Selected Problems and New Approaches to Movement Quickness[1], and Consequences for Its Training Methodology

By Prof. Monika Bauersfeld, Ph.D.

Translated by James Major, Davis Diamonds Gymnastics

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Abstract: For the past few years, the scientific investigation of quickness as a physical ability has lagged behind that of strength and endurance. On one hand, quickness is a prerequisite for performance, but on the other, the fundamental scientific laws remain to be discovered that reveal consequences for training methods. In particular, there is demonstrating that an elementary ability exists, that is called quickness, that is not determined by other abilities, and whose expression is distinct in a time pattern. From an inter-disciplinary investigation of an example, drop-jumping, first consequences are considered for responsible application in further development of quickness.

1. Problem Statement

Over the past years, the fundamental trend became ever more apparent that a better athletic performance can be performed in the same or even shorter amount of time. This also indicates that training is more effective. In particular, a consistently stronger focus on the specific requirements of an athletic performance is thought to be a dominant cause of this development. This is most apparent there where there has been progress in clarifying the structure of the performance. In these cases, a deeper insight into the individual prerequisites for performance, and their explicit development, is moving ever more to the forefront. Where available knowledge and discoveries are insufficient, deductions are insufficiently founded to successfully train according to the specific requirements for further performance development. Instead, certain performance determining factors become limiting for further development. Recently, quickness has become this kind of limiting element in many cases, as well as for future development. The causes of insufficient quickness development are, above all, insufficient insight into the principles upon which the development of quickness is

[1] Translator's note: for reasons that will become apparent from the following research results, the German word "Schnelligkeit", usually translated as the English "speed", has been translated here as "quickness".

founded, but also in insufficient application into practice of what is known. Here, we agree with W.-D. Heß, citing Farfel', that, "Nevertheless, we still don't have a grasp on quickness as a movement quality from the standpoint of the compliance of the skeleton and connective tissues or the activity of the nerve processes. In this case, the theory and practice of sports has as good as no internal parameters available. Therefore, the choice of means and methods is made more difficult" (Heß, 1984).

Previous research leads to conclusions that,

- The scientific research on the physical ability "quickness" is behind that of endurance or strength;
- "Quickness by itself" does not exist, or that "quickness of an individual movement" and "power" are synonymous. (Particularly often, "quickness" and "sprinting" are treated as equivalent).
- Advice is contradictory on how and when quickness can be identified and then possible to develop. (General rules and principles can barely be given, illustrating the fact that basic principles are not yet known, or insufficiently formulated).

Insight into the structure of quickness is apparently more difficult to gain than into other physical abilities. A majority of authors immediately turn towards compex examples of quickness in performances and away from inner mechanisms or limiting causes. This leads to the conclusion that without a deeper insight into the mechanisms, no further progress in development can be expected. From this point of view, in the following we will present a way of making further progress. However, we emphasize that quickness is just one factor in athletic performance. Treated by itself, we must always take into account the role of quickness in the overall system of performance factors and their development.

The potential level of athletic performance is determined, above all, by the state and functional potential of human organ systems (in particular the nerve-muscle system with its central and peripheral parts, the respiratory, and circulatory systems, among others). Depending on how the body is working during athletic training and competitions, specific forms of reciprocal effects occur between systems, the sub-coordinative systems. In particular, insights into the structure of the physical abilities, the structure's components, and conditions for its development, become key questions (depending on the role of these factors in most athletic performances). From the point of view of training methodology, differentiating between the physical abilities is of basic importance for achieving a high degree of purposeful integration. Each ability, and each of its components, is based on its own fundamental rules and thereby on a relative proprietary system of development. This understanding is a prerequisite for a successful study of the complex of prerequisites for performance, for the choices of emphasis in the development process, as for the long-term development of performance, and the absolutely necessary greater integration. Here, it seems appropriate to adopt the approach of Verchoshanskij and Tatjan (1973) who chose the concept of “elementary forms of physical abilities”. Verchoshanskij formulated the following theses concerning power:

1. The elementary forms of motor abilities function independently and cannot be transformed into other abilities.
2. Ability-specific methods are necessary to develop a motor ability.
3. The transformation of the motor abilities during athletic performances is made by certain forms of functional reciprocal effects (structure) between elementary abilities, that are required in every case, and which are developed only with an activity specific to the motor apparatus appropriate to the athletic movement.

