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OBSAH

PHILOSOPHICAL AND SOCIO-CULTURAL CONDITIONALITY OF HUMAN MOVEMENT AS A MEANS OF QUALITY OF LIFE DETERMINATION

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The quality of life has, concededly, its predispositions. They are of course, in the human being, with regard to the structure of his/her personality, very variable. That is why, to speak about the philosophical and socio-cultural conditionality of movement as a means of quality of life determination, is very difficult. But, nevertheless, it is necessary. So, this paper examines, from the point of view of these relations, first the problem of health, further the problem of movement, respectively human movement and, consequently, the problem of physical exercises as a specific human movement behavior. It takes notice of the relation of physical exercises to that physical fitness which is oriented towards achievement and also to the kind of physical fitness which is oriented towards health. And then, understandably, it remains by this orientation towards health.

Keywords: Human movement, quality of life, life style, health, fitness, welfare, arété, body, physical exercises.

INDTRODUCTION

The title of my paper is at first sight very broad, but I suppose that this cannot be avoided from the viewpoint of any problem solved at this conference. With regard to the breadth of this accepted topic I cannot make claims for more than highlighting some items regarding the above-mentioned conditionality.

The proceedings of the conference are aimed at the relations between movement and health. These relations understandably are not clear but can be expressed in different stages ranging from very positive to very negative. It is necessary to emphasise that health concerns the whole human individual's personality, encompassing the physical, mental, and spiritual as well as the social spheres. We do not have to and cannot totally agree with the opinion of the World Health Organization (WHO), expressed as early as in 1947, according to which health is not understood as the mere absence of illness but as "a disposition of physical, mental and social welfare (well-being)". Health is, in this expression, described in the sense of the coverage of the whole human individual's personality, without any reduction into partial segments. Löwith (1975) clearly expresses his opinion on the unity of any human being when he says: "A person can be examined anatomically, physiologically, biologically and mentally and in this way some personal aspects can be made clear. But even if we were to summarise all these different aspects, it would not show us a human being as such. Insofar as that is concerned, a human being is neither an anatomically prepared complex nor a physiologically functioning organism, nor something examined by various psychologies." A human being is thus a union of mutually complementing parts that cannot be isolated (with the exception of when it is done for research reasons). But the above-mentioned "status" of some "welfare" can be expressed only on the level of individual *feeling*. The important thing is how a human individual feels and how he/she can cope with eventual problems and how he can *adjust his/her life* to them. This feeling cannot be measured and is basically also *incommunicable*. And this is the problem. Even if the mentioned definition gives us simple instructions on how to approach health in a complex manner, it is evident and to a certain extent also understandable that over the long period of existence of this opinion, our health concept is still reduced mainly to the physical sphere and even sometimes only limited to the absence of illness. From the base of understanding health as only the absence of illness, two possibilities are derived – I "have" good health (= I'm not ill) so I do not care about health or I "haven't" good health (= I'm ill) so I will have to seek professional care. The first case doesn't motivate anything; the second case motivates using science (mediated by a doctor) or an organisation (health service). That is why a person tries to use a health service – because it can return him/her to health. This approach to health has an absolutely consumer character and it is in entire harmony with the *philosophy of a consumer society, in which* health is understood as a product that can be bought or gotten for free. The values of a consumer society without a doubt affect the whole life of contemporary advanced societies. They have also affected the health sphere, thus causing an indefinite reduction of the entire complicated problem. (The modus of I "have" health is entirely something else than the modus: I "am" healthy – see Fromm "To be or to have?")

The sphere of physical health is relatively easily diagnosed and measured, which corresponds to the dualistic, *Cartesian* concept of a human being that was, thanks to *phenomenological* philosophy, already overcome, but in its intentions the human being is still being approached. A human being is then understood in the sense of a wrong interpretation of the term *fysis* and in the sense of understanding the physical body as an instrument. Naturally *fysis* doesn't mean matter, nor the material body, but expresses *sprouting and growth*. Understanding health in the sense of *fysis* is then a necessary basis for understanding health in the sense of process. Fysis is process. Fysis is the motion of the living and alive body itself. "The motion of our body is an expression of our life..." says Hogenova (2002). The same *fysis* is said by Aristotel to be the inner source of motion in a human being. Fysis in old Greek philosophy is naturalness. But, even though it is the inner source of motion in a human being, this source affects a given situation, of which a person is a part. (Patočka, 1995) adds to this that a person is, in a given situation, in this way that it is not separate from him and he/she is not without influence on it. With reference to Heidegger and others Hogenová states that *fysis* is a concept "...which belongs among the most difficult in the whole of western metaphysics" (1995). Sprouting and growth are also connected not only with positive but also with negative development that happens between our origin-birth and end-death. Feelings connected with growth are not surely identical with feelings connected with our gradual coming to the end and death. Is it possible then to talk about health as about a "feeling of welfare"? Of course it is. But it is a problem of *realising one's own possibilities*, concerning the individual "overlap into the world", into *the complex of the world*. Everyone is, in essence, different as compared to others; an individual "feeling of welfare" is, in each human being, differently identified. A "feeling of welfare" *isn't a criterion which determines quality or quantity*. A feeling of welfare follows only *from knowledge of reachable harmony between "me" and the "world"*. The problem of health formation is in the enhancement of possibilities for reaching this harmony, which differs in everybody. These possibilities are greater the more an individual realises his/her own integrity and the more he/she realises his/her own belonging to the world. "No mental individual is thinkable as a function of variables but as a creative power that is always connected to the complex, to the sense" (Merlau-Ponty, 1986).

A feeling of welfare is thus the problem of the rational consideration of possibilities that the individual has in this world. It is a problem of balancing the situation and orientation of life within possibilities that are at one's disposal. We come up to the problem not only feeling a human being to be a unity and a complex of mutually connected components, but also to the problem of a human being as part of the world complex. Understanding a human being in relation to the world has been the problem of philosophy from its beginning so we could name tens of philosophers within this context. The majority of them thus see *the unity of a human being in the unity of the world*. Many of them regard a human being to be a *micro-cosmos* that contains everything that is contained in the *macro-cosmos*. The World and "Man" constitute a harmonic complex. This opinion is then clearly expressed in old Greek expression/concept *arété.* According to Hogenová (2002) to be a healthy human being means to be "areted" into the complex. To understand and examine a human being in this unity of his/hers that is thus a part of world unity is understandably very difficult, but it is the only possible way. A fundamental *understanding of one's unity, of human unity and of the world's unity means also a mutual overlap of the physical, mental and social and overlapings of what is human "into the world"*. Health is thus the problem of human unity and world unity. The world is therefore an inconceivable amount of mutually supplementing "diversities". Each of them is, or can be "areted" into the complex of the world. Health is thus put into context with the term *"balance"* – in the sense of stability between the external and internal environment, which supposes the ability of adequately react to the impulses of different character. Stopped here and sent the text this far to Hodaň and Karásková. It is a solution of the discrepancy between the maintenance and development of genetic potential and unfavourable conditions of the external environment. Of course, the term balance itself has got a *"deadening"* character evoking calmness and immobility. A steady state is the state of immobility, reaching stability; the maintenance of constantly unbalanced stability is a never-ending process. *In the case of a health problem, stability is necessarily always unbalanced, and it is always again and again repeatedly reached*, mainly thanks to the negative effects that come from the outer world and threaten our health. But also in the very process of health formation, this stability is disturbed by the very effort to reach a higher quality of health standards.

From the above mentioned statements it follows that health is a process, creation and struggle that never ends. This statement is, to some extent, in discrepancy with the above- mentioned definition of WHO that characterises health as a "state". While the *dynamics are hidden in the process, an expressed state implies immobility*. The term "state" in the definition mentioned must be necessarily understood as an expression of a momentary level that was reached in the process of health creation. Thus not as something that is given, constant but as part of a process that was (either objectively or subjectively) found for a while to be interrupted. (Investigation of whatever process generally is possible only if we gradually "stop" it at particular stages.) That's why we also speak of health creation or also of strengthening or health promotion. Health as a process is understood in the sense of positive and negative. Imagine a scale where from the neutral (zero) point there is an ascension to, on one side of the chart, positive values and on the other side of the chart, negative values. Then the zero value expresses the state when a person is not suffering from illness but is not "healthy", however, in the sense of the WHO definition. Movement from the zero point toward the feeling of physical, mental and social welfare represents a certain degree of positive health, whereas otherwise a move towards death as determined by illnesses, represents a certain degree of negative health (Fojtík, 1999).

– +
death __________ 0 __________ feeling of welfare
negative health positive health

From the broadly conceived WHO definition, of course, necessarily follows the problem of the objective evaluation of health that can often be to a certain degree in discrepancy with subjective feeling. Relatively easy is the examination of physical health – not only from the point of view of the diagnosis of illnesses (negative health) but also from the point of view of testing for fitness, efficiency, etc. (positive health). A number of testing methods and techniques exist including elaborated norms with regard to gender as well as age. (In case of "norms" I must say one brief note. A norm, whatever norm is the expression of a certain average. From the diversity of individuals, the environments where they live as well as from the activities that they perform it follows that for somebody it will be too high of a goal, almost unreachable and for somebody else it will be too low. It has got only a certain orientational character. A norm is hidden in the individual and is a given, based on his/her specialities and the demands of his/her life. Between the "norm" of a top athlete and the "norm" of a non-athletic individual of the same age there is a great difference. It is similar to the difference between the "norm" of an adolescent and the "norm" of an aged man.) Less "simple" are, from this point of view, the remaining components – mental and social. Thus the whole *health complex* evaluation is very difficult, that's why mainly physical health is evidently dominant according to the perceptions of a majority of the people. It is understandably connected with the fact that overall problems of social and mental health mainly lower one's life quality in general, whereas problems of physical health can end in death. They are connected with the fact of our being a fundamental, biological, animal and human entity (also here it is necessary to realise the important relationship between *physical* and *mental*). During practical activity as well as during research therefore there is a reduction into partial components and the WHO definition is thus operationalised.

In reaction to above mentioned WHO definition Stokols (2000) talks about *healthfulness* which he regards to be a multidimensional phenomenon covering *physical health, emotional welfare and social cohesion*. By this he moves the whole problem into a slightly different, concrete and thus intelligible form. With the term emotional welfare he expresses a balanced state of the psyche reflecting stability between the internal and external environment, adequately reacting to impulses, etc. From this there also follows a distinct link to the fundamental function of physical health. Social cohesion is, then, the expression of the positive relationship of an individual and society, the realisation of accepted social roles, etc. There is evident linkage of three personality dimensions: physical, → mental, spiritual and → social. It means that the level of the physical and mental state determines the level of social "output". It isn't said that these relations are only unidirectional. Feedback is also important – social dysfunction can evoke mental (emotional) dysfunction that can result in physical dysfunction.

If we realise only these briefly sketched relations, from which it follows that *health is actually a constant process of reaching optimal harmony between those internal and external factors that determine it, as well as harmony among its individual items.* Continuity of a process with the aim of reaching complex health is also expressed by the English term *wellness* that, according to the dictionary, means *good health as an actively observed target*. It is thus a process constantly focused on reaching (in finality, an out of reach) target. Stumbo and Peterson (2004) in this connection cite the authors Hurley and Schlaadt who regard wellness as *"...such an approach to personal health that emphasises personal responsibility for (physical and mental) well-being through conduct focusing on a health supporting life style"*. Ardell (in Stumbo & Peterson, 2004) adds that it is a positive and active approach requiring a *"...coordinated, preventive and integrated life style, unique for each person". The* process hidden below the term "wellness" thus aims at the fact that one gets, with one's level, mostly and above all "healthy threats" following from the environment one lives in and from activities one performs. Within this connection thus Stumbo and Peterson (2004) speculate about "high-level wellness" which they regard to be an *integrated method of activities oriented to the maximalisation of individual potential in an environment in which an individual lives.* From the above-mentioned reasoning it follows that *wellness has a direct relationship to life style and quality of life*.

To the problem of "illness" or "disease", of course, is related another important problem concerning its seriousness. In our basic orientation we are obstructed by the fact, that in the Czech language environment, there are not mutual differences which are terminologically distinguished; in whatever case we thus speak about illness or disease. In the English language environment there are terminological distinctions on several levels that are important in relation to health, the quality of life and movement, respectively. Stumbo and Peterson (2004) with reference to other authors present the following distinction: "Disease is the failure (disorder) of the adaptation mechanism of an organism to adequately react to impulses and pressures to it resulting in functional or structural disorders at the cellular, tissue and organ level." This expression thus is about the body, the so-called physical body, in the sense of its diagnostical functions. *Illness is defined as the feeling of imbalance between human capacity and the necessary answers of the organism resulting in a lowered ability to survive and to create the necessary standards for quality of life.* It is a certain state of being, the subjective *experience* of some disharmony, whether *with* or *without* objective records of biological, physical, biochemical or any other disorder, it is the human experience of dysfunction and a decrease or loss of *one's feeling of well-being. Illness* thus precedes disease. (Another existing term, *sickness,* is not, from our point of view, important.) At a somewhat different level there is the term *disability* that expresses *inability in the sense of physical or mental weakening* (function decrease), *essentially limiting one or more main life activities.* It concerns thus inborn or gained changes of permanent character disallowing participation in certain activities.

As was already said it is necessary to put the term health into connection with the term *"fysis"* in the sense of sprouting or development. This expresses a certain form of movement. Other forms of movement, caused by internal or external impulses, are expressed by the term *"kinesis"*. Both terms are connected as well as the terms "health" and "movement". Uniting these terms respectively in their essence expresses the reality that movement *is one of the most important factors in health formation*.

The Category of movement is one of the basic categories, which is at the centre of interest of philosophy throughout its history. The development of opinions is sufficiently described; in this context we could name a number of philosophers dating from antiquity to the present but it is not the issue now to be discussed. So as the interpretations of the world, human beings and the body differ, also the interpretation of movement differs and, understandably, relations among these terms differ, too. Human movement is a very complex problem that is very diverse and can be seen from various directions. In no case can the problem of "movement" be separated from the problem of the "body". Movement is understood differently within the Cartesian perception of the body and differently within phenomenological perception.

At the present time we find a number of different characteristics. From the view of human movement they might be generalised into these forms:

- *Movement is considered the synonym for changes of some space parameters of the body or object or a material point within time and space.* From this it follows that *movement* is, in this sense, linked to the category of the body (respectively matter), *space and time*. Without holding out all three entities, movement is not possible. In a human being it is movement externally perceived, observable, measurable, assessable, etc. It is the simplest kind of movement realised within mechanical regularities. Directivity to this kind of human movement is of course the reduction of human possibilities and is the expression of the Cartesian understanding of the body as the instrument that is purposefully prepared to achieve a certain performance level and it doesn't matter of whatever character the performance will be. Mainly, it will be the highest level no matter what connections to it there are. At present, performance in society creates a very suitable thought environment for this perception of body and movement and it contributes importantly to the reduction of a human being. What the consequences of such a unilaterally oriented approach to quality of life and subsequently to health are is quite evident.
- *Movement is a change of form.* Understanding movement as a change of form has got two possibilities in the case of a human being. One of them is naturally connected with the natural development of a human being and is connected with birth, development, aging, and death. It is a fundamental biological movement, expressing the biological essence of a human being. It is the real old Greek *fysis*, expressing sprouting and growth. These natural changes are understandably influenceable by environment, education, and intentional intervention. The natural biological development of a human being doesn't happen under optimal conditions, but, on the other hand, with the growth of civilisation, under conditions that often influence these changes very negatively. Then these changes are optimised by purposeful external intervention and it can be said that "formative aging" is decelerated; which is understandably positive. This purposeful external intervention evidently evokes the second possibility, namely a purposeful change of form motivated by the reason that arises, of course, out of this natural development. It is the change of form understood as a certain, externally perceived,

observable, valuable and measurable performance level. Intentionally I have used the same terms as in the previous case, which is completely the same phenomenon. This phenomenon is again connected with the contemporary philosophy of a performance and consumption-oriented society. Thanks to the media's presentation of different "patterns", there in an unnatural as opposed to a natural development, which is on one hand characterised by the excessive growth of muscles and on the other hand by excessive slimness. Even if both are unnatural, the second, ending often in anorexia, is more dangerous. And where did these "models" and "patterns" appear? It is only the creation of agencies, presentations in media, and one of the ways to earn money. But yet neither a universal pattern nor any universal criterion can exist. The ideal, the model, certainly was Vestonice Venus once upon a time, for someone it can certainly now be a model sumo wrestler, for somebody else it could be a world champion in bodybuilding, for somebody further it could be a world-famous model, etc. There are thus cultural differences, differences caused by regional traditions, differences in perception of aesthetics, "beauty", etc. There cannot be only one universal model. And what is more, if whoever accepts this thought of a "universal model", he/she who is somatically similar to this model can approach it to a certain extent. "Beauty", in our case physical beauty, cannot be unified. It is very varied and connected with the proportionality of these individual preconditions that each of us is a carrier of. The main criterion is thus in us ourselves. These approaches to us, influenced by "changes of form", are again connected with the Cartesian perception of the body. The body is rather perceived as a solid organ, that is, according to precisely elaborated methods, "true". And this "true body" is the presentation of this performance. The impact upon quality of life and health is quite evident.

