

SENSITIVE AND CRITICAL PERIODS OF MOTOR CO-ORDINATION DEVELOPMENT AND ITS RELATION TO MOTOR LEARNING

by

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The optimal age for motor learning is difficult to define. The conditions seem best up to early adulthood, however lifelong sensitivity allows motor learning process to continue throughout one's life, in the presence of frequent repetitions and appropriate motivation, depending on the difficulty of the learning task. The periods before puberty are nevertheless to be used particularly intensively for appropriate stimuli (especially with regard to co-ordination and speed), because it makes sense to influence the maturing functions. It has been also proved that co-ordination abilities can be trained particularly well at this age. However this does not mean that no effects can be achieved at more advanced ages. Broad co-ordination seems to be favorable for later success in motor learning.

Key word: sensitive and critical periods, motor co-ordination, motor learning.

Introduction

Coaches and physical education teachers know and take into consideration the supposed periods of enhanced and reduced trainability, which are called sensitive or critical periods (phases). In this regard, coaches of young athletes in highly technical sport disciplines know that the most important skills have to be acquired and refined before puberty starts.

Coaches and teachers have no doubts that these phases are marked by a very good motor learning ability of children and are proved to be the "best motor learning age in childhood" (Meinel 1960). As an example the statement of the multiple world champion and famous coach in roller skating Obrecht

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(1982) should be referred to: "...between the 10th and 12th year of age the most difficult elements of roller skating shall be practiced. This is the best age to develop one's abilities."

In contrast, the literature on this topic is far less uniform. In many textbooks the points of view or practical experience mentioned above have been simply adopted or represented in a general way. All periods of special accelerated development determined by average curves in cross-section studies have been compared and represented in a general way in summaries about the supposed sensitive phases.

Other authors generally doubt the existence of these sensitive phases (Baur 1987) or prove by means of learning experiments that better motor learning success can be achieved outside of the "best motor learning age" (Fetz 1989; Joch/Hasenberg 1990, 1993; Willimczik et al. 1999). The following research questions have been established:

- Are periods of faster development of certain motor abilities identical with phases of increased trainability?
- Are the clear accelerations of development in childhood caused by maturity processes and/or by changed requirements in the social environment?
- Do better motor learning results outside of the "best motor learning age" confirm that it does not exist?
- Is the assumption of sensitive phases in childhood possibly caused by the following "critical" phase of puberty?

Motor learning in childhood

First it is important to state clearly that doubts about the best motor learning age in the lifespan being in late childhood – i.e. before puberty – are quite legitimate and we share them. However, the formulations of Meinel (1960) and Winter (1980) in different editions of their works like "The best learning age in childhood" (1960) or "Phases of the best motor learning age in childhood" (1987) relate to childhood and not to lifelong motor development. For Meinel (1960) childhood ends at puberty. Up to this time it is surely the best motor learning age, the *first* culmination of the motor development, also because of the high level of coordination.

In our opinion the extensive learning-studies of Joch and Hasenberg (1990; 1993) as well as Willimczik et al. (1999) – for this purpose – were actually not necessary. The realization that motor learning capacity can be improved also after the age of 12-13 years as a result of increased motor experience and intensive practice has been often proved. Our investigations confirm too, that optimal coordination development takes place in later adolescence and early adulthood. This well developed coordination is a good basis for corresponding motor learning results, which Fetz (1989) and others prove empirically.

Sensitive and critical periods in the development of coordination

The question whether the first peak in motor development in childhood is followed by a "critical period" in development obviously has to be discussed (Hirtz, Starosta 1989; Starosta, Hirtz 1989, 1989a, 1990; Starosta et al.1989).

Regardless of the problem of the best motor learning age, there is the question whether childhood (especially the age between 7 and 12 years) presents especially favorable conditions for the development of coordination (also of mobility and certain aspects of speed) and if it is an especially "sensitive period" – as we maintain.

The empirical studies have many methodical advantages, which have led to corresponding results:

- It is possible to trace individual development by means of longitudinal data. Thus individual effects of a strong coordination influence in the younger age have been clearly established. Furthermore one has been able to "expose" the stagnation phase of coordination development after the 12th-13th year, which is generally described with average curves, as a *regression phase* in individual motor development, by proving the direct relation with the pubertal growth spurt and impaired coordination potential in individual cases.
- There is no automatical conclusion from a determined phase of clear growth rates that there is a sensitive period, as is usually presented in literature. On the contrary, authors tried hard to prove with 2-3 year long experiments, that significantly greater effects are reached with stimulation (coordination

exercises), roughly equal in content, extent and intensity, could be achieved between the 8th and 10th years of life than in early pubescence or early adulthood. The more intensive reactivity of the human body to training stimuli is the decisive factor in the sensitive phase.