Accepting these theses includes the idea that they support a requirement to differentiate or identify the elementary abilities and their components, and are not just valid for power. We assume that elementary abilities are an absolute requirement for achieving high, athletic performance, but not by themselves sufficient. If Verchoshanskij’s first and second positions are valid, then unrecognized elementary abilities can hardly have the specific methods necessary for their development. In many publications, power is characterized as a complex physical ability. When, on the basis of this characterization, the power ability, and the power performances that are based on it, are mainly determined by a strength and a quickness component, then quickness itself must be an elementary motor ability, in other words independent of other abilities. This then is evidence of an important prerequisite for further progress of training theory and thereby an important condition for improving the development of quickness.

Given the idea that power performances have a strength and a quickness component, the present research looks at evidence that there is an element in powerful movements that is relatively independent from strength. In research by Verchoshanskij, Kirchgässner and Wagner, Ionov and Oreshcuk, Satajkin, Persugjan and Farfel’, Bothmischel and Halbing among others, phenomena are presented that are independent of the size of the resistance and constant in time. Hochmuth and Gundlach support this position, “Increasing muscular strength is, on the one hand, necessary to increase power in a competition exercise, but on the other, not sufficient.” This implies that in powerful movements there is an independent component that has a performance determining importance, but by itself is not sufficient for high power performances. This phenomenon is given the working title “time pattern”, which includes the duration of a movement (main phase), as well as sequence, and strength of the impulses. The assumption is that in a time pattern, there is a quickness component, or even quickness itself.

The next task is to demonstrate that there exists a component in power performances that meets the requirements of an elementary component, in other words a performance determining component that is not determined by the level of strength and that is expressed in a certain time pattern. Proof of such a component, and it's biological mechanisms in more detail, is required for its development. Given this point of view, we abandon the current concept of quickness and formulate the following working concept: quickness is an elementary ability prerequisite for performance, in order to make certain actions, in certain conditions, with certain time patterns. Quickness is mainly influenced by neuro-muscular control mechanisms and its level of development is reflected in movement-specific time patterns. Within motor actions, quickness always acts together with other performance prerequisites, and is influenced by its level of development (Bauersfeld, 1982).

2. Selected Experimental Results from Basic, Applied Research

The multi-layered and complex problem of quickness, as well as the research technology available for the desired interdisciplinary approach, did not permit investigating an example of a complicated competition exercise. Therefore, interdisciplinary research was made on the drop-jump, a relatively simple, but obvious power movement that can be objectively studied. The choice of drop-jump, where the subject is given the task of jumping as high as possible immediately after landing from a drop downwards, was made from the following considerations. Deceleration-acceleration movements occur in many athletic skills. They are characterized by common traits, as well as specifics related to the task. Its level of development influences the results, in some cases a lot. A drop-jump is a typical counter-movement exercise; first slowing, then accelerating. Without ignoring the part that is specific to the task, we may expect that information about quickness gained from this example can be widely generalized. Biomechanical research methods were used (force-plate dynamometer[2], high frequency kinematography, and research methods to objectify neuro-muscular processes (electro-myography))[3].

The focus was on the following questions, among others:

- What role does the time pattern play in power performances?
- What is the relationship between the time pattern and strength?
- Which performance determining internal processes are the basis of the time pattern?

Ground contact time was used as expressing the time pattern that characterizes the power ability. The strength ability was evaluated as the maximum force exerted during the course of the acceleration phase because it is assumed that the level of the

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[2] The investigations using force-plate dynamometers were performed together with the Biomechanical Laboratory of the FKS under the direction of M. Knauf.

[3] The electro-myographic investigations were made together with the Physiology Dept. of the DHfK under the direction of G. Wittekopf.

maximum force reflects the strength abilities of a subject. Peak power during the acceleration phase was used as a measure of the complex performance.

Subjects made three attempts from five different drop heights (23 cm, 38 cm, 68 cm, 88 cm, and 108 cm) each, down onto the force-plate. These different drop heights were chosen in order to clarify the role of strength during the deceleration phase as the experiment technology did not permit the maximum force during the deceleration phase to be quantified. The hypothesis was that differences in performance would be characterized by different time patterns, among other factors, and that its degree of expression would not be primarily determined by the level of strength.

Ground contact times showed a great deal of variation between subjects. These ranged between a minimum of 110 ms [millisecond or thousandth of a second] to a maximum 257 ms. Graphs of the force-time data consistently showed just two kinds of curve: the typical single peak or the two-peaked curves frequently described in the literature. Single peak force-time curves only occured during ground contact times up to 170 ms, while two-peak force-time curves first appeared with ground contact times longer than 170 ms (Fig. 1). Consequently, we divided ground contact times into shorter and longer ground contact times, or shorter and longer time patterns.