- *Movement is related to a phenomenon of non-material(?) thoughts.* (Adding question marks connects us with the diversity of opinions on the materiality of the non-materiality of a thought.) This movement is, understandably, inseparably connected with human movement and it doesn't matter whether movement is understood in the sense of the dualistic perception of a body or in the sense of monistics. It is always led by a thought that orients the purpose and the aim of movement.
- Movement is understood in the sense of *social and cultural processes and mobility of their participants*. It is the most typical and the highest type of human movement. In cases of this movement, no reduction whatever is possible. It is the movement that is a product of a body understood in the monistic sense, non-reducing human body into form. It is the movement of a soulful, experiencing body, movement that expresses a human being as he/she is, with movement-expressing himself/herself. It depends on the structure of the human body, its ability to move, on previous experiences and on the situations that evoke movement. All this blends together, mutually reflects and in its final shape is influenced by our own human subjectivity, our vision of the world, of the situation, our way of solving particular situations, externally imperceptible and objectively hard to explain intentions, etc. *Even if human movement has its cultural and social background, it always has its individual uniqueness.* It is not possible to confirm the basic statement that movement inherently belongs to life, that it is the precondition as well as the manifestation of human life. Rýdl (1996) says: "Movement is a fundamental way of human existence and not only as pure and mechanical locomotion, a pure product of muscle activities and their chemism, but in the whole width as life and existential need even of a spirited body as well as a personating spirit as inner intention, impelling, or, more or less consciously endeavoring, as in a body manifesting spiritual motion and in everything this is one of the most characteristic expressions of human life."

These forms of movement could lead us to a mechanistic understanding of it. But they are only the possibilities of reception of movement. In the case of a human being it is necessary to understand his/her movement in its complexity as an expression of his/her being. Human movement is, in each of its forms, like a reaction to an external or internal (thought, image/fantasy, emotion...) impulse. This reaction is a result of complicated processes accompanied by changes of internal states; which can be "published" only through movement in the sense of concrete muscle activity. Movement thus doesn't concern, as it can be in a reduced form the most frequently understood, the muscles or the movement system but also moods, thoughts, feelings, etc.... *Movement exteriorises almost all possible forms of human conduct as well as any internal motion.* Movement is social power motivating human cohesion, concerning either pairs or a whole mass. In this sense movement is also the instrument of either verbal or non-verbal communication. *Movement* as the externally registered expression of an individual as well as social life *is an inseparable, basic part of culture*. At the same time it is also the cultural instrument that a human being utilises for his/her development as well as for perfection. A human being participates in the formation of culture through movement. *Movement is*, on the whole the development of a human *cultural phenomenon*. The development of movement goes hand in hand with the development of thinking and language. It is the expression of the reality that a human is a social being. Human movement is then understandably social movement, necessarily reflecting regularities of mechanical and biological movement. The profound, partial but precise scientific analysis of movement can be done from all the aspects that have been mentioned. Many scientific disciplines give reasons for movement from the point of view of human existence. All these procedures allow us to give reason to movement in life only on the level of understanding a human being from the point of view of a type of "human thinking". But phylogenesis determined by the external world has changed a human being into the present "social human being".

Solving the problem of the movement of a human being as a social being brings us to a totally different position that is often ignored. This over-looking is caused not only by the demandingness of a certain necessary complexity, but also by the dominance of pragmatic approaches and a narrowly utilitarian point of view, the aim of which is a partial analysis of movement from the point of specific criteria. These approaches are surely inestimable, which is confirmed by a number of cases from top sport to physiotherapy, but from the point of view of complexity of motion, insufficient.

Social movement is typical for a human being. It concerns both historical social movements and the movement of a concrete individual. It concerns those movements that are aimed at a certain target, to reaching a certain value. Social movement is not random movement but targeted even if the target can be mediated. *All consciously realised human movements have the character of social movement.* They necessarily respect, as has been said, the regularity of mechanical and biological movement, but besides that they also respect individual and social conditions, environment, cultural level and so on. *Social movement, as typically human, is the most complex expression of human movement in the world.*

From the viewpoint of the complex concept of a human being as a social being it is necessary to look differently upon one's movement conception. In this form movement is not a mechanical, physiological nor mental problem, but a philosophical problem.

Human movement, "moving", thus must be understood as a certain *form of human behaviour*. We can talk about human *"motion behaviour"*. Movement is, in this case, perceived as a complex that is presented as a certain manifestation of human behaviour. If we want to understand the sense of such understood movement we have to abstract away from all the partial aspects.

A complex understanding of movement is enabled by the fact that it is comprehended in relation to a given subject (who is its holder and producer), in relation to the environment where a subject moves; alternatively, it is comprehended as behaviour of the subject who reacts to the environment. *Into the problem of movement is thus intentionally introduced a subject, the problem of subject and environment, the reaction of a subject to an environment, to different relations and so on. Any* "simple" scientific description or analysis of partial aspects of movement gets into another complex level. There can appear the danger that the scientific level switches to the non-scientific level. As it has been said the only possible way out is the philosophical approach.

Such understood movement presents a continuous flow, in which a *moving subject as well as the world is covered*; *thus the environment and relations in which he/she moves*. By certain movement behaviour the subject responds to specific external and internal impulses in a way that is adequate to the external conditions, to the external world. It is the expression of the *engagement of a specific individual with a given specific situation*, "that" individual into "this" situation. The concrete movement solution of a concrete problem cannot be an "ad hoc" solution. *It is the result of social as well as individual history, anticipation of the future, a given morality, accepted principles, values and norms but also intentions, wishes, etc.* Serious consequences follow from this reality: *movement behaviour is the act or process that can be concretely perceived, but this perceived movement manifestation relates to something that is out of external perception, which is perceived and reflected only by the moving subject*. We can then observe or even assess *how* a subject moves but that is basically it. Motives, reasons, sense, experiences... are saved inside the moving subject, they are basically incommunicable.

In the fundamental and inseparable link of human movement, quite basic developmental changes happened, have happened, and continue to happen. There isn't space here to discuss all the development so let's devote our attention to the present. All human movement is presented in many forms, to us ourselves it is also in various relations. Most of human movement has the character of everyday, working, interest, armed, etc., but let's admit that also sporting belongs to this list, in the sense of performance, so called top sport. It is the movement of its own sense, the target lies outside of anyone. So that it is targeted at performing activities that are determined by individual quality and individual preconditions. The backward impact on a human being in this sense is not important, is thus random and more negatively influencing. It is the movement into which human beings insert themselves, and present themselves in its result. The sense and aim of this moving also negatively influences quality of life and later the health of a moving human being. Moving activities have a totally different character, of which the aim and sense is the individual him/herself. If in the previous case he/she produced something which lies outside of him/herself, in this case he/she produces him/herself.

The sense of this movement is not a product existing outside of anyone but a particular individual, who realises it and becomes, more or less, a perfect product of his/her own movement. If in the previous case the body acted as (let's admit as a perfect) instrument, in this case it is an experiencing, soulful body. Thus not the body as an instrument, but the body as a personalised "I". That's why this is the movement that has (if correctly performed) only a positive relation to quality of life. It is the movement in which all the dimensions of human personality are closely linked and in a mutually determined functioning relationship.

There are movements that are very distant from primitive biological need so it seems that, from this viewpoint, as if it would be purposeless. Their purposefulness is shifted into a higher level in order to ensure other needs and values. The purpose of this new sphere of movement, very quickly expanding, is to *experience one's own being through movement*. This concerns, not only the *deep, intensively experienced knowledge of one's own being* on a level somewhere else unattainable but also about a desirable move of life from the field of *living* into the field of *experiencing*. It is a new quality for the other developments of anyone and is very demanding. The level and value changes are also seen in other spheres. Thanks to the development of technology, communication means, medial means, etc., movement is, from human life, removed, in the sense of amount and intensity. For life at present, hypokinesis is typical and that is why a human being can be called "homo sedens". An absolute absence of movement appears and its negative biological impact is quite evident. Biological necessity is not perceived on the level of securing food or defence but on the level of *maintenance of biological life overall* (see problems of civilised illnesses connected with hypokinesis). Authentic complexity of movements is, thanks to these trends, reduced. Movement, in common as well as in working life, specialises in certain partial practical functions in which a concrete individual becomes unsubstitutable. Just and only through these "functions", the human being becomes visible, thanks to them he/she occupies, in his/her environment, an important position. The individual *conducts him or herself more as a "function" than as an individual*. The splitting and total desintegration of a human personality happens very intensively. This process goes on from the individual further into society. The above-mentioned splitting of a human into functions is thus, at the same time, the determination of his/her approach to the world. Also he/she starts to understand the world as the sum of functions. The consequence of this is the non-complexity of perceiving and thinking and of approaches to solving problems. A further consequence of this is also a perception of the importance of phenomena on the basis of selectness, on the basis of one's own finality following from the experience of one's own "functions". *Individual disintegration thus proceeds into a disintegrated comprehension of the world* and practically to its disintegration. We cannot, of course, have doubts about the negative consequences of these phenomena. From the above-mentioned negative trends, of course, follows the necessity of understanding movement in the integrative sense, compensating for these tendencies and overcoming the process of human disintegration.

Opinions on the presence of movement in human life are surely very various and in accordance with these opinions *the life of each individual differs mutually*. Opinions can be bilaterally very extreme. A famous personality of world science claimed that he has a body so that he can carry (or place) his brain. It is in my opinion the absurd statement of a unilaterally oriented man who had not understood the essence and sense of movement. The mentioned statement consequently means that the aim of movement is only the "transfer of the brain from one place to another". The chanting about human movement in the Olympic poem by P. de Coubertin is of a different character. It begins with the words: "You are a divine gift, a potion of life..." Even if in the first case there is a rigorous statement, in the second case it is evidently about poetic exaggeration; these two statements are extremely contradictory. A similar *contradiction* is however *evident in the whole development of movement* – a celebration of movement and the body in the Antique period, an absence of movement and a devastation of the body in the Middle Ages, a huge opinion but also a plurality "of realisation" in the present.

What is the space between these contrasts? What is real? Of course, we cannot doubt the fundamental statement that movement inherently belongs to life, that life without movement is not possible. Only the perception of movement as an inseparable part of life is different. It already has been claimed that in the most general sense movement can be characterised as whatever change. Perceived change however can have various character, so it can take place at different levels. So we can speak about different kind of movements and about different criteria of its division. The diversity of these criteria follows from a certain concrete "sense" of movement behaviour. Its fulfilment to its full extent is enabled by the fundamental principle of *"self-movement"* that is typical for human movement. "Self-movement" doesn't arise from the conscious necessity to preserve life or achieve other goals. It is *the expression of a specific biological "movement need"*. That one is not already the expression of the primary necessity for food acquisition, defence or reproduction. It springs from the interior of a human being and returns back again. Its volume as well as intensity is conditioned by biological age. *It is movement as externally non-started and non-evoked experience.* A movement, through which a human experiences him or herself on the basic level. With regard to the absence of whatever intention it could be said that it is "purposeless" movement, "movement for movement". *This movement manifestation* of the ability to "experience one self" *has principal existencial meaning for each of us*. It is just the principle of "self-movement" that shows us the way to intentional movement behaviour.

Physical exercises are the specific manifestation of movement behaviour. In the process of their origin as well as historical development both mentioned principles are combined – *fundamental "self-movement" as the inner expression of experiencing one's own self-passing in intentional movement manifestation of cultural character – movement behaviour as the result of abstraction from other movement activities of existentional character with the aim of improving these existential activities.* This process *culminates in understanding physical exercise as intentional movement behaviour, the aim of which is to improve and develop a human being in the sphere of physical, mental as well as in the social sphere in the sense of socialisation and cultivation.* The last two terms, socialisation and cultivation, I regard as fundamental, because even if an individual is our aim, this individual is a part as well as a creator of human society.

Physical exercises are part of every movement that a human is able to produce. They are the main representatives of these movement activities mentioned above that are directly targeted at human being or precisely said, into a human being. Not only because they come from the basic experience of this form of movement but mainly because their sense is a various but complex "processing", forming a human being. *An individual him or herself is the object of physical exercise* by the realisation of them. An other than positive impact can be caused only by their wrong and inadequate application. In certain circumstances, especially in top sport, it can happen that they become a target themselves and a person will be only the instrument of their production.

Movement is inseparably connected with the whole development and existence of human beings. *Terms such as human movement and existence also inseparably belong together.* Thanks to the position that movement has, it is also interesting for many scientific disciplines:

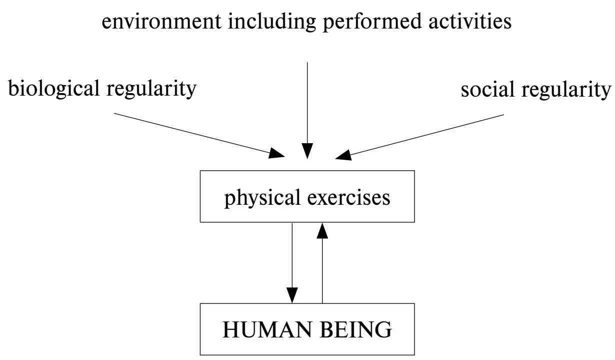
- *philosophy* studies movement and also human movement, in all its dimensions and relations from its origin,
- *pedagogy* considers the educational possibilities of human movement,
- *medical science* investigates human movement in relation to physical and mental health, fitness, longevity, etc.
- *physics* investigates human movement from the viewpoint of mechanical laws,
- *sociology* studies human movement mainly in the socio-cultural sense,
- *aesthetics* studies human movement from the viewpoint of its beauty as well as communication meaning,
- *psychology* studies human movement mainly from the viewpoint of its motivational and educational aspects as well as mental health,
- *ethics* studies human movement from the morality viewpoint,
- *economics* studies human movement from the viewpoint of the comprehension of specific movements in various environments and relations as economical commodities.

Human movement also gets into its consequences in the sphere of *law sciences*.

This listing, of course, does not mean anything else than that human movement and namely its specific kind – physical exercises – become, in certain contexts, *also* an interest of the above-mentioned disciplines. They are not of first and foremost interest but are rather marginal and random. The above listing presents rather a certain *potential that is hidden in these disciplines.*

Physical exercises, thanks to their aim towards a human individual, actually stand as a filter among human beings and the spontaneous random incidence of the external environment and activities realized there, as well as among them and randomly acting biological and societal regularities. Their essence is in optimisation of these effects.

Fig. 1



(From this statement, of course, top and performance sports, in which physical exercises are also contained, must be extracted to a certain extent. Sport assumes a healthy human being but this assumption of health, necessary for sport achievement, is permanently threatened by its own excessively demanding process. In this case thus physical exercises, just as whatever other exceedingly realised activity, threatens human health, because they are the targets themselves. Health is then strengthened or restored also by non-physical means.)

From the viewpoint of physical exercises we most often talk about adaptation to a physical burden and thus about the ability of an organism to *optimally* react to physical strain. This is in fact, with regard to the above mentioned facts, a reduction again. It is to a certain extent understandable, because it relates to basic biological existence but, once again, does not strain one's humanity as such. At the same time, it increases the ability of one's adaptability to psychological strain but for anyone human, adaptation to social strain is typical. Yet, just in society, human social roles are realised and the final "output" is in fact social, even though it is understandably caused at the physical and psychological level. Strictly these social roles, the environment and society's reactions are stress-causing factors, towards which anyone gains the ability to resist. If I speak about fitness, then I have in mind this whole complex, which understandably can be divided into separate parts. But this is mainly for the reason as such: What is the whole complex missing? With gradually increasing strain understandably grows the ability of this entire adaptation. Its result is then a certain level of physical fitness on the basis of which a human person is able to perform certain achievements (living, working, sporting and so on) without threatening the function of the organism by this. So there exists a direct relation movement – adaptation – fitness – health (Dylevský et al., 1997, and others).

Regarding the basic function of fitness we would be able to present tens of definitions of fitness but in this case it makes no sense. In our case there is an important fact that at the present time fitness is oriented towards two basic trends:

- *physical fitness oriented towards achievement* (this concerns mainly sport),
- *physical fitness oriented toward health* (this concerns normal life).

From the viewpoint of the importance of physical exercises it is, for us, important that just physical fitness be oriented towards health. Bunc (1995) assumes that *physical fitness oriented towards health influences health status and has a preventive effect on health problems arising from hypokinesis*. Thus physical fitness oriented towards health can be seen as a defence against the consequences of hypokinesis. Let's try turning over this relation to answer the question of what it is necessary to do, so, as we live our life, we can do so most optimally and with a minimum of threat. Without doubt it will be such a state of the organism that, with its level, gets above the demands of our normal life to that extent so that it prevents not only the exhaustion following from life but efficiently defends against negative effects from the surrounding environment. Thus: *physical fitness oriented towards health is the result of intentional movement behaviour that is characterised by an optimal reaction of the organism to normal life (working, hobbys and other activities) to burdens and to the negative effects of the surrounding environment*. The level of such characterised fitness is relative, in each stage of life it is displayed according to different demands – it is different in a child preparing for social roles and also different in a human being in each stage of productive age, as it is different in seniors.