- Finally, it is worth to answer the question whether this increased coordination capacity affects motor learning. For this purpose additional motor learning experiments were carried out and found the appropriate evidence. It has nothing to do with the best motor learning age, but exclusively with the evidence of a sensitive period for coordination influences and with its effects on motor learning results.

Furthermore impairments in the degree of acquiring sports techniques were established in individual cases among the impairments of coordination capacity in pubescence. These results have been confirmed by Starosta in talented young competitive athletes in sport disciplines requiring complex skills (figure skating).

Some results confirm these statements:

1. Effects of coordination training in younger schoolchildren

The reaction time of the experimental children to acoustic and optical signals was reduced as a result of intensive influence of coordination between the 8th and 11th years of age significantly more (normally by 30-40 milliseconds) than for children of the same age in corresponding comparative populations (Fig.1). Perception results improved in the same time by 42% compared with 25% for the control group. As expected, the strongly coordinative training had strong effects on the development of balance ability, coordination under time restriction as well as strength differentiation. The influence of training on sense of rhythm and three-dimensional aspects of kinesthetic differentiation was less pronounced.

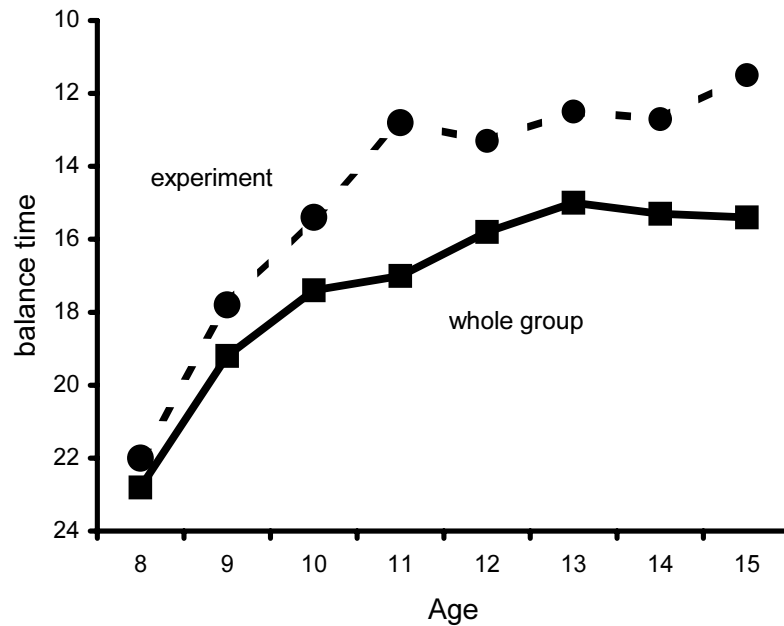


Fig.1. Development of balance in females in the pedagogical experiment (HIRTZ 1988)

2. Regression phases of development of coordination in early pubescence

The growth spurt due to puberty (increase in height of 7 to 14 cm and in weight of 8-13 kg annually), which is combined with a change of the body proportions (Fig.2), affects 86% of the girls between the age of 10.5 and 12.5 years (5th and 6th grade) and 90% of the boys between the age of 12.5 and 14.5 years (7th and 8th grade). In 76% of these girls and 90% of these boys this growth spurt is combined with a clear impairment of coordination, either immediately or with a one-year delay. The extent of these impairments is sometimes considerable: more than half of these children experience a growth spurt of 10 to 20%, a further third of even 20 to 30%. It is under 10 to 20% only in 15% of the children. These impairments are largest and longest in case of sense of rhythm and kinesthetic differentiation. They are less pronounced in case of reaction time. The relation between the pubertal growth spurt and the impairment of the coordination capacity have been proved in longitudinal studies of individual cases. Fig. 2 shows the development of balance in females. The decrements are clearly visible in particular cases of age.