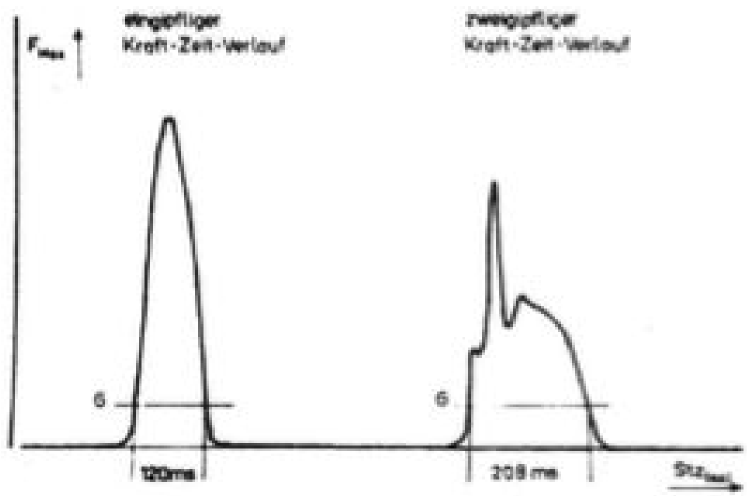
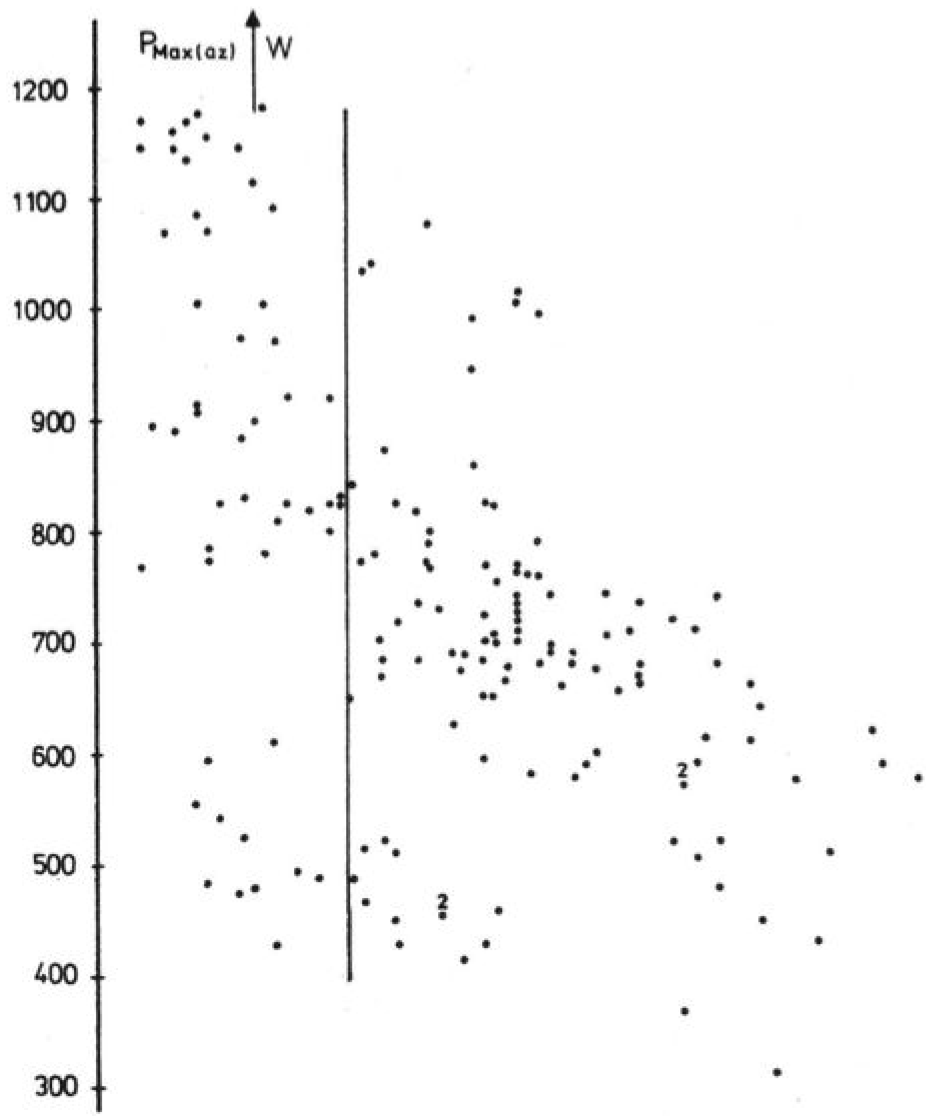


Fig. 1. Typical single peak (left) and double peak (right) force-time curves.