Fitness oriented towards health consists of several components, among them individual authors have gradually included: *cardio respiratory endurance, muscle strength and endurance, composition of body and weight, flexibility, neuromuscular relaxation, anaerobic and aerobic ability*, respectively speaking about components, *morphological, muscles, motoric, cardio respiratory and metabolic,* eventually *aerobic, muscle, skeletal, motoric and the composition of body* (Fojtík, 1999).

From this incomplete listing the complication of the assessment of fitness oriented towards health is evident. Regarding the fact that it is genetically conditioned, the quality of one's own process leading to fitness is relative and thus hardly valuable. The achieved result has then an orientational character, or one's own subjective feeling that brings us information about the level of strain connected with overcoming the "difficulties of normal life". The relationship of movement activity is, to this kind of fitness, very close. Activity is the condition for adaptation and thus reaching a certain level of fitness and, on the contrary, however the level of fitness undermines and is sufficiently demanding, intensive physical activity. From this it follows that double motivation can be present to physical activity. In a simple form it can be expressed like this:

a) *people exercise because they are healthy and thanks to their natural (genetically undermined) fitness they are motivated so that they devote their overage of energy to intensive intentional movement* – this motivation is evidently more frequent in children and youth, which is basically natural,
b) *people exercise because they feel deficiencies in managing the demands of common life so they want to be more fit and healthier* – this motivation is linked to higher age (especially in those who did not establish motivation from youth in time), is more difficult, and requires great volitional effort.

The level of the final effect of the relation of movement – adaptation – fitness is understandably influenced by *environment, diet, movement routine and total life style*. Final changes of physical fitness oriented towards health and the therewith connected physical health, markedly influence positive changes in the mental and social sphere.

Even if exploration in these spheres is not so frequent as in the physical sphere (this seems as basic as in the sense of life preservation), after all positive effects are sufficiently proved and related to mutual links and the real existence of a psycho-somatic apparatus. That's why physical activity is an important part of mental hygiene. It is a condition of the prevention of a whole range of so called psychosomatic illnesses and lowers emotional tension (Míček, 1984). Physical activity relates to the *overall development of the human personality and its overall cognitive capacity* (Rolland, 1990). Koch's papers (1960, 1979) speak about the differences between the intelligence development of a child when intentionally moving and not moving. With regard to the large amount of physical exercises that are themselves mentally demanding, with regard to the fact that they are realised in demanding situations and in a demanding environment, they train anyone in *tolerance against stresses and gradually adapt anyone to stressful life situations* (Mota & Cruze, 1998; Hošek, 1994; and others). A range of authors have drawn attention to the influence of physical activity, to the *overall mental condition of an individual*. Thanks to the above- mentioned physical demandingness, *will, mental endurance, persistence, self-discipline, decisiveness and courage, etc.* are trained. Not in vain "survival" activities are used in the training of managers where in demanding activities and demanding environment just these characteristics are trained.

With exceptions physical activity is realised in larger or smaller groups. A specific microclimate is thus created in which specific interindividual relations appear. Demandingness of the process itself as well as an environment in which physical activity is realised evokes a specific kind of behaviour as the answer to existing situations, respectively, the condition for its solution. *Mutual tolerance, mutual respect, responsibility for other people, mutual help, leadership, the ability to be aware of one's own position in the group, the ability to subordinate, etc.* are gradually "trained". By its own demandingness to interindividual relations, common living situations in this environment are often overcome. Thus "trained" people manage these situations easily, with greater grasp. Some researchers in the past spoke about a *lower frequency of social conflicts, abouta decreaseinf conflicts in the course about the supremacy – subordination, etc.* of these people. Family is a specific kind of social environment and is considered to be an elementary unit of society in which the first social contacts and relating problems occur. Many authors follow Berdychová (1978), who, as the first in our Czech environment, started to study the problem of physical activity in the family.

Physical activity in the family belongs among important factors consolidating the social health of the family. From that it follows that: *mutual communication among particular members of the family improves; parents better perceive specialities of their children and can better guide their development; children get to know specific features and abilities of their parents, get close to them; on the basis of mutual knowledge there is mutual natural respect, but also mutual confidence, devotion etc., which increase; mutual links are established on the basis of concrete situations; children obtain the necessary impulses for leading their adult life.*

The final effect of physical activity, especially in mental and social spheres, is in addition intensified by experiencing (see the relevant literature). A certain kind of experience is understandably the *consequence of not only whatever activity, but also the perception of external impulses* (nature, music, literature, pictures and others). These experiences are of course connected with certain analysers so that they have limited character – an aesthetic experience from the perception of a picture or music, a feeling of satisfaction from a well-done activity, satisfaction from a successful examination, etc. Physical activity brings experiences of a different kind. Their base is in corporality (the body perceives and reacts), *in concrete physical as well as mental feelings accompanied by other sensations of an aesthetic or social* nature. Physical experience is thus very complex and that's why it is stronger and permanent than other experiences.

(Note: The Mentioned positive effects are understandably possible only when correct guidance of physical activity is provided. Moreover, it includes "healthy oriented" activity and doesn't have a "performance" character. To a different mechanism is related "performance oriented" activity because the target of this activity is markedly different – performance. This also influences the sense of activity, its course as well as its effect in all spheres – physical, mental and social. It is a totally independent sphere and its solution cannot be an application of the above mentioned effects.)

Likely because physical exercises, as a certain form of movement, have a physical character, affecting a human being through his/her material body, it is also why the perception of their incidence on the physical dimension of a human being occurs most often. Very elaborate mechanisms exist; through them it is possible to influence the prevention, development or maintenance of physical health (see the relevant literature). If we realise the incidence on the mental sphere if it occurs, however it might be rather mediated, as the consequence of physical and mental relations, as a consequence of this basic physical process that is connected with certain mental feelings (fatigue, pain, fear, unusual or demanding environment, weather conditions etc.), we will see that they are necessary to overcome. The perception of incidence on the social sphere is at an even lower level and thus just this is the expression of the overlapping of a human being with society and with the world. Most activities of physical character are realised in larger or smaller, quite heterogeneous groups that themselves are quite socially demanding. This demandingness is intensified by the demandingness of situations to which their own processes occur, by rising conflicts, the necessity of cooperation, mutual help and so on. A social microclimate in an "exercising" group is very demanding and markedly changes social perception as well as the reaction of an individual. Physical exercises are thus able to affect quite intentionally and concentratedly not only the physical sphere but with the same quality (not only derived) also the mental and social sphere; and of course, a complex of all of the above. It concerns physical exercises that are part of our "Western" systems, it moreover concerns some Eastern systems which are more and more involved and quite intentionally oriented towards health in its complexity.

What causes these reduced partial approaches to human being, to health as well as the means of its formation – physical exercise? It is evidently the inability to see a man *as a whole, as a mutually interconnected unity of all mutually influenceable, influencing and compensating parts* (here I would like to emphasise that it is just the mutual ability to influence and compensate). It is *the inability of understanding the unity of a human being and the world as well as misunderstanding the essence of movement* (in our case physical exercises). It is an evident *consequence of misunderstanding the philosophy of the body*.

The assumption and manifestation of life cannot be reduced only to the physical sphere but it is necessary to respect the mutual interconnection of physical, mental (where we can include also "spirituality") and social aspects. This mutual link is justified as:

a) It is necessary to refuse the still lasting *Cartesian opinions* connected with splitting a human being into two (inconsistent) substances – the *"body"* (corpus) and the *"soul"* (animus), as well as possibly the *"mind"* (mens). This disunity allows for an inadmissible "reduction" of a human being into particular components. On the contrary it is necessary to understand in the spirit of phenomenology the philosophy of a *human being as a unit*. It means understanding that a human being is just *through his/her body quite present in this world* that *he/she is a body* and also *has a body*. Whatever our feelings and whatever our thoughts, it is not possible without the body. "Material" and "non-material" ("animal" and "transcendental", Anzenbacher, 1991) penetrates into unity; one without the other is not possible. For this reason we cannot even agree to the relationship to health as in the well-known saying "mens sana in corpore sano" because it is a dualistic expression even if admitting the same importance to both spheres. We lean towards the expression "homo sanus" (healthy human). From this concept follows, that if we speak about the human body, we don't speak about it as a certain part of the human being but as an integral component of the complete human being, about the embodiment of the human individual as being in the world.
b) This monistic understanding of a human being is thus moved even further behind the connection of "corporality" and "spirituality". If human beings are, through their bodies, "present in this world", (if "my body is me") and are perceived like this by the surrounding society in which we live, so we are perceived as social beings. An individual "body" gets into relations with other "bodies" so that it becomes a social problem. The "Body" obtains a social character. A "Body" thus represents different social roles that a human being has accepted. The final representation of a human, as well as the final representation of a "body" is understood in a social sense. It is that final output that is understandably determined by both the physical and mental level. In this embrace it is possible to go even further and understand the "body" as not only part of the society but also of nature and of the whole world. (For details about the problems of "body" as a concept see the literature concerning the philosophy of the body.)

If we come back to the basis of these considerations to the movement as an assumption and a manifestation of the human body, we have to understand it also in the sense of final (and thus the most important) social output. Human movement itself is very various not only in the sense of different kinds of movement but also in the sense of its volume, intensity and frequency. Not only one mention exists that with growth of civilisation, human physical movement is on the decline and that of course, negatively reflects on the human being (with the growth of hypokinetic civilisation diseases, the insufficient physical preparation of adepts for army service and the like). It seems that more apposite for our kind than "homo sapiens sapiens" or "homo faber" begins to be the expression "homo sedens". Understandably with a consciousness of all the consequences that follow from this.

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FILOZOFICKÁ A SOCIOKULTURNÍ PODMÍNĚNOST LIDSKÉHO POHYBU JAKO DETERMINANTY KVALITY ŽIVOTA
(Souhrn anglického textu)

Kvalita života má nesporně svoje předpoklady. Ty jsou u člověka, vzhledem ke struktuře jeho osobnosti, velmi variabilní. Proto je velmi obtížné hovořit o filozofické a sociokulturní podmíněnosti pohybu jako determinanty kvality života. Nicméně je to však potřebné. Tento příspěvek tedy zkoumá z hlediska těchto vztahů především problém zdraví, potom problém pohybu, resp. lidského pohybu a následně problém tělesných cvičení jako záměrného pohybového chování člověka. Obrací pozornost na vztah tělesných cvičení k tělesné zdatnosti orientované na výkon a k fyzické zdatnosti orientované na zdraví. A pochopitelně zůstává u této orientace na zdraví.

Klíčová slova: lidský pohyb, kvalita života, životní styl, zdraví, zdatnost, blaho, arété, tělo, tělesná cvičení.

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THE VARIABILITY ASSESSMENT OF THE DYNAMIC GAIT PARAMETERS OF PERSONS WITH UNILATERAL TRANS-TIBIAL AMPUTATION

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Human gait is a genetically fixed motion model. The use of prosthesis changes the structure of the gait, the distribution of energy increases. The aim of this study was to compare the intra and inter individual variability of the basic dynamic gait parameters of physically active persons with unilateral trans-tibial amputation. A group of 11 males (age 46.1 ± 12.0 years, body weight 82.5 ± 13.9 kg) with unilateral trans-tibial amputation was analysed. The basic dynamic parameters (AMTI) of the gait of each subject with conventional and dynamic prosthetic foot were measured. The inter-individual variability in the group of the evaluated person is higher in comparison with the intraindividual variability. The sizes of the coefficients of reliability are exceeded for measured parameters (time, force, force impulse) in antero-posterior and in vertical direction the value 0.976. The extent of these values depends on the individual properties of evaluated person (for example the instability of the knee etc.).

Keywords: Gait, variability, dynamic, trans-tibial prosthesis.

INTRODUCTION

Human gait is a genetically fixed motion model, which forms due the individual properties during ontogenetic evolution. On one hand it is a movement activity with a lot of similar attributes during the execution by the various sorts of people. On the other hand it is also possible to observe by person different modifications. These differences related with health, mental components, changes in the external conditions etc. Every person chooses meanly the possibility the cadence of the gait, which allows him minimise the energy distribution. Soderberg (1997), Trew and Everett (1997) determines the magnitude of the vertical oscillation of the centre of mass as the criterion of the economy of the gait. For the facility of the quantitative analysis of the gait the maximal restriction of the negative parameters is needful. Very often is the gait of given individual described only on the basis of one attempt (one stride).

The situation is complicated for the persons who used the prosthesis. The changing of the locomotive stereotype may influent the replacement of the limb (segment), which does not related "directly" with the execution of the gait. The afferent information from the periphery is very important for the reflex modification of the movement pattern (Králíček, 1995). But this information disappears by the use of the prosthetics foot. Concurrently the identical input can produce various answers, in dependency on the phase of the gait cycle during that the input is affected (Mayer, 2000). The functional disorders of the motion system are appearing in the diverse muscles activation (Rose & Gamble, 1994). The use of prosthesis changes the structure of the gait, the distribution of energy increases (Torburn et al., 1990; Macfarlane, Nielsen, & Shurr, 1997; Whittle, 1997). The prosthetic foot is less capable of absorbing and generating energy in comparison of the healthy limb. All these factors increase requirements on the stability of the movement. Inter and intrarater reliability of the two minutes walk test in individuals with trans-tibial amputation evaluated Brooks et al. (2002). The various type of the prosthesis influences also the loading of the sound limb (Bateni & Olney, 2002; Janura, Svoboda, & Elfmark, 2005). In doing so we have to start with the presumption that the properties of the prosthetic components of comfort and mobility are the two most important characteristics (Klute, Berge, & Segal, 2004; Van der Linde et al., 2004; May, 2002).

OBJECTIVES

The aim of this study is to compare the intra and inter-individual variability of the basic dynamic gait parameters of physically active persons with unilateral trans-tibial amputation.

The application of the prosthetic foot does not have to be the reason of the differences increasing if we assess the intraindividual variability of the gait parameters. The technique of this movement activity in common conditions can induce by the healthy person the sense of the security. It means to use "stand-by" if the conditions get worse. The abilities for person with the prosthetic foot are considerably reduced.

MATERIAL AND METHODS

The group of 11 males (age 46.1 ± 12.0 years, body weight 82.5 ± 13.9 kg) with unilateral trans-tibial amputation was analysed. These subjects had been wearing their current prosthesis on average for 13.8 ± 12.5 years. The basic dynamic parameters (AMTI) of three walks of each subject with conventional (SACH) and dynamic (SUREFLEX) foot were measured. The force platforms data were normalised by the gravity force and analysed with the Matlab software.

The conventional prosthetic foot (low activity degree of the user) is stable foot with hardwood keel. Movement in the ankle is realised in the sagittal plane only. Stability in the end of the stance phase is poor. For the dynamic prosthetic foot (middle activity of the user) with the keel from graphite composite a good energy accumulation and subsequent release is typical. It is more expensive but also more comfortable for the active person. In ten subjects, the indication for amputation was traumatic reason whereas cerebral pathology was the indication in one candidate. In three of the subjects amputation was carried out for the right leg, while in the other eight it was the left leg. Six of the subjects had the KBM socket (conventional socket for transfer of load and suspension of the prosthesis, can be also applied with a silicon liner). Five of the amputees had the TSB socket prosthesis (full-fledged stump-socket fit with even pressure distribution, only with silicon liner). All amputees perform ordinary everyday activities, four of them practice active sports.

Prior to the measurement itself, each subject underwent adjustment and setting of the dynamic prosthetic foot by three prosthetic technicians. After testing the movement activity and after completion of three trial runs for this study, the dynamic foot was substituted by a conventional prosthetic foot and the entire procedure was repeated.

The statistical analysis of the examined data the programme Statistica 6.0 (ANOVA, coefficient of reliability) was used.

RESULTS AND DISCUSSION

The values of the coefficient of reliability for separated group of parameters are given in TABLE 1.

TABLE 1
The range of the coefficient of reliability of measured parameters on sound and prosthetic limb

	Prosthetics limb		Sound limb	
	SACH	Sureflex	SACH	Sureflex
Time parameters – step	>0.976	>0.982	>0.991	>0.991
Time parameters – stride	0.997–0.999			
Force parameters – step	>0.994	>0.989	>0.994	>0.994
Impulsion of force – step	>0.990	>0.976	>0.983	>0.993

Notice
In TABLE 1 are introduced the values of the parameters measured in antero-posterior (AP) and in vertical (V) direction. For medio-lateral (ML) direction we notice a considerable accrual of the intraindividual variability of the force variables.

INTRAINDIVIDUAL VARIABILITY

The graphical depiction of the force-time dependency on the prosthetic limb in AP and in vertical direction by the selected person is on the Fig. 1. Even though they exist differences between these individual attempts it is possible to find similar characteristics. They are typical for the gait with given type (sometimes also with both types) of the prosthetic foot.

On the Fig. 2 is the comparison of the reaction force curve in vertical direction on the sound and disable limbs, various types of the prosthetic foot are used. The shape of the curves for three attempts with given type of prosthesis is similar. The magnitude of the maximum force in the acceleration and braking phase differs. Tendencies of the changes between sound and prosthetic limbs are similar. The values in the walking with the classic prosthetic foot are bigger for both (disable and sound) limbs.

