIER, A.; Rieder, M.: **Zur Kontrolle konditioneller Leistungskomponenten**. In: Appell, H. J.; Mester, J. (Hrsg.): Erfassen und Messen sportlicher Leistungen. Sankt Augustin: Academia, 22-64, 1992.

PACH, M.: **Empirische Untersuchung zur Abgrenzung verschiedener Kraftausdauerfähigkeiten**. München: Universität München (Dissertation), 1990.

ROTH, K.: **Strukturanalyse koordinativer Fähigkeiten**. Wiesbaden: Limpert, 1982.

SCHNABEL, G.: **Die Bewegungskoordination - Grundablauf und Erscheinungsformen in der Bewegungstätigkeit des Sportlers**. In: Meinel, K.; Schnabel, G. (Red.): Bewegungslehre. Berlin: Sportverlag, 59-220, 1976.

SCHNABEL, G.: **Grundkonzept ''Sportliche Leistung"**. In: Schnabel, G.; Harre; D.; Borde, A. (1994): Trainingswissenschaft. Leistung, Training, Wettkampf. Berlin: Sportverlag, 33-92, 1994.

SCHNABEL, G.; Harre; D.; Borde, A.: **Trainingswissenschaft. Leistung, Training, Wettkampf**. Berlin: Sportverlag, 1994.

SCHMIDTBLEICHER, D.: **Maximalkraft und Bewegungsschnelligkeit**. Wiesbaden: Limpert, 1980.

VERCHOSHANSKIJ, J. V.: **Effektiv trainieren**. Berlin: Sportverlag, 1988.

VERCHOSHANSKIJ, J. V.: **Ein neues Trainingssystem für zyklische Sportarten**. Münster: Philippka, 1992.

VERCHOSHANSKIJ, J. V.: **Ein neues Trainingssystem für azyklische Sportarten**. Münster: Philippka, 1995.

WILLIMCZIK, K.: **Leistungsbestimmende Merkmale der 110-m-Hürdentechnik**. Ein Beitrag zur Bewegungslehre und Trainingslehre der Leibesübungen. Berlin: Bartels & Wernitz, 1972.

ZACIORSKIJ, V. M.: **Die körperlichen Eigenschaften des Sportlers**. Berlin: Bartels & Wernitz, 1972, 1977[3].

ENDEREÇO PARA CORRESPONDÊNCIA:

Prof. Doutor ANDREAS HOHMANN
Institute of Sport Science
Otto-von-Guericke-University of Magdeburg
Alemanha.