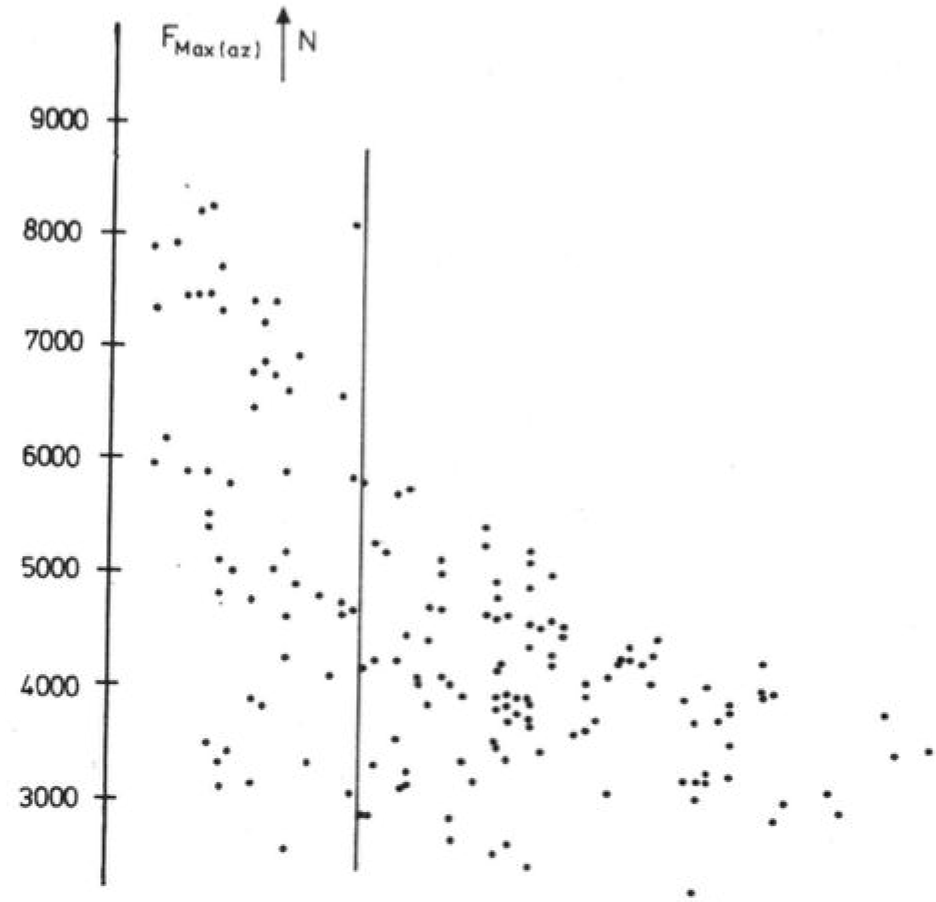
Fig. 2. shows that the highest power maximums are only produced in the short time pattern and high power maximums are not seen in the longer time pattern. But we also see that the shorter time pattern can be made with low power maximums. Consequently, the shorter time pattern is a necessary, but not sufficient, prerequisite for high power performance. This underlines the opinion stated before that, on the basis of a single performance prerequisite, even in the case of above average expression, high

performances are not possible. High power maxima require high force maxima during the acceleration phase, in addition to a shorter time pattern.This conclusion



Shorter time pattern (up to 170 ms) Longer time pattern (from 171 ms)

Fig. 2. The relationship between power maximum and time pattern. [Each data point is a trial].



Shorter time pattern (up to 170 ms)

Longer time pattern (from 171 ms)

Fig. 3. The relationship between maximum force and time pattern. [Each data point is a trial].

is also supported by comparing male and female subjects. There were no principle differences between the measured ground contact times, however the power maximums of the women were significantly different from those of the men (Table 1).

Table 1. Mean ground contact times (ms) and mean power maxima in Watts (W) of selected male and female subjects.