Fig. 1
The shape of the reaction force curve in antero-posterior and in vertical direction by the use of the various type of the prosthetic foot

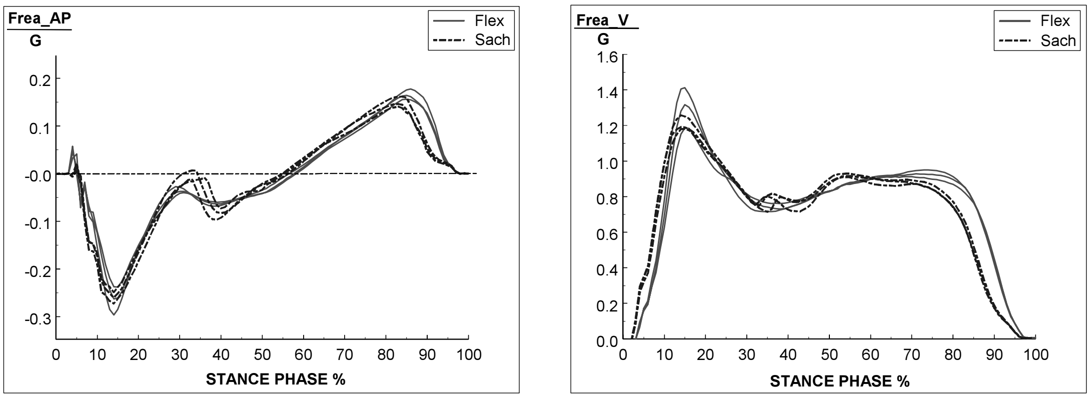
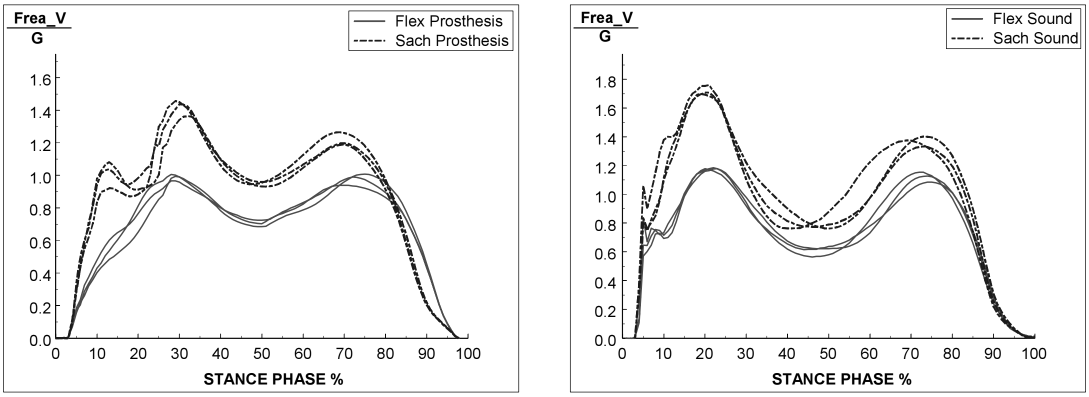


Fig. 2
The shape of the vertical component of the reaction force in contact phase of the step on the prosthetic (various types of the prosthetic foot) and sound limb

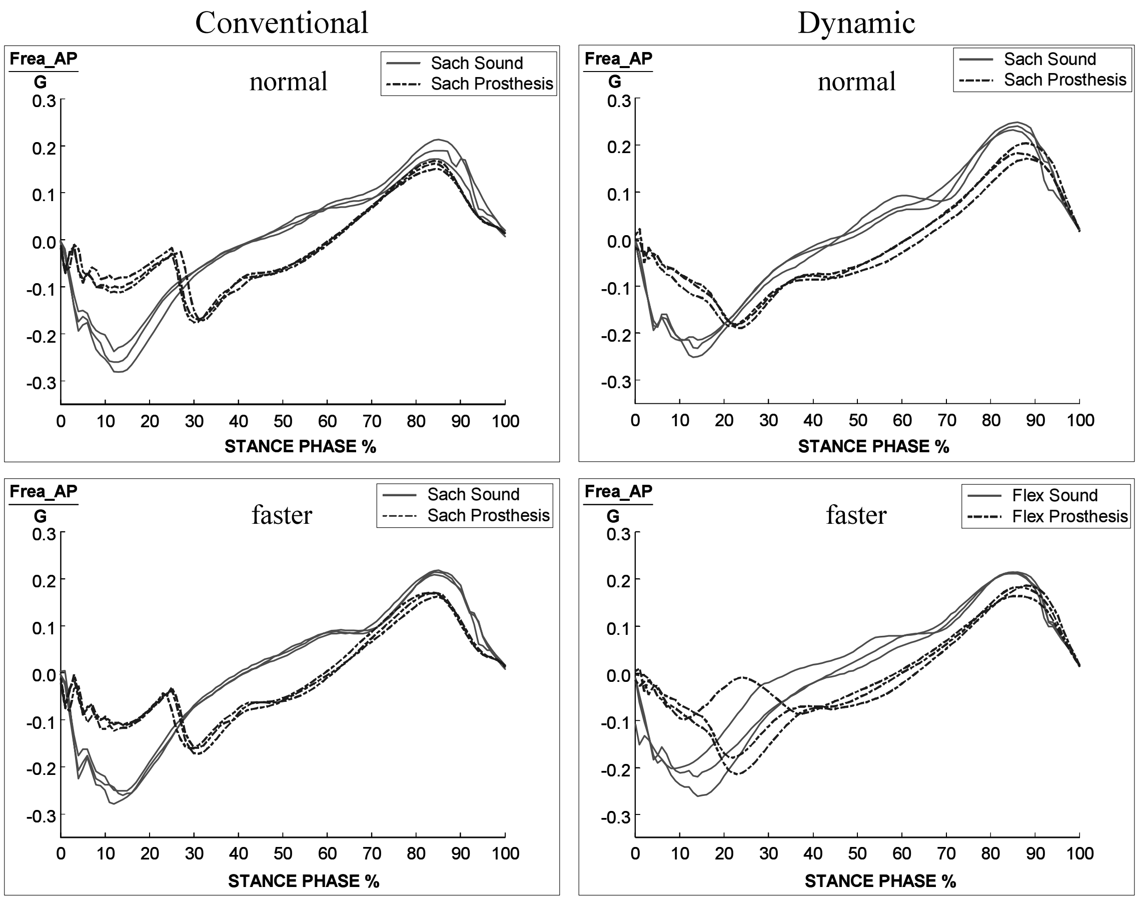


INTERINDIVIDUAL VARIABILITY

The traits of the selected components of the reaction force differs considerable among measured persons. The magnitude of the force impulse in the acceleration and in the braking phase of the step is changing. The number of the local extreme of the reaction force increases when using the prosthetic foot. The "classic" double apex curve is replaced by the curve with three and more apex. In the end of the braking phase is coming up the additional "deceleration" just before subsequent acceleration of the motion. There exist also differences in the magnitude of the maximal force in the vertical direction in the contact of the foot with the pad like that in the time of the achievement of this maximum. For some persons we did not find the increasing of the force in the final part of take off. The significant differences among individual subjects we found also during the gait with the dynamic prosthetic foot. The size of these differences is smaller in comparison with the use of the conventional foot.

The magnitude of variability for various gait speeds is related to the overall health state and motion activity level of a given person. For people who execute common daily activities in a limited range, the variability of dynamic variables decreases with the use of a conventional foot (Fig. 3). Therefore the influence of speed accruement is necessarily considered in relation to the properties of the prosthetic foot and the internal variables of the locomotion system of each person.

Fig. 3
The influence of the gait speed on the shape of the force curve in the antero-posterior direction when using both conventional and dynamic prosthetic feet in users with a lower motion activity level



In subjects with amputations it is impossible to individually determine if the usage of prosthetic devices results in a decrease or, conversely, in an enhancement of parameter variability. The character of changes can be a criterion for the quality standard assessment of prosthetic tool setting. The variability of kinetic (GRF) parameters changes with walking speed alteration. From the movement control standpoint, the optimal speed was found to be (5.5–5.8 km.h^{-1}), which applies only for the propulsion control mechanism (Masani, Kouzaki, & Fukunaga, 2002).

Variance in gait speed within sessions is greater in healthy subjects as compared to persons with trans-femoral amputation (Boonstra, Fidler, & Eisma, 1993). Loading asymmetry increases during walking between the artificial limb and healthy limb. In healthy individuals the reaction force difference is under 10% (Hamil et al., 1983 in Nolan et al., 2003; Herzog et al., 1989), in amputees this difference is exceeded by 23% (Engsberg et al., 1993). It is impossible to increase the gait speed in subjects with amputation if this increase results in a loading of the asymmetry growth (Nolan et al., 2003). The variability of gait parameters over 5 days in persons with trans-femoral amputation is greater than during one day (Dundass, Yao, & Mechefske, 2003). The amount of this variation among trials increases for amputees as compared with healthy subjects (Zahedi et al., 1997).

CONLUSIONS

The execution of the gait in the group of person with trans-tibial amputation is stable from the point of view of the basic dynamic parameters. The interindividual variability in the group of the evaluated person is bigger in comparison with the intraindividual variability. The sizes of the coefficients of reliability are exceeded for measured parameters (time, force, force impulse) in antero-posterior and in vertical direction the value 0.976. The extent of these values depends on the individual properties of evaluated person (for example the instability of the knee etc.). The similar tendencies were found for the stability of the dynamic parameters on both types of the prosthetic foot as well as on the sound limb. The variability of the measured parameters in medio-lateral direction significantly increases inside the group like that for individual person.

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HODNOCENÍ VARIABILITY DYNAMICKÝCH PARAMETRŮ CHŮZE U OSOB S JEDNOSTRANNOU TRANS-TIBIÁLNÍ AMPUTACÍ

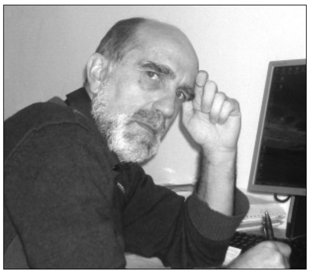
(Souhrn anglického textu)

Při analýze pohybové činnosti člověka musíme vždy řešit otázky, které se vztahují k validitě naměřených hodnot. Realizace každého pohybu, tedy i chůze, se vyznačuje určitou mírou variability. Přitom variabilitu v určitém rozsahu nelze považovat jako něco negativního, co může být způsobeno problémy v nervovém nebo kosterně-svalovém systému. „Přirozená" variabilita (variabilita ve „fyziologickém" rozsahu) je součástí zdravých biologických systémů. Reedukace chůze u osob s trans-tibiální amputací se projevuje ve změně variability kinematických a dynamických charakteristik. Pro možnost kvantifikace těchto změn a pro určení vlivu různých typů protetických chodidel (klasické – SACH, dynamické – SUREFLEX) jsme provedli dynamickou analýzu chůze u 11 mužů (věk 46,1 ± 12,0 roku, hmotnost 82,5 ± 13,9 kg) s jednostrannou trans-tibiální amputací. Interindividuální variabilita v rámci dané skupiny je větší v porovnání s intraindividuální variabilitou. Hodnoty koeficientu reliability jsou pro měřené parametry (čas, síla, impuls síly) v antero-posteriorním a ve vertikálním směru větší než 0,976. Jejich velikost souvisí s individuálními vlastnostmi sledovaných osob.

Pro oba typy protetického chodidla, podobně jako pro zdravou končetinu, jsou tendence pro stabilitu dynamických parametrů podobné. Stabilita měřených parametrů v medio-laterálním směru se významně snižuje uvnitř sledované skupiny i pro jednotlivé osoby. Velikost variability při různé rychlosti chůze souvisí se zdravotním stavem a se stupněm pohybové aktivity daného probanda. Pro osoby, které vykonávají běžné denní aktivity v omezeném rozsahu, je variabilita dynamických parametrů chůze nižší při použití klasického chodidla.

Klíčová slova: chůze, variabilita, dynamika, transtibiální protéza.

Doc. RNDr. Miroslav Janura, Dr.



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MYOELECTRIC COMPARISON OF TABLE TENNIS FOREHAND STROKE USING DIFFERENT BALL SIZES

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The aim of this study was to examine the differences between forehand top spin strokes with 38 mm and 40 mm balls in table tennis. The participant was filmed as he executed the strokes. To ensure the same condition for all the performances (the same approaching ball trajectory), a table tennis machine was used. Electrodes were placed on the right side of the player's body due to his right-handedness. Absolute muscle involvement was estimated on the basis of averaged EMG signals (mV) measured in all muscles (m. biceps brachii, m. deltoideus, m. pectoralis major). Analysis of variance (ANOVA) was used for calculating differences between overall mean values of averaged EMG signals among all muscles. The peak EMG amplitude of the m. deltoideus anterior reached a value of 2.5 mV, for the 38 mm ball stroke. The comparable contraction values in strokes with balls of both sizes were obtained with the m. deltoideus medialis: the peak values ranged between 2.3 and 2.8 mV with a 38 mm ball and between 2.2 and 3.0 mV with a 40 mm ball. For the m. biceps brachii the peak EMG amplitude ranged from 1 to 2.2 mV and from 1.3 to 2.4 mV for the 38 mm and 40 mm ball strokes, respectively. A similar result was obtained for the m. pectoralis major contractions. Rather uneven intensities of contractions were obtained for the 38 mm ball strokes, ranging from 1.5 mV to 2.6 mV. More balanced values were obtained for the 40 mm ball strokes ranging from 1.6 to 2.2 mV. These findings showed us that in three observed muscles (m. deltoideus anterior, m. biceps brachii, m. pectoralis major) differences in the intensity of EMG signals are significant, so we can conclude that the player uses more muscle activities in a stroke with the larger ball, and also we conclude that the contraction of m. pectoralis major is more powerful when the player hits the larger ball.

Keywords: Table tennis, forehand stroke, EMG, muscle activity.

INTRODUCTION

The ultimate concern in high-performance sport is the final performance, whether it is while training or at the competition. The final output that is observed is dependent on a complexity of factors. Each of them may contribute a variable amount to the performance. In modern table tennis we have changed some rules and some materials due to slowing down the game. But, nevertheless, the majority of top-level players prefer to concentrate on attacking or counter-attacking. Most international competitors favour the forehand spin stroke to produce high velocity and high rotation. However, the stroke angle has been changed since the circumference of the ball has been enlarged. The shoulder girdle muscles are today exposed to different loads than before because shoulder abduction should be performed more quickly and vertically now.

Physical conditioning and strength training, as well as modern physical fitness diagnostic procedures are becoming ever more important in the contemporary sports training process, including table tennis. In the course of table tennis history, systematic programmed training has become more important after attack strokes have been introduced. Numerous injuries to the shoulder girdle muscles compel us to investigate the strains to which individual muscles are prone in the execution of certain table tennis strokes (Priest & Nagel, 1976; Dervišević & Hadžić, 2002). Some specific tests allow the measurement of specific fundamental factors that are assumed to be important in the performance.

The first functional classification of individual muscles according to certain table tennis techniques was presented by Ogimura (1973). A multiple world champion with a markedly attacking style assigned a great influence primarily to the *m. biceps brachii*, *m. deltoideus*, *m. pectoralis major* and stomach muscles. *M. biceps brachii* is especially important in his opinion because it is responsible for flexion of the arm in performance of quick forehand spin strokes. Performance of basic returns is based, according to him, on the good functioning of *m. triceps brachii* and the back muscles. Ogimura's classification is, probably, based on his personal observations and self-observations and considerations, since no data are available on the systematic influence that particular muscles or muscle groups have on performance of strokes.

Hiruta et al. (1992) found that the level of muscle strength and muscle power for elite table tennis players was similar to that of the average person. One of the reasons why the back strength and the vertical jump were performed so badly seems to be connected to the lack of muscle strength training.

Yet Takeuchi et al. (2002) pointed out that due to the larger diameter and mass of the 40 mm ball, physiological effects may be present and technical adjustments may be required. About 63% of the respondents reported more physical fatigue after the games using the 40 mm ball (compared with 38 mm ball). Therefore, a high level of physical fitness, especially speed endurance, should be enhanced in order to overcome the physical challenges resulting from the larger mass of ball and the longer rallies.

At the beginning of the year 2000, the International Table Tennis Federation announced the replacement of the 38 mm ball with the 40 mm ball. It became evident that, due to the decreased ball speed and rotation, players would have to devote more time to physical preparation if they wanted to perform as well as before. The performance differences between the players in better physical condition and those less prepared became apparent at the World Championship in Osaka in 2001. At the first world championship played with the larger ball, the number of strokes per rally increased, meaning that matches lasted longer and became more demanding. Taking into account the rigours of a two week competition, it turned out that physical preparation, and the additional strengthening of the shoulder area in particular, would become a crucial factor for sport success.

As with most of the acyclic movements, a three-part movement pattern can be observed in table tennis strokes: the preparation phase, followed by the main phase, during which a motoric problem is being solved (i. e. the ball hitting the racket), and the closing phase.

The function of the preparation phase is to optimally prepare for an efficient and economical performance in the main phase. In table tennis, the preparation phase is represented by an arm swing. The principal characteristic of this phase is that its performance is done in the opposite direction to the main phase. The swing of the arm with the racket gives the musculature an optimal means of functioning and a favourable angle of the joints involved in this movement (shoulder, elbow and wrist). The main phase represents the activation of all muscle groups involved in the so-called kinetic chain. The closing phase solely represents an inertness of the main phase which must be immediately interrupted in order to prepare for a new stroke.