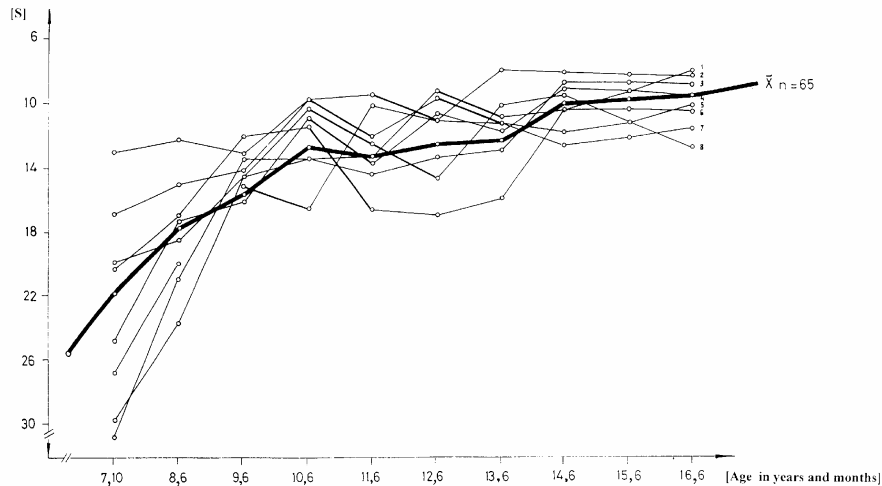


Fig.2. Development of balance of females in comparison with the whole group n=65 (longitudinal study – P.Hirtz, Greifswald 1975-1984)

After this phase (i.e. in girls after the 13th year and in boys after the 15th year, decreases in performance are scarcely observed. Mostly, slight increases of coordination occur.

3. Impairment of acquired sport-motor skills in pubescence

Clear stagnation and impairment with respect to the degree of acquisition of sport-motor skills in result of the pubertal growth spurt were established in all pupils from experimental group (with the exception of two girls). All regressive phenomena were combined with a clear increase in height and weight, either simultaneous or delayed by 1 year. In 42% of the girls there was a clear decrease in all 6 sport techniques performance. This was equal to between 20 and 50% in 73% of the girls. However this regression depended on the kind of sport technique. They are clearly greater where the coordination demands are higher (somersault on the ground or knee upswing on the horizontal bar) than in techniques, which depend more on strength (headstand or hip upswing on the horizontal bar - only 38% of the girls with a falling-off). In 25% of the girls there are even improvements in the latter techniques during pubescence. In that case the influence of increased strength during pubescence is visible. The phase of instability lasts from one to two years. After completion of pubescence

75% achieve their previous values of fitness or improved them in some sport-motor skills (Fig.3).

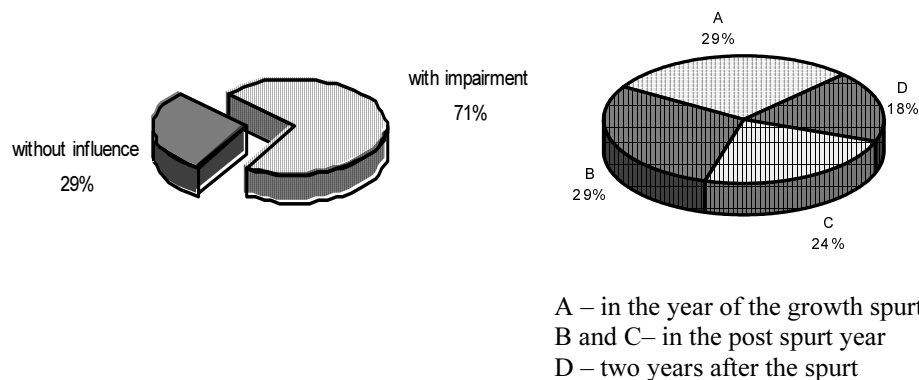


Fig. 3. Impairments of acquired motor skills in pubescence on the example of the knee upswing on the horizontal bar (Hirtz/Schwarzer 1993)

These results have been confirmed by Starosta and Hirtz (1989) in talented young athletes, representing technical sport disciplines (figure skating). Fig. 4 shows the growth spurt, the coordinative development and the sports technique of two young figure skaters. Clear impairments are visible in the sports techniques in the year of the growth spurt.