Male		Female	
Ground contact time (ms)	Maximum Power (W)	Ground contact time (ms)	Maximum Power (W)
126	902	122	462
131	910	122	496

148	844	149	471

Given that the ground contact times of males and females were not principally different, we conclude that power performances are determined by two, relatively independent, components. The greater power maximums of males obviously come from higher forces exerted during equivalent time patterns. Therefore, the degree of expression of the strength abilities does not fundamentally influence making a shorter or longer time pattern. The shorter time pattern is possible with peak forces of 3000 Newtons [N] as well as 8000 N (Fig. 3).

Considering ground contact times in different external conditions, for example drop-jumps from different heights, it appears that the shorter time pattern by the same subject occurs during lower as well as higher drop heights (Table 2). This is important to the extent that, as drop height increases, deceleration forces significantly increase. Thereby, some subjects experienced [deceleration forces] of 15 to 20 times their body mass. Nevertheless, the individual time pattern remained relatively stable.

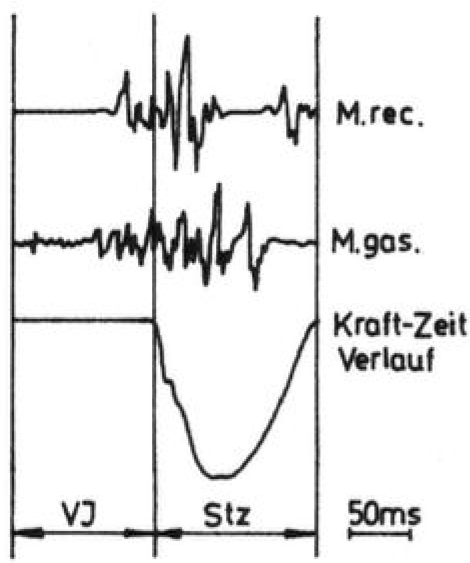
Table 2. Mean ground contact times (ms) from various drop heights by selected subjects.

Subject	Time pattern			Drop Height		
		23 cm	48 cm	68 cm	88 cm	108 cm
D	shorter	113	127	125	124	127
H	longer	188	204	307	194	200
R	Shorter /longer	114	129	165	175	187

A number of the subjects were able to consistently make the shorter time pattern, even in very different external conditions, while other [subjects] consistently made the longer time pattern. Another group of subjects studied made the shorter time pattern from lower drop heights and the longer time pattern from the higher drop heights. The inverse phenomenon never occurred [e.g. longer time pattern from lower drop heights and the shorter time pattern from the higher drop heights].

The data from the electro-myographic investigation were the recorded bioelectric activity of four muscles. Among them, the m. gastrocnemius and the m. rectus femoris fit the description of prime movers according to Wittekopf (1978) and Ratov (1963). In summary, the different time patterns are influenced to a great degree by neuro-muscular control processes. The inter-muscle coordination between those two muscles was investigated. These processes were reflected in different activation patterns of the m. gastrocnemius and m. rectus femoris during the shorter and longer time patterns of the investigated exercise. The activation of the m. gastrocnemius was characterized by the fact that its activation during the shorter time process was not interrupted by phases with lower activation during the pre-innervation and the ground contact time (Fig. 4). By the end of the pre-innervation there followed a distinct increase in activity, a high peak amplitude of the m. gastrocnemius was produced, demonstrating an optimal coordination between the m. gastrocnemius and m. rectus femoris. In the case of the longer time pattern, the activation pattern of the m. gastrocnemius

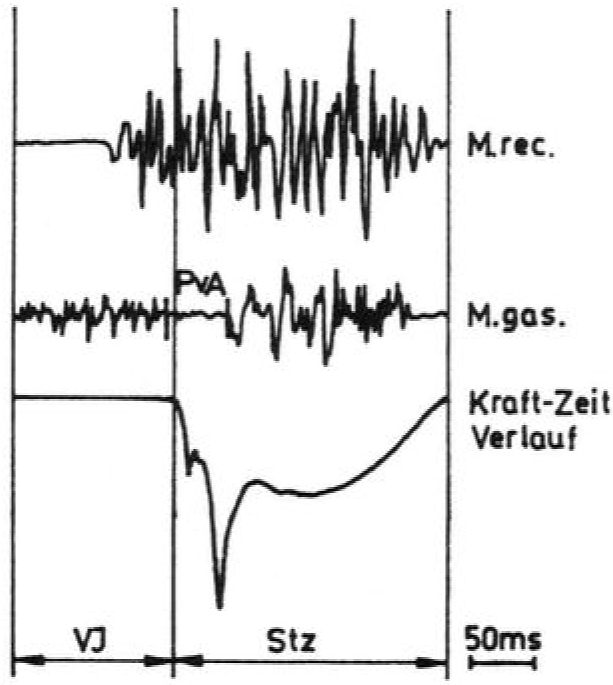
Fig. 4. Typical activity of the m. rectus femoris and m. gastrocnemius during the shorter time pattern. The upper most line traces the electrical activity of the m. rectus femoris [M.rec.]. The middle line traces the electrical activity of the m. gastrocnemius [M.gas.]. The lowest line is the force-time curve, pointing downward for an increase in force [Kraft-Zeit-Verlauf]. The left hand side shows the pre-innervation phase (VI) and the right hand side the ground contact time (Stz).