From the viewpoint of which individual muscles are involved in a stroke performance, the appropriate physical condition of a table tennis player is questionable. A larger ball requires that the player possess better physical condition, which is determined by the different biomechanical characteristics of a forehand spin stroke. A review of the literature indicates that investigations attempting to examine body action in table tennis have been few and limited in scope.

The aim of our research was to find out if there are differences between forehand top spin strokes with a 38 mm as opposed to a 40 mm ball regarding the shoulder and upper body muscles. The gathered data should facilitate planning of the training process of table tennis players.

METHODS

Design

To design an optimal physical preparation for table tennis players, it is essential first to establish exactly which muscles of the shoulder area work harder due to the large ball (40 mm). We measured the magnitude of the difference in myoelectric signals between the forehand strokes performed with the 38 mm and the 40 mm balls. The greater turn (in the 40 mm ball strike) should ensure the greater angular velocity of the shoulders, which should also assist in generating higher linear velocities of the arm, forearm and hand segments. We analysed the muscles that are primarily involved in the forehand attack: *m. deltoideus, m. biceps brachii and m. pectoralis major.*

Participants

The intensity, as well as the duration of the contraction of the above-mentioned muscles was measured on a professional male table tennis player, a member of the national team. The data were collected and analysed both visually and quantitatively.

Materials

The EMG signal measurement technique is a standardized one and corresponds to the classical procedure of detection, amplification and registration of bioelectrical activity changes in the skeletal musculature (Mereletti, 1999). It uses a differential mode of detection, with two electrodes, positioned at the midpoint of the measured muscle at a standardized distance of 3 cm (centre to centre) along the muscular fibres. The differential detection successfully suppresses noise (Medved, 2001). The "Elite 2002" (BTS Bioengineering, Milan, Italy) biomechanical system was used for data collection and analysis.

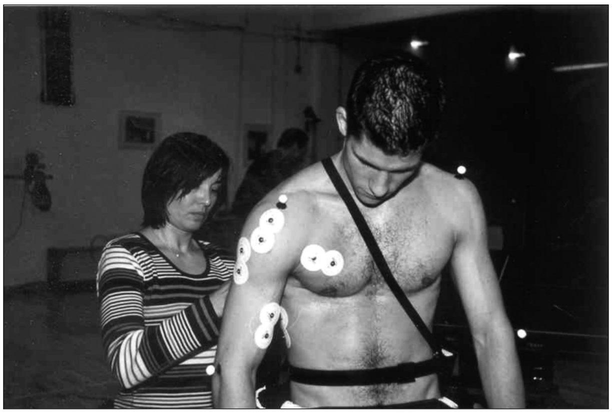
Procedure

The measurements were conducted during 100 forehand top spin strokes performed with balls of two sizes: 38 mm and 40 mm. The participant was filmed as he executed the strokes. To ensure the same conditions for all the performances (the same approaching ball trajectory), a table tennis machine was used. Electrodes were placed on the right side of the player's body due to his right-handedness. The intensity and duration of contractions of the following muscles were measured (Fig. 1):

1. Channel – *m.deltoideus anterior*
2. Channel – *m. deltoideus medialis*
3. Channel – *m. biceps brachii*
4. Channel – *m. pectoralis major*

In this study we have also used a method of kinematic analysis which enables the precise registration and evaluation of the most significant parameters of forehand top spin strikes.

Fig. 1
Electrodes placement



Methods for measured signal processing

Averaged EMG signals were translated into a numerical ASCI format and stored into the computer. SPSS statistical package was used for the statistical signal process.

Absolute muscle involvement was estimated on the basis of averaged EMG signals (mV) measured in all muscles (Medved, 2001). The mean value of averaged EMG signals was calculated for each analyzed muscle, and for both balls. Descriptive statistical parameters (min, max, mean, and SD) were calculated for these data. Analysis of variance (ANOVA) was used for calculating differences between overall mean values of averaged EMG signals among all muscles.

RESULTS

At first it looks as if there are no differences in the intensity of contraction of the observed muscles when striking the 38 mm ball. A more thorough analysis of the signal amplitudes of the observed, loaded muscles, though, reveals certain differences in the features of contraction in favour of the larger ball strokes, as expected.

Fig. 2a
EMG signal of m. deltoideus anterior with a 38 mm ball

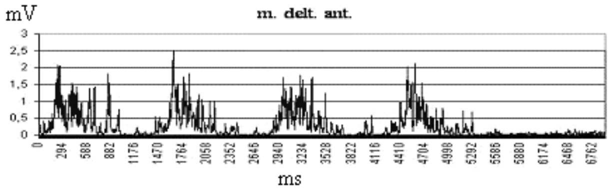


Fig. 2b
EMG signal of m. deltoideus anterior with a 40 mm ball

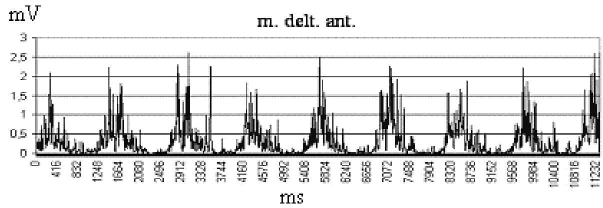


Fig. 3a
EMG signal of m. pectoralis major with a 38 mm ball

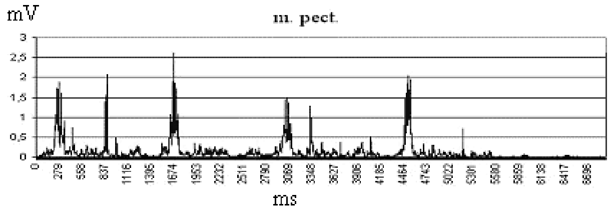
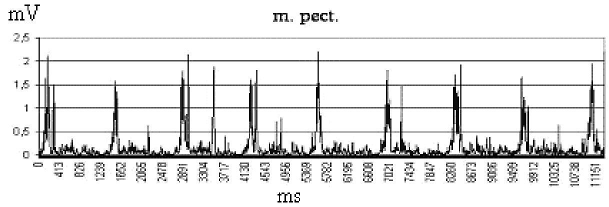


Fig. 3b
EMG signal of m. pectoralis major with a 40 mm ball



The peak EMG amplitude of the *m. deltoideus anterior* (Fig. 2a) reached a value of 2.5 mV, for the 38 mm ball stroke, but only for one out of the four registered strokes, whereas for the rest of the three registered strokes the value approximated 2 mV. With the 40 mm ball (Fig. 2b), nine strokes were registered, and in seven of them the peak EMG amplitude was higher than 2 mV, and in two it exceeded a value of 2.6 mV.

The comparable contraction values in strokes with balls of both sizes were obtained with the *m. deltoideus medialis*: the peak values ranged between 2.3 and 2.8 mV with the 38 mm ball and between 2.2 and 3.0 mV with the 40 mm ball. Due to the results, obviously, *m. deltoideus* is highly involved in stroke execution due to the fact that its primary function is upper arm abduction. In a forehand stroke, the upper arm moves from adduction to a front raise diagonally inwards.

Greater differences in contraction intensities are obvious from the data obtained for the other two observed muscles. For the *m. biceps brachii* the peak EMG amplitude ranged from 1 to 2.2 mV and from 1.3 to 2.4 mV for the 38 mm and 40 mm ball strokes, respectively. The difference is by no means irrelevant when compared to the minute size differences between the old and the new ball.

A similar result was obtained for the *m. pectoralis major* contractions. Rather uneven intensities of contractions (Fig. 3a) were obtained for the 38 mm ball strokes, ranging from 1.5 mV to 2.6 mV. More balanced values were obtained for the 40 mm ball strokes ranging from 1.6 to 2.2 mV (Fig. 3b).

Another substantial difference existed in the all detected muscles contractions (Fig. 2b, 3b). The 38 mm ball stroke contraction has only one peak (the maximal contraction), whereas in the 40 mm ball stroke two peaks occurred. This peculiarity could be explained by additional voluntary contraction (the so-called squeezing). It further means that muscle contraction in the 40 mm ball stroke lasts somewhat longer than in the 38 mm ball stroke.

There were significant differences in ANOVA, in results between *m. deltoideus anterior, m. biceps brachii* and *m. pectoralis major*. In the *m. deltoideus medialis* there were no statistically significant differences between strokes with a 38 and 40 mm ball.

Results of the kinematic analysis of the forehand top spin stroke point out to us that there are differences between the strokes with a 38 as opposed to a 40 mm ball. The peak velocities and speeds of the bat ranged from 8.488 m/s with the smaller ball to 9.485 m/s with the larger ball. Peak velocities of the shoulder, of two different strokes, were found to differ significantly in the vertical direction. The speed of the shoulder ranged from 4.650 m/s in the stroke with smaller ball to 5.619 m/s with the larger ball.

TABLE 1

Basic parameters of EMG signals in mV (descriptive statistics)

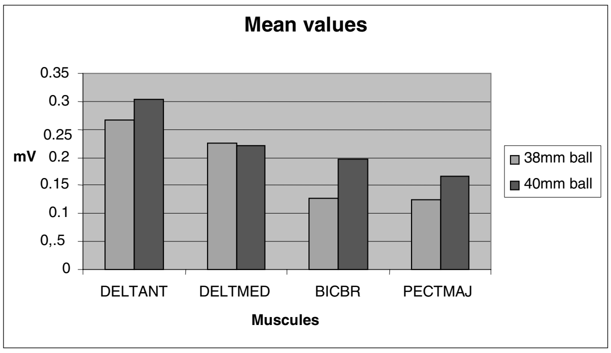
	Maximum		Minimum		Mean		SD	
	38 mm	**40 mm**	**38 mm**	**40 mm**	**38 mm**	**40 mm**	**38 mm**	**40 mm**
DELTANT	2.50492	2.61745	0.00179	0.00234	0.26669	0.30419	0.37062	0.38737
DELTMED	2.75649	2.97182	0.00507	0.00187	0.22477	0.22006	0.33699	0.35829
BICBR	2.11823	2.34271	0.00011	0.00312	0.12668	0.19720	0.22696	0.33222
PECTMAJ	2.60692	2.19047	0.00027	0.00316	0.12478	0.16702	0.25376	0.28705

TABLE 2

Results of ANOVA

		Sum of squares	df	Mean square	F	Sig.
DELTANT	Between Groups	6.029	1	6.029	41.509	.000
	Within Groups	2644.814	18210	.145		
	Total	2650.842	18211			
DELTMED	Between Groups	9.527E-02	1	9.527E-02	.776	.378
	Within Groups	2235.398	18210	.123		
	Total	2235.493	18211			
BICBR	Between Groups	21.320	1	21.320	242.141	.000
	Within Groups	1603.358	18210	8.805E-02		
	Total	1624.678	18211			
PECTMAJ	Between Groups	7.649	1	7.649	101.223	.000
	Within Groups	1376.131	18210	7.557E-02		
	Total	1383.781	18211			

Fig. 4
Mean values of EMG signals



DISCUSSION

The deltoid muscle is the dominant force providing arm elevation. The deltoid muscle's sheer force tends to displace the humerus in a cephalic direction opposed by the weight of the arm and the action of the rotator cuff musculature. The rotator cuff is critical for providing assistance in abduction, opposing the upward sheer force of the deltoid muscle, and providing for joint stability by glenohumeral compression (Grana, Lombardo, Sharkey, & Stone, 1989).

Although the value of strength in table tennis is no longer an issue of debate, we should be careful not to work on the development of massive strength exclusively. Our first concern should be to ensure all-round strengthening of the body and herewith to avoid injuries. When selecting exercises for a strengthening programme, an analysis of movements involved in a particular stroke, in terms of type, speed, direction, etc., should be done in order to be sure which groups of muscles are involved in these movements (Kondrič, Furjan-Mandić, & Medved, 2003).

It is also very important to mention biomechanical considerations concerning the aerodynamic force of drag, which is a very important factor in relation to the different diameter of the balls. In the case when the machine catapults the balls at the same initial velocity, the ball with a larger diameter has a smaller velocity (due to the bigger drag) at the moment of hitting, and so the subject has more opportunity to hit this ball with a higher velocity of the bat. The second thought is about the subconscious reaction of the player to a larger ball. Experience has shown that the velocity of this one is lower and the player hits it with a higher sharpness to compensate for the higher drag.

Special exercises should be designed to approximate as closely as possible the pattern and rate of movements of an actual table tennis stroke execution. This will activate and train stroke-related groups of muscles, thus enhancing their specific neuro-muscular functions needed for a particular performance. Dynamic electromyographic studies of the four rotator cuff muscles and the deltoid muscle during arm elevation have shown that all were active throughout the full range of movement (Glousman et al., 1988; Gowan et al., 1987). Inmann et al. (1944) interpreted this as an obligatory multi directional force couple to counteract the effect of the deltoid muscle's longitudinal alignment.

Nevertheless, we must not forget that movement acceleration of a joint involved in a particular stroke will depend on the state of certain muscles, which can influence the joint's degree of flexibility. From this point of view, it is obvious that both the ligamentous structures and muscular ability to contract and relax are important. Therefore, it is essential that table tennis players have good flexibility to assist movement and to control a particular stroke performance. It is also well established that muscle damage can be prevented by training, whether it involves concentric (Bosman et al., 1993) or eccentric exercise (Clarkson & Tremblay, 1988; Balnave & Thompson, 1993).

In our research we did not take into account the rubber gluing although it could have affected the measured parameters. Namely, several layers of glue can change the characteristic of rubber due to which velocity of the ball can be enhanced.

CONCLUSIONS

It is important to document the muscle activity of forward flexion, abduction, external rotation, and internal rotation. Classically, abduction and external rotation strength is diminished or absent with rotator cuff disease. The obtained measurements and graphical displays from the experiment indicate that in general, there is a significant difference in operation of the studied muscles between forehand attack strike using a 38 mm as opposed to a 40 mm ball. Although in three observed muscles *(m. deltoideus anterior, m. biceps brachii, m. pectoralis major)* differences in the intensity of EMG signals are significant, we can conclude that the player uses more muscle activities in a stroke with the larger ball. The presumption is that the differences would be even greater if the player hadn't undertaken training for more than a year with the larger ball, i. e. if we had done this experiment at the beginning of the use of the 40 mm ball.

We conclude that the contraction of *m. pectoralis major* is more powerful when the player hits the larger ball. From this point of view more attention should be paid to the development of this muscle in the physical preparation of the table tennis player. Qualified table tennis players should, therefore, develop those muscles and muscle groups that are needed for their specific style of play after they have established a broad foundation of physical fitness. The speed of the game and particularly of the shot utilized in this study suggests that the focus in training should be on speed and power development with no real need for massive strength.

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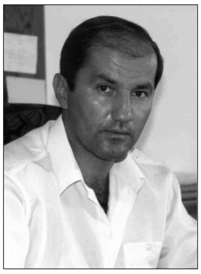
MYOELEKTRICKÉ SROVNÁNÍ FOREHANDOVÉHO ÚDERU VE STOLNÍM TENISE PŘI POUŽITÍ MÍČKŮ RŮZNÝCH VELIKOSTÍ

(Souhrn anglického textu)

Cílem této studie bylo prozkoumat rozdíly mezi forehandovými horními točivými údery s 38mm a 40mm míčky ve stolním tenise. Účastník byl při provádění úderů filmován. Za účelem zajištění totožných podmínek při veškerých výkonech (stejné trajektorie přibližujícího se míčku) byl použit nahrávací stroj pro stolní tenis. Vzhledem k hráčově pravorukosti byly elektrody umístěny na pravé straně hráčova těla. Absolutní svalové zapojení bylo odhadováno na základě zprůměrovaných EMG signálů (mV) měřených ve všech svalech (m. biceps brachii, m. deltoideus, m. pectoralis major). Pro výpočet rozdílů mezi celkovými středními hodnotami zprůměrovaných EMG signálů mezi všemi svaly byla použita analýza rozptylu (ANOVA). Vrcholová amplituda EMG m. deltoideus anterior dosahovala u úderu s 38mm míčkem hodnoty 2,5 mV. U m. deltoideus medialis byly dosaženy s míčky obou velikostí srovnatelné hodnoty kontrakce: vrcholové hodnoty se pohybovaly v rozmezí 2,3 a 2,8 mV u 38mm míčku a v rozmezí 2,2 a 3,0 mV u 40mm míčku. U m. biceps brachii se vrcholová amplituda EMG pohybovala mezi 1 až 2,2 mV u úderů s 38mm míčky a od 1,3 do 2,4 mV u úderů s 40mm míčky. Podobného výsledku bylo dosaženo u kontrakcí m. pectoralis major. U úderů s 38mm míčkem byla dosahována poměrně nerovnoměrná intenzita kontrakcí, a to v rozmezí od 1,5 mV do 2,6 mV. Vyváženějších hodnot bylo dosaženo u úderů s 40mm míčky, kdy se tyto pohybovaly mezi 1,6 až 2,2 mV. Tato zjištění nám ukázala, že u třech sledovaných svalů (m. deltoideus anterior, m. biceps brachii, m. pectoralis major) existují významné rozdíly v intenzitě EMG signálů, a můžeme tedy učinit závěr, že hráč při úderu s větším míčkem používá více svalové aktivity a že kontrakce m. pectoralis major je při úderu do většího míčku silnější.