Conclusions

1. The best age for motor learning is difficult to determine. The predispositions seem best up to early adulthood, however lifelong plasticity allows motor learning process to continue throughout the ontogenetic development, given high levels of exercise stimulation and appropriate motivation, depending on the difficulty of the learning task (and the proportion of strength involved).
2. The periods before puberty are nevertheless to be used particularly intensively for appropriate stimuli (especially with regard to coordination and speed). It is sensible to influence the maturing functions and has been proved that coordination can be trained particularly well at this age.
3. The period of puberty is in individual cases related with impairments of coordination, depending also on biological age, the intensity of the growth

spurt and the extent and intensity of physical exercise, which are reflected in the degree to which sport-motor skills and sports techniques are developed.

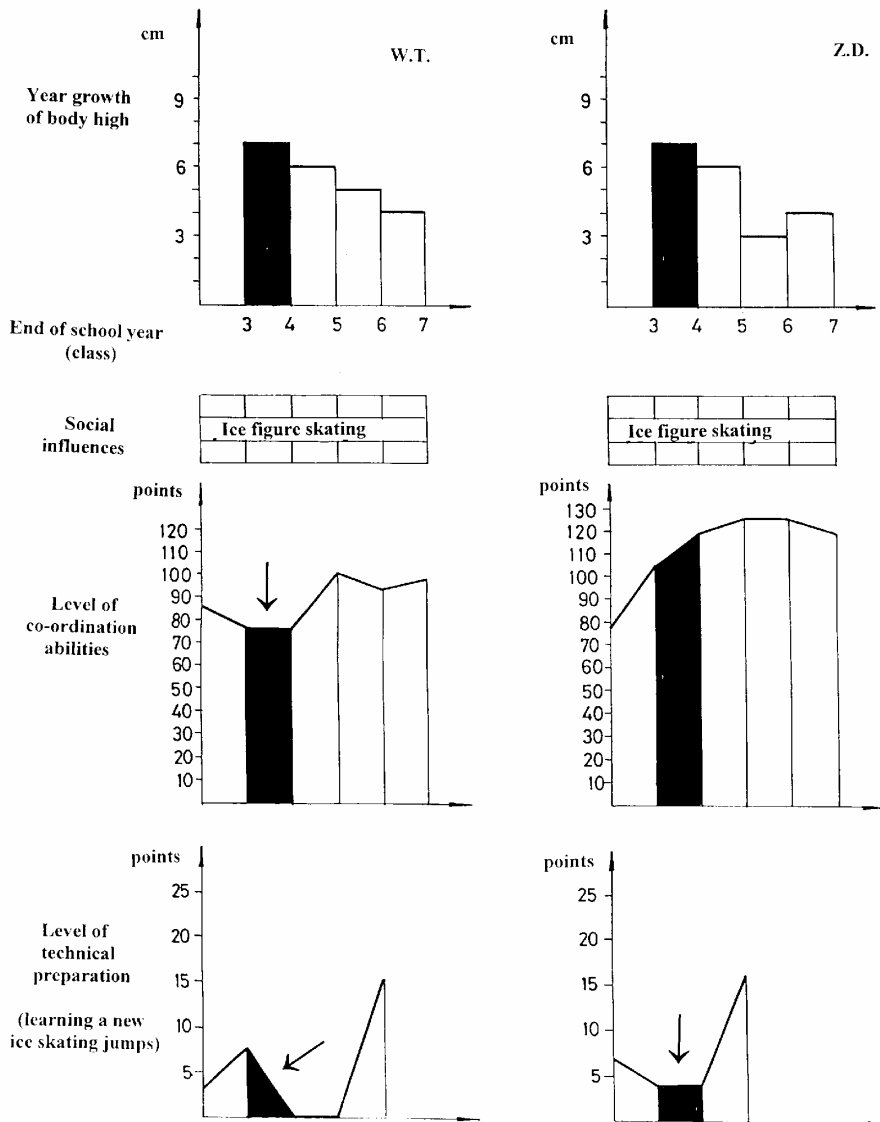


Fig. 4. Growth, coordinative development and sports technique of two young figure skaters (Starosta and Starosta 1988)

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video feedback in fostering motor learning, motivation and self-assessment during a physical education program with young children [14]; Visual-motor integration is a complex ability that combines fine motor coordination (an aspect of school readiness) and visual-spatial reasoning skills [15]; Playing and exercising during the school day are important in fulfilling the recommendations for daily physical activity for children, as well as in promoting their mental and social health [16]

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