effort is interrupted by a phase with less activation. In some cases, this occurs during the pre-innervation, but always by the beginning of the ground contact time (Fig. 5). Moreover, an optimal coordination between muscles is not achieved.

Fig. 5. Typical activity of the m. rectus femoris and m. gastrocnemius during the longer time pattern. The upper most line traces the electrical activity of the m. rectus femoris [M.rec.]. The middle line traces the electrical activity of the m. gastrocnemius [M.gas.]. The lowest line is the force-time curve, pointing downward for an increase in force

[Kraft-Zeit-Verlauf, with the typical double peaks]. The left hand side shows the pre-innervation phase (VI) and the right hand side the ground contact time (Stz).



According to current neuro-physiology, quick movements are controlled by programs, in other words they run according to a previously existing program stored in the central nervous system. Given its duration, the exercise studied here should be classified as such [a quick movement]. Nevertheless, the results show the existence of two, different time patterns. In the case of the shorter time pattern, a movement program has been created that consisted of an initial command (singular, direct, quick impulse), while in the case of the longer time pattern, a programed control is working that is expressed in a phase of less activity of the m. gastrocnemius and then to a re-set. As the phase of reduced activity occurs at least in part prior to [the drop] landing, it is obviously not influenced by peripheral factors external to the body. The current state of research does not permit any answers as to possible cause. The appearance of phases of reduced activation largely independent of peripheral factors (immediately prior to landing, independent of drop height) indicates that the time pattern of quick movements consists of a closed unit. This conclusion is also supported by other research. The opinion often given in the theory and practice [of athletic training] that drop-jumps should be divided into a concentric and an eccentric phase, and accordingly trained differently, does not seem reasonable given the present results. These results were also supported by further investigations with other subjects that demonstrated them in a different power performance movement.

In summary, we can conclude:

1. Shorter time patterns are a necessary, but in no way sufficient, condition for high power performances, and are specific to a movement. As one example among others, this is evident from the fact that world elite performances in track-and-field sprinting are only attainable with ground contact times under 100 ms (a movement specific time pattern). Some children and recruit[4] level athletes also have such short ground contact times, but nevertheless produce significantly slower speeds (Bauersfeld, 1981, 1982, 1983, 1984, 1985; Voß, 1982; Müller & Dehmel, 1985; Henniger, 1985, Müller, 1985, 1986).
2. Shorter time patterns are not primarily determined by the level of expression of strength. This is above all supported by the fact that short time patterns during drop-jumps are found in untrained children, recruit level athletes (female gymnasts, male and female speed skaters, male and female track-and-field athletes, bicycle racers) and elite athletes, each with very different strength ability (Voß, 1982, 1985; Müller & Dehmel, 1985; Henniger, 1985, 1986; Bauersfeld, 1984, 1985).
3. Shorter time patterns are a certain quality (typical innervation pattern) of neuro-muscular control mechanisms and are associated with a typical force-time curve. The different, typical innervation pattern, and the different force-time curves of the shorter time pattern compared with the longer, can be found in athletes making the shorter time pattern, but with different abilities to perform (Bauersfeld, 1984; Gundlach, 1986).
4. The first pilot investigations of the resistance to fatigue (stability) of the time pattern showed that the time pattern of an individual is not changed during 100 successive drop-jumps from 35 cm, in extreme cases 350 jumps in a row. Subjects performed the entire set of jumps consistently with either a shorter or longer time pattern, even as the number of jumps increased and the power performance decreased (Bauersfeld, 1984; Narveleit & Meyer, 1986).[5]

3. Consequences derived for training methodology

The present research results make it possible to infer preliminary methodological consequences even though in some cases they cannot be supported as yet by training experiments. However, these results are also supported by the fact that in research, among others by Siris, Gajdarska, and Rachev (1963), phenomena are presented that correspond to the concept of time patterns. These authors also consider

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[4] Translator's note: Here and in the following, by "recruit athletes" [ger. Nachwuchssportler], Dr. Bauersfeld means prospective recruits to the National Team, and not recreational, novice, or beginning athletes.