Klíčová slova: stolní tenis, forehandový úder, EMG, svalová aktivita.

Miran Kondrič, Ph.D.



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NUMERICAL SIMULATION IN BIOMECHANICS – A FORENSIC EXAMPLE

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The paper presents an example of a forensic application of biomechanical methods including numerical simulation with human body models. By means of a case study of an unwitnessed lethal fall the course of the biomechanical forensic reconstruction is demonstrated. The traces available at the place of finding and the injuries of the victim are the facts that the analysis is based on. The ultimate expected result of the biomechanical analysis is the assignment of all available traces and the explanation of the event.

The injuries observed in the described case were partly typical fall injuries, but there were also some injuries that could not be prima vista assigned. The police investigation at the place of finding also brought to light some facts that could not be satisfactorily explained at first. By using numerical simulation, additional information was obtained that enabled us to explain many aspects of the case that could not have been analysed otherwise. Numerical simulation offers objective and quantitative data enabling a far more exact analysis of the studied event – the kinematical as well as dynamical parameters of the human body and its interaction with the surroundings structures can be studied and even the human body's internal forces can be analysed enabling thus an accurate injury prediction. All the important unknown parameters (initial conditions of the simulated event, i. e. body position, body orientation, initial velocity etc.) can be easily varied so that all the possibilities can be taken into account. Another very important asset of this method is its powerful visualisation capability that enhances the understanding of the studied events even for persons without extensive biomechanical knowledge. The major limitation of numerical simulation at the moment is the lack of muscle activity; the models represent only a totally passive human body so far.

Keywords: Forensic biomechanics, numerical simulation, human body model, fall.

INTRODUCTION

Forensic biomechanics is a discipline undergoing rapid development in recent years thanks to its increasing knowledge and technology level. Many forensic biomechanical problems were for long assessed only qualitatively, based on the experience of the expert. This paper presents the advantages of a new tool employed in forensic biomechanics that enables an objective and quantitative analysis of human kinematics and human body loading – numerical simulation.

Falls are a frequent cause of serious or even lethal injuries. Questions are sometimes raised regarding third party fault especially in unwitnessed cases with fatal outcomes. To distinguish between a suicide, an accident, and third party fault is a very challenging task that comprises various aspects. Considerable attention has been paid to this problem in the literature (Püschel & Wischhusen, 2005; Shaw & Hsu, 1998; and others). A necessary condition for the clarification of unwitnessed falls is their reconstruction based on a thorough biomechanical analysis involving the assessment of suffered injuries, the kinematical analysis of the fall and the assignment of the available traces. Based on a real case, the aim of this paper is to present the methods of biomechanics in this specific type of forensic application. In addition to the traditional approach of using numerical simulation with human models, this method has also been employed and has proven to be a very promising tool in forensic biomechanics (Adamec et al., 2003; Muggenthaler et al., 2003; Adamec et al., 2005). The benefits as well as potential drawbacks of numerical simulation are discussed.

METHODS

A corpse was found on a pavement in front of a newly built apartment house in Munich in the early morning hours. There were blood stains, reported by the police to be strikingly far away from the corpse (2.2 m). The state attorney requested an autopsy in order to clarify the cause of death. Because of numerous, partly atypical injuries that could not be prima vista integrated into one event, a biomechanist was called in. The biomechanical analysis of the case was based on the place, on finding measurements, and on the autopsy results.

Relevant autopsy results

The victim was a 57 year old man, stature 176 cm, body mass 68.9 kg. There was a skin laceration in the occiput region; there was a skull fracture hereunder with a 6 cm × 10 cm fragment. At the border between the lumbar and buttocks region on the left hand side a superficial injury was found apparently caused by extensive strain of the skin. Teeth 11 and 22 were knocked out (and found near the corpse), teeth 21 and 23 were broken. The aorta was partially torn at the typical location. There was a haematoma in the right m. sternocleidomastoideus and a comminuted fracture of the upper part of the sternum. All ribs were fractured and left with soft tissue perforations. Compression fractures of the VI.–VIII. thoracic vertebral bodies were observed. The pelvic injuries comprised both SI joint destruction and a comminuted fracture of the left ilium. The right liver lobe was lacerated. There were no injuries whatsoever on both upper extremities, no marks of suffocation.

Relevant parameters of the place of the finding

The basic parameters documented for the biomechanical analysis were the end position of the body and the overall geometry of the place. A picture of the place of the finding with the end position of the body and a drawing with the most relevant parameters is presented in Fig. 1. A balcony – like passages were identified as the only possible platform for a fall (heights of 270–1125 cm, 1^{st}–4^{th} floor), because all other building parts were inaccessible. A definite head impact location could be identified on the pavement (skin and hair traces) at a horizontal distance of 397 cm from the balconies. The corpse lay another 2 m farther. The height of the guard rail at each balcony was 118 cm; there were no traces on the balconies.

Biomechanical analysis

The victim evidently suffered a very severe blunt trauma; the injury severity allows for the assumption that the highest balcony was the fall platform. Also, the guard rail of the balcony was considered (height 1233 cm above the ground). The relatively high horizontal distance supported further this assumption. An accidental fall as the result of a balance loss (slipping, tripping etc.) was excluded because the centre of body gravity of the victim is located lower then the guard rail height.

Most of the injuries can be attributed (based on their location and characteristics) to a fall on the back side of the body with a slight left hand side accentuation. This does not necessarily hold for the teeth and sternum injuries, neither for the skin defect in the lumbar/buttocks region. In order to clarify the course of the fall including the location of the head impact and the end position of the body, a series of numerical simulations were performed with the MADYMO human model. A 50% Human Male Pedestrian model version 6.2 was used because its body parameters correspond very well to those of the victim (174 cm vs. 176 cm, 75 kg vs. 69 kg). The model has been extensively validated for impact situations and represents human kinematics very well (MADYMO, 2004).

As the starting point of the simulation, two alternative initial positions of the human model were chosen: a stance at the verge of the highest balcony (would correspond to a person who had climbed over the balcony guard rail) and a stance on the balcony guard rail. From a standing position the model tilts away from the balcony. As no hints were at hand regarding the direction of the movement, the forward (i. e. the model stands initially with the balcony behind his back) as well as the backward (i. e. the model stands initially facing the balcony) fall directions were considered and simulated. The used model is passive, i. e. no muscle actions were taken into account. However, a person falling like this would not be completely passive (as if unconscious); it can be assumed that the legs would be kept stretched. For this reason, all the degrees of freedom of the lower extremities were locked into the simulation until the models reached a tilting angle of 40 degrees. Then they were released and along with the rest of the degrees of freedom they were constrained only to the extent that corresponds to a passive human body.

The human model kinematics during the forward fall from a height of 1125 cm (the balcony floor) is shown in Fig. 2. The kinematics of the model from the guard rail height of the same balcony (1233 cm) differs only very slightly from this case, all the predicted injury locations are the same and are in agreement with the observed injuries and also the end position of the body is well predicted.

On the contrary, the backward fall kinematics predicts a completely different injury pattern and the end position of the body is significantly different (Fig. 2).

With the help of numerical simulation, the injury mechanism of some of the injuries that could not be assigned at first glance was clarified. Shortly after the head's impact with the ground a contact could be observed between the jaw and the upper part of the chest (Fig. 3). This can easily explain the observed teeth injuries as well as the fracture of the sternum. The trunk impacts the ground after the head and then a rebound can be observed. During this rebound, an extensive flexion of the trunk and the strain injury of the skin in the lumbar region can be explained (Fig. 4).

The simulation explains very well the distance between the head impact location and the end position of the body. In the simulation this distance spans 230 cm and 275 cm for the fall from the balcony floor and the guard rail height, respectively. The real distance was 220 cm and it corresponds thus with the simulation.

The horizontal distance of the head impact location from the balcony is, in the simulation, 249 cm, i. e. 148 cm less than the observed real measure. It means that there was an active force involved; the real falling was not completely passive. The numerical simulation does not allow for resolving whether it was an active movement of the falling/jumping person or whether the horizontal force was caused by third party involvement. The necessary additional horizontal velocity during the flying phase of 1.2 m/s^2 could be explained both by a "step forward" as well as by third party intervention in terms of pushing/throwing the person out of the balcony.

Fig. 1
The place of the finding, photos and a drawing with the relevant parameters (head impact location designated)

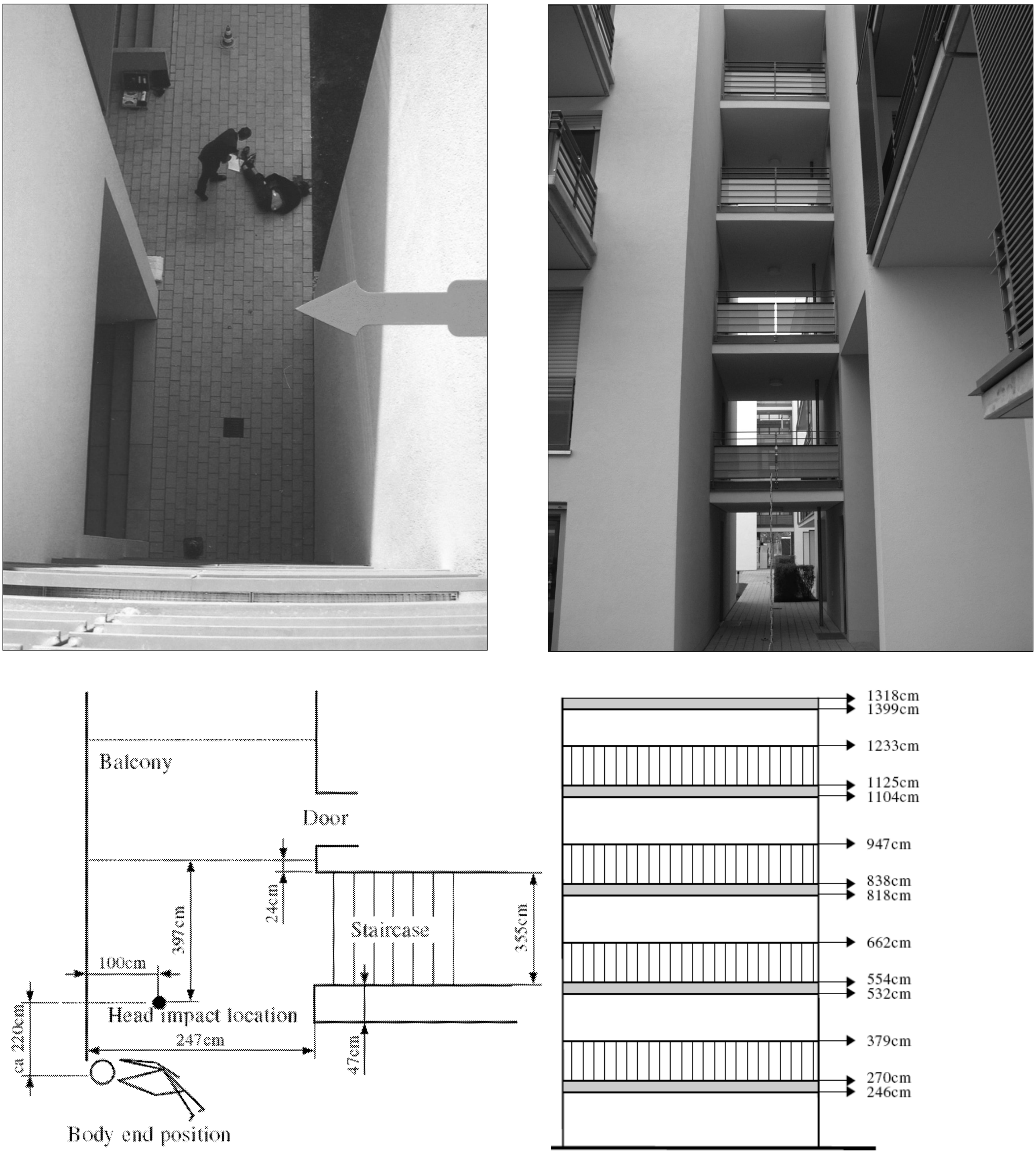

Fig. 2
Human body model kinematics during the fall backwards (top) and forwards (bottom)

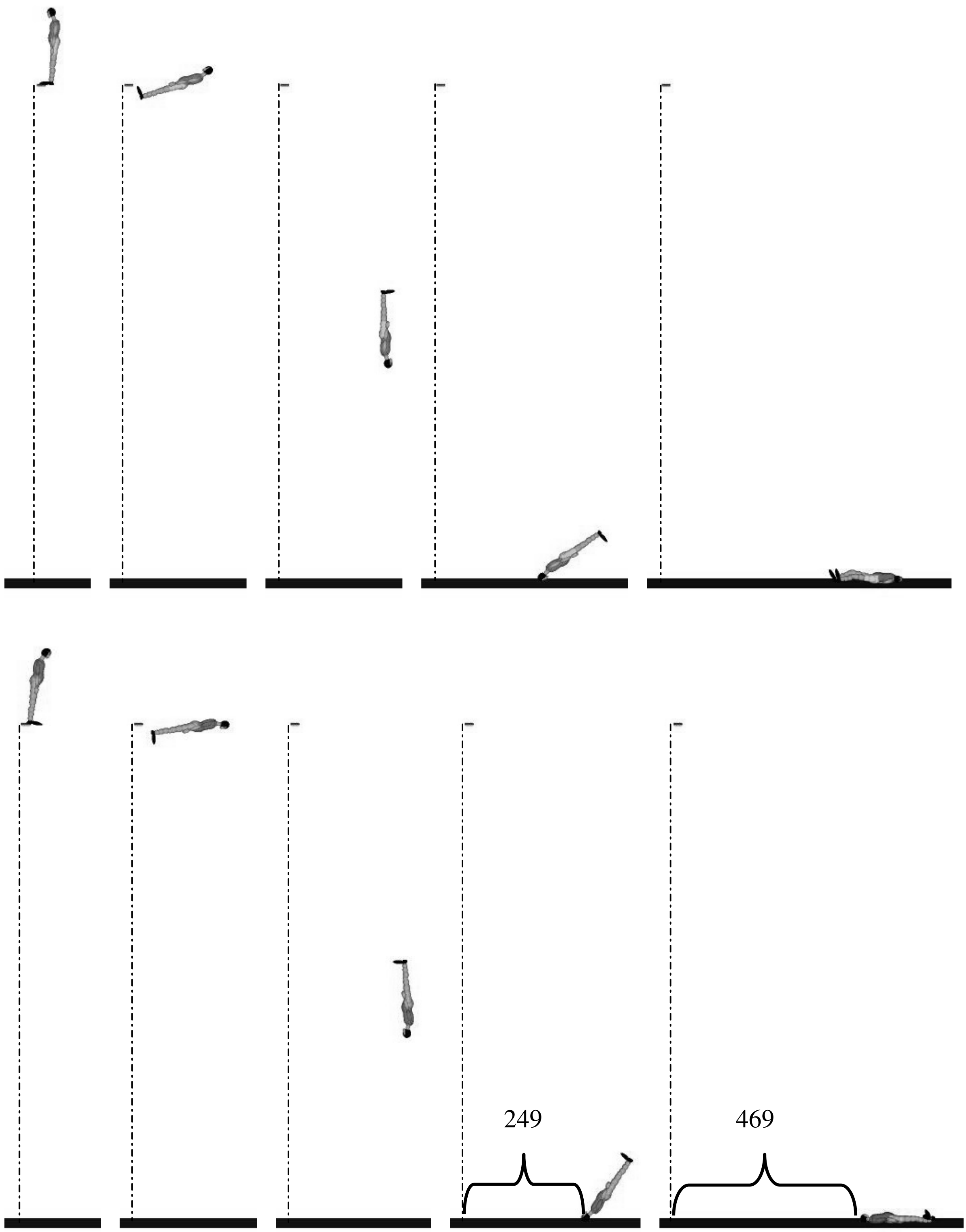

Fig. 3
Chest/jaw contact shortly after the head impact

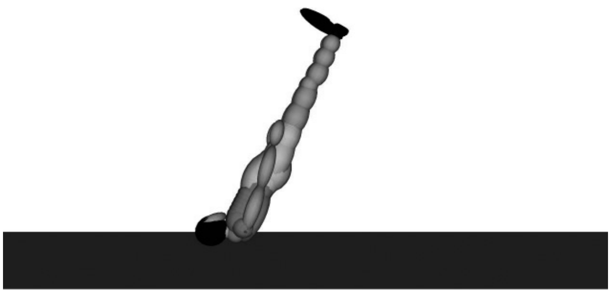

Fig. 4
Trunk flexion during the rebound phase after the first trunk impact to the ground

Summary of the analysis

With the help of numerical simulation, all observed injuries could be assigned to a single event. There were no traces of a fight on the whole site and none of the injuries suggested an act of violence (above all, there were no injuries whatsoever on the upper extremities). There were no hints suggesting an impaired state of consciousness (negative toxicological findings). The expert opinion suggested suicidal behaviour of the victim. The police investigation provided later hints suggesting that the awkward personal situation of the victim might have been the motive. A former suicide attempt was also ascertained.