[5] The literature references listed by name and year of publication are available from the author.

power movements to be a performance determining factor that is not dominated by the strength ability, but reflecting the quality of the neuro-muscular control processes, agreeing with our conception.

The following consequences emerge:

1. Further confirmation of the relative independence of strength and quickness (movement specific time patterns) as components of power performances have great importance for how the training is organized as apparently the time pattern cannot be changed by improving strength abilities. A certain increase in strength probably improves performance within a given time pattern. Among others, this also appears in experimental investigations of the duration of the take-off time in long-jumping (the world's best attain take-off times under 120 ms). In the results of a two-year experiment, long-jump distance increased significantly. This was primarily achieved by developing the strength component during the take-off because the take-off time remained relatively constant.

Table 3. Contents of power training (according to Hochmuth & Gundlach, 1982).

Training Exercise	Velocity Attained	Time Characteristic Achieved
Original competition exercise	Competition velocity at the level of ability at that time	Usually slower than the targeted time characteristic
Exercises with a relatively small increase in external resistance	Reduction in movement velocity	Longer than the targeted time characteristic
Exercises with movement velocity reduced on purpose	Reduction in movement velocity	Longer than the targeted time characteristic
Original competition exercise, or slightly changed, with sub-maximal performance	Reduction in movement velocity	Longer than the targeted time characteristic
Exercises with resistances less than during the competition exercise	Faster than the competition velocity	Can correspond to the time characteristic

On the one hand, the development of shorter time patterns and high levels of strength ability are two independent training tasks, but on the other hand, also have a composite character. If we look at current practice of power training (Table 3.) then it is apparent that one mainly trains at competition speed or at speeds that are slower than the competition speed. Time characteristics that correspond to future time patterns are to a certain degree only in exercises with loads less than the competition exercise. Nevertheless, the portion of these exercises in the training is exceptionally small. The fact that in power sports events there are often so-called transfer problems (in other words, improved strength abilities could only be partially applied in specific competition performances) could be founded in a wrong time pattern that does not correspond to the future performance requirements, that has been unintentionally stabilized during the long-term development of performance, given the results and current power training practice.

2. What emerged from the investigated exercises, but also from other investigated deceleration-acceleration movements, or movements at maximum velocity, during childhood as well as adulthood, indicates that quickness ability might be identifiable at an early stage, given its relative independence. Considering the sports-motor test exercises used today for talent identification, it is nevertheless apparent that not so much elementary abilities are measured but more integrated, therefore complex, prerequisites for performance. The performances made in these test exercises during talent identification are of low or intermediate level. It can be assumed that at this level of performance, the degrees of freedom are still relatively good, in other words the ability to compensate between elementary determinants of performance. This necessarily leads to “unfocused” talent identifications. Although the talented are also among those selected but, depending on the given compensations among elementary abilities, a large number of less talented are also selected. The precision of the talent identification results can thereby be improved by developing and using eminently practical measurements that above all permit conclusions about elementary performance prerequisites. This is particularly appropriate when these elementary performance prerequisites prove to be relatively stable and procosciously expressed. For the power events, this means, among other things, that the level of expression of the time patterns of typical power movements have to be taken into account. This does not make integrated, consequently complex test exercises irrelevant. These exercises can be used to give information for wider tasks in another direction. With these exercises, we measure in a better way the ability to integrate elementary performance prerequisites into complex performance potential, in other words the ability to exploit the present elementary performance prerequisites. In this case, what is involved is an ability that is also addressed, that is identifiable relatively early, is possible to develop, as well as having a high stability. Such a position is supported by literature originating in the Soviet Union in which the athlete’s capacity to effectively exploit their physical potential (in other words a high coefficient of exploitation), that already in the first years of training is developed and, correspondingly, is hardly possible to correct. This observation confirms the insights on time patterns from our own results. It

seems appropriate that this question be followed up as it is possible that it contains another reserve of performance.

3. These results confirm the necessity for a stronger development of time patterns from the point of view of future expression. Thereby, there arises a developmental complex that, compared with current practice, requires a new solution and therefore integration into the entire [training] system. Given the research results, including the development of time patterns during early developmental age, relatively early and also expressed in recruit level training, this therefore seems necessary because time patterns in adult age have a high stability. An early inclusion in recruit training is possible with the amount of various training influences. As our recruit training is oriented to a high degree towards strength and endurance, the danger exists of an unconscious development of mainly longer time patterns. We are close to concluding that the limit of performance of an athlete is highly co-determined by the time patterns developed during recruit training. If the time pattern has a certain basis function, then all other prerequisites for performance act within a certain time pattern (shorter or longer). If this time pattern does not correspond to the challenges of future performances in competition, there will be a stagnation in performance development, even in the case of clearly improved other performance prerequisites, when the possibilities to develop these time patterns is exhausted. Therefore, the need arises to more precisely determine the time patterns of future performances and any possibilities of developing them earlier. The evidence that time patterns occur in the investigated power movements that are largely influenced by neuro-muscular control mechanisms, relatively independent of strength level, requires that power strength training be more distinctly separated from training quickness. But at the same time, the training of quickness also needs a different accent. Therefore such a change in direction is of particular importance because the development of neuro-muscular control mechanisms is task-dependent and requires corresponding training stimuli.
4. Athletic actions cannot be performed with time patterns alone. Training time patterns in power movements is always influenced by the strength factor. An apparent contradiction arises between, on one hand a requirement to develop time patterns before the development of strength abilities, on the other to nevertheless accept that for the majority of movements, strength abilities still act as insufficient factors, inhibiting the future time pattern. It appears that overcoming this contradiction is the solution for the training method. What is involved is finding or creating those training conditions that minimize the effects of strength in the athletic behavior when training the time pattern, requiring a direct, quick production, in order to develop the time pattern that will be

necessary in the future. On one hand, this must be achieved with technological solutions (exercise machines, assisted conditions). On the other hand, from the extensive catalogue of exercises, those exercises that make possible training of future time patterns must be worked on and applied in practice. Above all, given the research results, these must be exercises that place only small demands on strength and are characterized by high velocities over short distances.

5. There are new tasks not just for conditioning, but also for technique training and technique-coordination development. There is no doubt that as correct as possible performance of a movement is an essential condition for high athletic performance. According to the research results, time characteristics have a greater importance beside the conscious learning of the spatial characteristics. Spatial and geometric characteristics dominate the sport-technical development of recruits and the teaching of technically ideal examples. There is an emphasis on recommended body positions, body angles, and paths. Time characteristics are limited mainly to verbal recommendations for rhythmic movement.

   The results presented here direct attention at the spatial and time characteristics of athletic technique more as a whole. They support the interpretation that the given movement program is stored to a great degree as a time pattern and that the difficulties in improving athletic technique are to be found in early developed, as well as exceptionally stable, time patterns. When developing time patterns, an important condition is ensuring the unity of the movement. The results show that the investigated movements have a time pattern that is locked into them. Every decomposition of movements into partial phases during the development of the time pattern does not lead to the time pattern that was envisioned. What should also be thought through is the question if the technique desired in recruits should not be organized more so that the time pattern that is necessary for high performance can be produced. In a number of power events, the time pattern produced by recruit athletes distinctly conflicts with that in high performance training, but is still required.

6. The high stability of the time pattern under fatigue found in the pilot investigations justifies considerations for cyclic movements with endurance characteristics. If it is demonstrated that in cyclic movements with endurance character, time patterns exist that are also an important performance prerequisite, with relatively good stability and relatively independent of the level of development of endurance, and are associated with higher velocities in certain time patterns in the future, then this has relevance for the training of recruits. Also here, the thought would be valid that the prerequisites for performance endurance and strength are only effective within a certain time pattern. If this time pattern is not up to future demands, then, even if unintentional, limits on performance are

developed in recruit athletes. For example, running at low speed, that eventually leads to slow time programs, but which are stabilized by frequent repetition, could be a cause of developmental difficulties. If we assume that endurance performances are primarily determined by the forward drive produced during an individual movement cycle, as well as its most frequent possible repetition, then we can conceive of consequences for the development of the individual cycles. If the training is accented towards a great forwards drive per unit of time, then also in endurance events attention must be paid to the future time pattern. In the training of recruits, this point of view indicates that there should be a stronger emphasis on under-distance at the speed predicted for success. What kind of problems this poses is clear from the example of a 5000 meter time of 13:00 minutes, which requires a mean velocity of 6.4 meters/second, a velocity that the majority of 9-11 year old Training Center (TZ) children rarely achieve when sprinting just 60 m.

Finally, we once more emphasize in these thoughts on quickness published here that, in all cases, quickness is one performance determining factor in the competition performance. Integrating the development of quickness into the training program as a whole therefore demands a great deal of responsibility given the present ideas.

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