DISCUSSION

Reconstructions of falls are a relatively frequent forensic application of biomechanics. A fall is, from the mechanical point of view, a relatively simple event (especially in the flight phase). The trajectory of the body centre of gravity can be computed by using simple methods and the results are, of course, in agreement with the simulation.

The advantages of numerical simulation are twofold. Firstly, numerical simulation offers a lot more information than the mere centre of gravity trajectory. After the first attempts to reconstruct a fall numerically (Sloan & Talbott, 1996) with 2D models with a few degrees of freedom that did not enable any quantitative assessment of body loading nor numerical simulation and the human body models were developed into a technology offering a detailed and quantitative (i. e. objective) information, not only about the kinematics, but also about the dynamics of the studied events. In the presented case, all the impacts with the ground as well as the body kinematics after the rebound to the end position of the body could be analysed and thus the injury mechanisms clarified. Secondly, the huge advantage of numerical simulation is the possibility to visualise the results in an understandable and effective way. A video or a sequence of pictures enhances the understanding of the studied event even to persons without extensive biomechanical knowledge.

The numerical human models have been validated extensively for impact situations and they offer information about external forces as well as about forces occurring inside the human body. This way the probability of injury occurrence can be assessed.

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NUMERICKÁ SIMULACE V BIOMECHANICE – FORENZNÍ PŘÍKLAD

(Souhrn anglického textu)

Příspěvek prezentuje vybraný příklad forenzní aplikace biomechanických metod zahrnujících numerickou simulaci s použitím modelů lidského těla. Postup biomechanické rekonstrukce je demonstrován na konkrétním případu smrtelného pádu z výšky. Základem biomechanické rekonstrukce jsou stopy na místě nálezu těla spolu se zraněními zjištěnými při provedné soudní pitvě. Konečným cílem biomechanické analýzy je jednoznačné a bezesporné přiřazení veškerých zjištěných stop a objasnění celé události z mechanického hlediska.

Některá zranění zjištěná v tomto konkrétním případě byla pro pád z výšky typická, část nálezu ale nebylo možno prima vista zařadit. Policejní vyšetřování na místě nálezu také přineslo některá fakta, která nebylo možno uspokojivě vysvětlit. Numerická simulace s použitím modelů lidského těla přinesla údaje umožňující vysvětlení mnoha do té doby nejasných aspektů případu. Tato metoda poskytuje objektivní a kvantitativní informace umožnující daleko přesnější analýzu studovaného jevu nebo události – kinematické i dynamické parametry lidského těla a jeho interakce s okolními strukturami. Dokonce je možné zjišťovat i síly působící uvnitř organismu a díky tomu přesněji predikovat trauma. Všechny důležité neznámé parametry (počáteční podmínky numerické simulace, jako pozice těla a jeho jednotlivých segmentů, jeho orientace v prostoru, počáteční rychlost atp.) lze parametrizovat a obsáhnout tak všechny možné konstelace. Další velmi důležitou předností této metody je propracovaná a efektivní vizualizace výsledků výpočtů, která usnadňujě pochopení studovaných událostí a jevů i bez důkladných biomechanických znalostí. Největší omezení použití modelů lidského těla představuje v současné době nemožnost simulovat aktivní pohyby; modely svých chováním odpovídají zcela pasivnímu lidskému tělu.

Klíčová slova: forenzní biomechanika, numerická simulace, model lidského těla, pád.

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BODY COMPOSITION AS A DETERMINING FACTOR IN THE AEROBIC FITNESS AND PHYSICAL PERFORMANCE OF CZECH CHILDREN

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Body composition (BC) may be used as a criterion of the actual biological state of children, in other words, their physical state of development. The aim of our study was to determine the interdependence of some body composition variables and aerobic fitness ($VO_2max.kg^{-1}$) and parameters of physical performance, ie. calculated total work (CTW) and maximal power output (MPO) on the treadmill in a group of Czech children and youth. The interdependence between frequently used indicators of aerobic fitness ($VO_2max.kg^{-1}$, CTW, and MPO), and BC (% BF, FFM, BCM and ECM/BCM) were studied in a group of 1235 Czech children (756 boys and 479 girls) aged from 6 to 14 years. Both aerobic fitness and physical performance variables were assessed by means of an incremental treadmill test with a constant slope of 5%. The age dependent initial speed was increased by 1 $km.h^{-1}$ till subjective exhaustion. Body composition was determined by whole body bioimpedance measurements using a modified prediction equation for children. The percentage of BF was negatively correlated with $VO_2max.kg^{-1}$, and CTW. Both FFM and BCM were positively related to CTW, MPO, and $VO_2max.kg^{-1}$. The ECM/BCM relationship was negatively related to $VO_2max.kg^{-1}$ and CTW. In conclusion, BC is an important determinant of physical performance in the laboratory (treadmill exercise tests) and in the field (running and/or walking tests). The BC parameters significantly influence the variables that could be used for characterisation of aerobic fitness. The results further demonstrate that when oxygen consumption is not feasible, physical performance characteristics together with parameters of BC seem to be a good predictor of aerobic fitness. This may be very helpful in large population studies.

Keywords: Body composition, oxygen consumption/uptake, aerobic fitness, physical performance, laboratory and field testing, children.

INTRODUCTION

An accurate assessment of body composition (BC) is necessary in order to properly identify a client's health risk as associated with an excessively low or high amount of related body fat (BF). This assessment can then be used to estimate a subject's ideal body mass and formulate an exercise and diet regimen. Periodic BC evaluation can be used to assess the effectiveness of exercise and diet interventions or monitor changes in BC associated with growth and maturation or states of disease (Bouchard et al., 1994). Thus there is a clinical need to measure not only the % of BF, but fat distribution, muscle mass, total body water content (TBW), body-water compartments (extracellular – ECW, and intracellular water – ICW), body-water volume changes, and bone mass as well (Roche, Heymsfield, & Lohman 1996; Segal et al., 1991).

At the present time, the above can be used together with classical parameters of BC which have already been in use for a long time such as BF content and free fat mass and also other variables which may characterise BC, such as body cell mass (BCM) and extracellular mass (ECM) (Wang et al., 2000). At the cellular level, FFM consists of BCM, extracellular fluids (ECF) and extracellular solids (ECS).

Numerous tools and methodologies have been developed to measure various BC parameters. Bioelectrical impedance analysis (BIA) seems to be one of the most used methods under field conditions. This method is based on the principle that lean tissue, which contains large amounts of water and electrolytes, is a good electrical conductor, and fat, which is anhydrous, is a poor conductor (Lukaski et al., 1985).

Regardless of which instrument is chosen to assess BC, the method is only as good as the measurement technique and prediction or conversion formula applied. The conversion formulas and prediction equations, the use of which are selected, must be restricted to the populations from which they were derived to remain valid (Bunc et al., 2001; Roche, Heymsfield, & Lohman, 1996).

Aerobic fitness (AF) is frequently considered the most important aspect of physical fitness (Shephard, 1994; Shephard & Bouchard, 1994). The generally accepted physiological criterion of AF – maximal oxygen uptake (VO_2max), is only a predisposition for physical performance (PP) (Astrand & Rodahl, 1986; Bunc, 1994). A high VO_2max does not guarantee good PP, since technique of motion and psychological factors may have an influence either positively or negatively. In work and exercise where the body is lifted, oxygen uptake should be related to the subject's body mass. In this case, the individual's VO_2max provides a measure of the "motor effect" (Astrand & Rodahl, 1986; Bunc, 1994). With this parameter the subject's ability to move her or his body can be evaluated. In practice this means that if we wish to characterise fitness level, we must evaluate VO_2max and physical performance at the same time.

The parameters which may characterise PP in the laboratory as calculated total work (CTW) and maximal power output (MPO) are highly associated with absolute values of VO_2max. Relative values of VO_2max (related to kg of body mass) are strongly related to the size and quality of the free fat component of body mass, which is logical because VO_2 during exercise depends on the oxygen demands of the exercising muscles (Astrand & Rodahl, 1986; Bunc, 2001).

The fact that differences in body size and BC influence the predisposition and interpretation of parameters such as absolute and relative maximal oxygen consumption and/or physical performance is well known (Astrand & Rodahl, 1986). Less well studied are the effects of differences of BC on performance predispositions like VO_2max, CTW and MPO in young subjects.

The aim of our study was to determine the interdependence of some body composition variables and aerobic fitness ($VO_2max.kg^{-1}$) and parameters of PP – calculated total work (CTW) and maximal power output (MPO) on the treadmill in a group of Czech children and youth.

SUBJECTS AND METHODS

In this study, a group of 1235 Czech children (756 boys and 479 girls) ranging in age from 6 to 14 years and differing in level of aerobic fitness (their maximal oxygen uptake was in the range of 32–65 $ml.kg^{-1}.min^{-1}$ in boys and from 30 to 60 $ml.kg^{-1}.min^{-1}$ in girls) was evaluated.

The BC variables were determined by the whole body's impedance multifrequency measurements using modified prediction equations which were verified for Czech children (Bunc, 2001).

Resistance and reactance were measured at four frequencies – 1, 5, 50 and 100 kHz (B. I. A. 2000 M, Data input, Germany) on the right side of the body by tetrapolar electrode configuration (four electrodes, two on the hands and two on the feet in accordance with the manufacturer's specification).

Maximal oxygen uptake was evaluated by means of an incremental exercise test to subjective exhaustion on a treadmill at 5% inclination. The respiratory variables and gas exchange were measured using an open system with the help of TEEM 100 diagnostics equipment.

The CTW was calculated as the sum of the workloads of all completed stages plus the workload of the last incomplete stage. The MPO was calculated by linear interpolation from power output during the previously completed stage and power increment between the last stage and the previously completed stage.

Values are presented as the mean of $\pm s_D$. Simple regression analysis was performed to describe the relationships among various parameters. Cross correlation and calculation of standard error of estimation were used to validate the regression equations. The 0.05 level of significance was used for all data analyses.

RESULTS

The selected variables of BC for each year of age are presented in TABLES 1, 2 and 3. Similarly, values of maximal oxygen uptake that were determined with the help of an incremental exercise on the treadmill are presented in TABLE 4. The mean values of the followed variables of BC are collected in TABLE 5.

The mean values of total body-water (in relative terms as a part of total body mass) was slightly higher in boys than in girls and these values were significantly higher in children (the mean in boys was 65.3 ± 3.8%, and in girls 62.6 ± 4.2%) than in adults of the same physical fitness status who were assessed by the same analyser (the mean in men ranging in age from 40 to 60 was 61.3 ± 4.8%, and in women it was 57.2 ± 5.0%). In children we found a negative significant interdependence of these values with regard to age ($r = -0.586$, $p < 0.0001$ in boys, and $r = -0.612$, $p < 0.0001$, $S_{EE} = 3.4\%$ in girls).

The mean values of BF were 19.7 ± 5.3% of the total body mass in boys, and 21.7 ± 5.0% in girls. In both sexes a positive significant gender interdependence was found ($r = -0.698$, $p < 0.0005$ in boys, and $r = -0.681$, $p < 0.005$ in girls).

The mean values of selected maximal functional variables, CTW and MPO are collected in TABLE 6. We found significant negative relationships between % BF and $VO_2max.kg^{-1}$ ($r = -0.511$, $p < 0.0001$ in boys; $r = -0.584$, $p < 0.0001$ in girls), MPO ($r = -0.471$, $p < 0.0005$; $r = -0.435$, $p < 0.0005$), and CTW ($r = -0.531$, $p < 0.0001$; $r = -0.495$, $p < 0.0001$).

Significant positive relationships were found between FFM and CTW ($r = 0.311$, $p < 0.0005$; $r = 0.421$, $p < 0.0005$), MPO ($r = 0.401$, $p < 0.0005$; $r = 0.456$, $p < 0.0005$), and $VO_2max.kg^{-1}$ ($r = 0.371$, $p < 0.0005$; $r = 0.332$, $p < 0.0005$).

Also we found significant relationships between BCM and CTW ($r = 0.583$, $p < 0.0001$; $r = 0.598$,

$p < 0.0005$), MPO ($r = 0.535$, $p < 0.0001$; $r = 0.578$, $p < 0.0005$), and $VO_2max.kg^{-1}$ ($r = 0.612$, $p < 0.0001$; $r = 0.751$, $p < 0.0005$).

The ECM/BCM relationship was significantly negatively correlated with CTW ($r = -0.671$, $p < 0.0001$; $r = -0.634$, $p < 0.0001$), MPO ($r = -0.683$, $p < 0.0001$; $r = -0.687$, $p < 0.0001$), and $VO_2max.kg^{-1}$ ($r = -0.787$; $p < 0.0001$; $r = -0.766$, $p < 0.0001$).

TABLE 1
Mean values ($\pm s_D$) of body fat in the percentages of body weight (% BF) that were determined by the whole body bioimpedance method

	N_{Boys}	Boys	N_{Girls}	Girls
Age (years)		% BF (%)		% BF (%)
6	80	22.4 ± 4.1	53	24.5 ± 4.0
7	78	21.4 ± 3.8	54	23.1 ± 3.8
8	86	20.4 ± 4.4	51	22.8 ± 3.9
9	82	20.1 ± 3.6	56	22.3 ± 3.6
10	85	19.9 ± 3.2	50	21.9 ± 3.3
11	88	19.5 ± 3.0	52	21.3 ± 3.1
12	84	18.2 ± 3.1	56	20.3 ± 3.0
13	86	17.9 ± 2.9	54	20.9 ± 2.6
14	87	18.0 ± 2.8	53	21.4 ± 3.0

TABLE 2
Mean values ($\pm s_D$) of the percentages of total body water (% TBW) determined by the whole body bioimpedance method

	Boys	Girls
Age (years)	% TBW (%)	% TBW (%)
6	69.2 ± 5.1	67.2 ± 4.8
7	68.4 ± 4.1	66.5 ± 4.3
8	67.3 ± 3.6	65.1 ± 4.6
9	66.6 ± 3.4	64.1 ± 4.0
10	65.3 ± 3.1	62.9 ± 4.2
11	64.3 ± 3.0	61.5 ± 3.6
12	63.7 ± 3.2	60.2 ± 3.4
13	62.4 ± 3.6	58.9 ± 3.8
14	60.7 ± 3.7	57.2 ± 3.6

TABLE 3
Mean values ($\pm s_D$) of the ECM/BCM relationship that were determined by the whole body bioimpedance method

	Boys	Girls
Age (years)	ECM/BCM	ECM/BCM
6	0.92 ± 0.08	0.95 ± 0.09
7	0.90 ± 0.09	0.92 ± 0.09
8	0.88 ± 0.08	0.91 ± 0.08
9	0.85 ± 0.07	0.88 ± 0.08
10	0.83 ± 0.09	0.87 ± 0.08
11	0.82 ± 0.07	0.84 ± 0.09
12	0.80 ± 0.07	0.82 ± 0.08
13	0.78 ± 0.06	0.81 ± 0.07
14	0.75 ± 0.06	0.78 ± 0.06

TABLE 4
Mean values ($\pm s_D$) of the maximal oxygen uptake ($VO_2max.kg^{-1}$) that was determined by an incremental test on the treadmill

	Boys	Girls
Age (years)	$VO_2max.kg^{-1}$ ($ml.min^{-1}.kg^{-1}$)	$VO_2max.kg^{-1}$ ($ml.min^{-1}.kg^{-1}$)
6	30.9 ± 4.3	30.0 ± 3.8
7	36.4 ± 5.1	33.6 ± 4.0
8	40.1 ± 4.8	35.9 ± 4.2
9	42.7 ± 5.2	37.9 ± 3.7
10	44.6 ± 5.3	39.7 ± 4.0
11	46.9 ± 4.6	40.4 ± 4.3
12	48.2 ± 4.5	41.9 ± 4.4
13	50.8 ± 4.9	42.1 ± 4.3
14	52.9 ± 4.4	42.3 ± 4.5

TABLE 5
Mean values ($\pm s_D$) of selected anthropometrical variables that were determined by the whole body bioimpedance method

	Boys	Girls
Age (years)	10.1 ± 2.8	10.1 ± 2.9
Body Mass (kg)	34.5 ± 3.4	35.1 ± 4.8
Height (cm)	147.5 ± 4.3	145.8 ± 4.7
% Body Fat (%)	19.8 ± 2.4	21.9 ± 3.1
TBW (l)	22.5 ± 3.4	22.1 ± 3.6
TBW/body mass (%)	65.3 ± 3.8	62.6 ± 4.2
BCM (kg)	14.9 ± 3.5	14.6 ± 3.6
ECM/BCM	0.84 ± 0.09	0.87 ± 0.10

TABLE 6
Mean values (± s_D) of selected functional variables and calculated total work (CTW) and maximal power output (MPO) that were determined on a treadmill with a slope of 5%

	Boys	Girls
$VO_2max.kg^{-1}$ ($ml.kg^{-1}.min^{-1}$)	43.7 ± 6.4	38.2 ± 4.2
CTW (kJ)	44.2 ± 6.2	36.2 ± 4.8
MPO (W)	140.9 ± 11.2	121.3 ± 10.2
v_{max} ($km.h^{-1}$) 5%	13.1 ± 2.3	12.0 ± 2.6

DISCUSSION

Body composition during prepuberty and mainly during puberty is a marker of metabolic changes that occur during this period of growth and maturation, and, thus, holds key information regarding current and future health. During puberty, the main components of body composition (total body fat, lean body mass, bone mineral content) all increase, but considerable sexual dimorphism exists (Okely, Booth, & Chey, 2004). Components of body composition show age to age correlations (i. e. "tracking"), especially from adolescence onwards. Furthermore, adipose tissue is endocrinologically active and is centrally involved in the interaction between adipocytokines, insulin and sex-steroid hormones, and thus influences cardiovascular and metabolic disease processes.

Age showed a significant effect for most body composition variables. Total body water is by far the most abundant of the constituents of the body. As a percentage of body mass, TBW decreases significantly with increasing age – it varies from 70 to 75% at birth to less than 40% in obese adults (Roche, Heymsfield, & Lohman, 1996). Our slightly lower data in Czech children are probably caused by the use of a different method of % TBW determination that in the above mentioned paper. Total body water is essential for life, serving as a solvent for biochemical reactions and as a transport media. Despite being the most abundant constituent of the body, it is often neglected because the volume of TBW is well regulated in normal healthy conditions. Indeed, a 15% decrease in body water due to dehydration is life threatening (Roche, Heymsfield, & Lohman, 1996). Even a small change in TBW however, can produce a measurable change in body mass and thus determination of TBW is central to measuring body composition.

Fat free mass rises throughout childhood similarly in boys and girls until puberty (Malina & Bouchard, 1991). The acceleration in FFM at this time in males reflects their augmented muscle mass at the time of the adolescent growth spurt. The absence of an increase in FFM at puberty in females means that girls reach adult levels approximately 5 years before males, whose FFM matures at the age of 19–20 years (Malina & Bouchard, 1991).

Average fat mass in females is greater than in males from mid-childhood on. These differences become more obvious in the pubertal years as girls accumulate greater adipose tissue. The percentage of body fat slowly declines during early childhood in both sexes after an early jump in infancy (Malina & Bouchard, 1991). As puberty approaches, females demonstrate a progressive rise that continues throughout adolescence. Males, on the other hand, show a slight increase in relative fatness in the late prepubertal age; their percentage of body fat then slowly declines, reflecting the development of FFM at puberty. Consequently, females have a greater percentage of body fat than males throughout childhood after the age of 3–4 years. In the late teen years, the average female has an about 50% higher percentage of body fat than the relative fatness of her counterpart.

The value of ECM/BCM may be used as a complementary criterion for the assessing of predispositions for exercise. The lower the ECM/BCM is, the better is the predisposition for physical exercise. In highly trained adult athletes, these values were at about 0.7. In our children, the mean values were 0.87 ± 0.12 in boys, and 0.96 ± 0.14 in girls. Both these values are similar to those in adults.

The ratio of ECM/BCM is a decisive parameter for sports events which require a big power output, like endurance running, cross country skiing, etc. The determination of the ECM/BCM ratio is mainly a problem of the selection of suitable types for every kind of sport.

The whole body impedance measurement at different frequencies is an attractive method of body composition assessment because it is quick, does not require a high degree of technician skill, and does not intrude on the client's privacy. Because it is difficult to obtain accurate measurements by using other methods for the determination of body composition (e. g. dual-energy x-ray absorptiometry, isotope dilution, etc.) on children, the impedance method is the preferred field and laboratory method for estimating body composition in these populations. Generally the impedance methods have limited accuracy because:

- we cannot measure the whole body (including the head, feet, and hands),
- the shape of the body deviates from the ideal cylinder,
- the conductive material is unequally distributed throughout the body, and
- the methods were not evaluated in large sample sizes.

In the present study, boys performed a bigger workload and achieved higher maximal work rates than girls, which corresponded with previously published observations of young athletes (e.g. Astrand & Rodahl, 1986).

The initial concern with the development of a youth fitness test must be definitional. The definition of physical fitness has evolved over the last 50 years but remains largely operationally defined by the tests used to measure it (Astrand & Rodahl, 1986; Franks et al., 1988). The tests used to measure physical fitness have, in turn, frequently been selected by the criteria of convenience (e.g. no equipment, little time involvement, ease of scoring) and tradition (e.g. familiar) rather than by physiological soundness representing specific components of fitness.

Physical fitness, and thus aerobic fitness, is not understood solely in terms of a potential for tolerating physical stress. Often it is viewed as one of the dimensions of health.

Aerobic fitness is not synonymous with health related fitness, though this has sometimes been supposed. Nevertheless, a large degree of cardiovascular fitness – maximal oxygen uptake – is one of the most important physiological indicators of good physical condition. It is necessary in many forms of strenuous occupational activity, and its maintenance makes a major contribution to quality of life in childhood and mainly in older age (Shephard, 1994).

The presented standards of maximal oxygen uptake and thus of AF do not significantly differ from the data of European population samples (e.g. Armstrong & Welsman, 1994; Lange Andersen et al., 1985; Seliger & Bartůněk, 1977; Welsman & Armstrong, 2000). Physical performance in younger groups (younger than 12 years) is similar to the data from other European countries but performance for older subjects is slightly lower than in other European studies. These differences increase with an increase in age. The reason for this is probably connected with the amount of physical activity, which significantly decreases with increasing age – from 4.7 hours of physical activity per week in young subjects (younger than 12 years) to 2.1 hours per week in older groups.

The mean speed during the motor tests can characterise the level of physical performance, and may be used for indirect determination of aerobic fitness under field conditions. The accuracy of VO_2max assessment and thus the determination of aerobic fitness from the mean speed of motion was altered at around 15%.

These differences may seem to be large, but one should note that the errors of cardiorespiratory measurements during exercise testing are at about the level of 5%. From this point of view it is legitimate to assume that the TABLE presented for the assessment of aerobic fitness in the field conditions is valid. Motivation has a similar influence on the results of this test as in other methods which use maximal parameters.

The primary determinant of success in physical activity like sport is the ability to sustain a high rate of energy expenditure for prolonged periods of time. Exercise training – induced physiological adaptations in virtually all systems of the body allow the subject to accomplish this. Aerobic capacity as described with the help of VO_2max, economy of motion and fractional utilisation of maximal capacity reflect the integrated responses of these physiological adaptations (Astrand & Rodahl, 1986).

The physiological adaptations to physical exercise that correspond to and facilitate improved VO_2max occur centrally in the cardiovascular system, centred on increased maximal cardiac output, and peripherally in the metabolic system, centred an increased arterio-venous O_2 difference.

In summary, based on the significant relationships between selected variables of the BC and aerobic fitness and physical performance in children, it could be concluded that the BC is an important determinant of functional and physical performance that often is overlooked. Pubertal and pre-pubertal body composition is important, not only for the assessment of contemporaneous nutritional status, but also for being linked directly to the possible onset of chronic disease later in life and is, therefore, useful for disease risk assessment and intervention early in life.

The results demonstrate that by evaluating training state and/or sports predisposition, it is necessary to assess both BC and functional characteristics. Calculated CTW and MPO and VO_2max are dependent on FFM and mainly on BCM. Therefore, we conclude that:

- determination of BC is necessary to interpret laboratory exercise testing,
- calculated performance variables together with laboratory PP characteristics such as CTW and MPO could us help with an assessment of predisposition for success in physical exercise.

The results demonstrate that when VO_2 is not feasible, physical performance characteristics together with parameters of body composition seem to be a good predictor of aerobic fitness; this may be very helpful in large population studies.

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TĚLESNÉ SLOŽENÍ JAKO URČUJÍCÍ FAKTOR AEROBNÍ ZDATNOSTI A TĚLESNÉ VÝKONNOSTI ČESKÝCH DĚTÍ

(Souhrn anglického textu)

Tělesné složení (TS) je možné použít jako kritérium aktuálního biologického stavu dětí – stavu rozvoje. Cílem naší studie bylo stanovit závislost parametrů tělesného složení a aerobní zdatnosti ($VO_2max.kg^{-1}$) a proměnných tělesné výkonnosti – počítaná celková práce (CTW) a maximální výkon (MPO) stanovené na běhátku u skupiny českých dětí.

Závislost mezi běžně užívanými parametry aerobní zdatnosti ($VO_2max.kg^{-1}$, CTW a MPO) a TS (% BF, FFM, BCM a ECM/BCM) byla stanovena u 1235 dětí (756 chlapců a 479 děvčat) ve věku 6 až 14 let. Aerobní zdatnost a tělesná výkonnost byly hodnoceny pomocí stupňovaného zatížení na běhacím koberci o stálém sklonu 5 %. Počáteční na věku závislá rychlost běhu byla zvyšována o 1 $km.h^{-1}$ až do okamžiku subjektivního vyčerpání. Tělesné složení bylo hodnoceno pomocí celotělové bioimpedanční metody s využitím predikčních rovnic pro děti. Procento BF vykazovalo zápornou signifikantní korelaci s $VO_2max.kg^{-1}$ a CTW. Obojí jak FFM tak BCM pozitivně korelovalo s CTW, MPO a $VO_2max.kg^{-1}$. Koeficient ECM/BCM byl v negativním vztahu s $VO_2max.kg^{-1}$ a CTW. Závěrem lze konstatovat, že TS je významným funkčním determinantem v laboratorních podmínkách (zátěžový test na běhátku) a v terénu (běžecký nebo chodecký test). Sledované proměnné, charakterizující TS, významně ovlivňují proměnné, které mohou definovat aerobní zdatnost. Výsledky dokládají, že jestliže není možné přímo měřit spotřebu kyslíku, lze k odhadu těchto proměnných využít parametrů tělesné výkonnosti a tělesného složení; toto může být velmi užitečné v případě velkých populačních studií.

Klíčová slova: tělesné složení, spotřeba kyslíku, aerobní zdatnost, tělesná výkonnost, děti, laboratorní testování.

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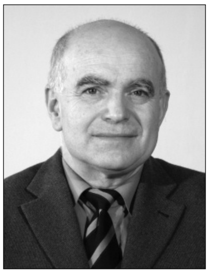

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SOMATIC ANALYSIS OF PE STUDENTS WITHIN A FOUR-YEAR RESEARCH PERIOD

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Modern theories and studies interpret sport performance as a defined system of elements which are characterized as components, determiners, factors, etc. Somatic factors concerning the support system are supposed to be a significant factor group. Body height, weight, length, width and circuit measurements belong to the group of somatic factors and they determine physical build (frequently characterized by a somatotype).

This paper deals with the physical build of 1st year PE students who can be considered a selected group of the population with a relatively large volume of physical activity. The research was carried out within the years 2001–2004, 265 students (166 men and 99 women) were included in a sample. Heath and Certer's method (Riegerová & Ulbrichová, 1993) was used to determine the somatotype.

As for average somatotypes, no significant differences concerning PE students were noted during the consequent years of research. The only exception was perhaps the endomorphic component which proved a distinctively downward trend (the value approached statistical significance at $\alpha = 0.05$).

PE students can be regarded as a group of the population with a large volume of physical activity, therefore a significant development of physical build as well as a somatotype reaching an optimum somatotype for PE students can be expected to be present (Riegerová & Ulbrichová, 1993). However, the measurements proved that students had fallen behind, especially in the mesomorphic component, which correlates with the population normative.

We do assume that our findings and results may prove a decreasing physical level and related somatic development in our population.

Keywords: PE students, somatotype, optimal somatotype, individual sportspersons, PE.

INTRODUCTION

Modern theories and studies interpret sport performance as a defined system of elements which are characterized as components, determiners, factors, etc. Somatic factors concerning the support system are supposed to be a significant factor group. Body height, weight, length, width and circuit measurements belong to the somatic factors and they determine physical build (frequently characterized by a somatotype).

As a variety of subjects taught at departments of physical education are practical disciplines, a certain level of sport efficiency is necessary and the PE students' performance and efficiency influence their success in their studies (Pavlík, 1999; Štěpnička et al., 1979).

Many previous studies have focused on this subject field (Belej & Gáborová, 1981; Riegerová et al., 1995; Štěpnička et al., 1979). The very last study was carried out almost ten years ago and other research studies are much older. Therefore we have decided to repeat the investigative research and find out whether there was a change in the somatotype of PE students in relation to the last measurements. As for the increased number of PE students admitted to Ostrava University who do not enter their studies (at the present time it concerns 20–25%, in previous years 5–8%) we have to accept students who passed the entrance exams, nevertheless their results are under average concerning the testing score of successful students. This situation leads to admitting such weaker students. Therefore we do assume that there have been changes in our students' somatotypes.

RESEARCH OBJECT

The aim of the project is to compare the state and quality of PE students' somatotypes in particular components regarding the healthy population as well as absolute values. The research was done within the years 2001–2004.

METHODOLOGY OF APPLIED PROCEDURE AND CHOICE OF GROUP

Group characteristics

The basic group consisted of all admitted students of physical education. Altogether 99 women and 166 men were included in the sample. The research was carried out within the years 2001–2004.

Procedure of measurements and applied methods

Measurements were carried out at the very beginning of each academic year, within a diagnostic week. Heath and Certer's method (Riegerová & Ulbrichová, 1993) was used to determine the somatotype. Measurements were realized by just one skilled trainer. The statistic analysis of received results was based on the analysis of variance by means of the SPSS product (research time period 2001–2004).

The standards index (Ni) Bláha et al. (1986) was applied to compare the average somatotype values of PE students (women) to the average values of women gymnasts at the Czechoslovak spartakiada (national gymnastics festival) whose values are usually used as a population normative.

RESULTS AND DISCUSSION

TABLE 1 refers to the development of average values regarding partial somatotype components and characterizes probability of test criteria F used for basic analysis of variance (ANOVA).

TABLE 1a
Average somatotypes of PE students and ANOVA results

Year of study	Endomorphic component		Mesomorphic component		Ectomorphic component	
	($\bar{x}$)	Ni	($\bar{x}$)	Ni	($\bar{x}$)	Ni
2001 (n = 39)	2.50	−0.57	3.70	−1.59	3.00	+0.46
2002 (n = 39)	2.50	−0.57	3.60	−1.70	3.10	+0.55
2003 (n = 40)	2.20	−0.85	3.80	−1.48	3.00	+0.46
2004 (n = 48)	2.10	−0.95	4.10	−1.17	3.00	+0.46
ANOVA Probability of **the F-test**		0.07		0.22		0.90

The value development of the endomorphic component is undergoing a downward trend, which proves the obvious comparison made within the years 2001–2004 (the value approached statistical significance at $\alpha = 0.05$). There is one question remaining: whether the decrease in the endomorphic component by half a point can distinctively improve sport performance and efficiency as well as increase the PE students' success in passing practical subjects of their study field.

The value development of the mesomorphic and ectomorphic components is obviously statistically of no importance. The mesomorphic component has gone up slightly, nevertheless the biggest difference noticed between the year 2002 and the year 2004 is, in neither case, of any importance. The ectomorphic component is of constant value.

The comparison concerning spartakiada gymnasts copies the development of individual somatotype components. Concerning the endomorphic component, the first group and the second group are characterized within the average, whereas the third group and the fourth group are below the average (a slight downward trend of endomorphy). In terms of the mesomorphic component of the first and the second group, the values are intensively below average as well as the third and the fourth group, which reach below average values (a slightly rising character of mesomorphy). The trend of the ectomorphic component is constant (as mentioned above) and the values of all groups have reached the average.

TABLE 1b
Average somatotypes of PE women students and ANOVA results

Year of study	Endomorphic component		Mesomorphic component		Ectomorphic component	
	($\bar{x}$)	Ni	($\bar{x}$)	Ni	($\bar{x}$)	Ni
2001 (n = 19)	3.4	−0.51	2.9	−2.67	2.8	+0.27
2002 (n = 19)	3.2	−0.68	3.6	−1.69	2.8	+0.27
2003 (n = 15)	3.4	−0.51	2.8	−2.81	3.1	+0.55
2004 (n = 46)	3.3	−0.60	3.1	−2.39	2.9	+0.36
ANOVA Probability of **the F-test**		0.91		0.22		0.67

The development of individual somatotype components is obviously of no importance as it was only in the results of the men (just the endomorphic component approached statistical importance). When comparing the individual grades there was no development trend among women students and the values are constant within the whole time period. To the contrary, there was a decreasing trend within the endomorphic component and downward significant trend within the mesomorphic component concerning the group of men students.

The comparison concerning spartakiada gymnasts copies the development of individual somatotype components. The values of all groups reach the average regarding the endomorphic component. The values of the mesomorphic component are intensively below average (the only exception is noted in 2002, where the value is also below average). The values regarding the ectomorphic component of all groups reach the average.

The optimal somatotype for PE students has been specified by Štěpnička et al. (1979). The same values of somatotype components are recognized as optimal by Riegerová and Ulbrichová (1993).

The optimal somatotype for PE students is supposed to be the type of somatotype whose values of endomorphic component are <3 and of a mesomorphic component of >5.

TABLE 2a
Occurrence of optimal somatotype regarding PE study within the group of men

Year of study	Frequency of optimal somatotype occurrence	Occurrence of optimal somatotype (%)
2001 (n = 39)	6	15.38
2002 (n = 39)	5	12.82
2003 (n = 40)	6	15.00
2004 (n = 48)	5	10.41

TABLE 2a presents the number of male students whose optimal somatotype was found and proved. Obviously, the number of these male students concerning all groups is very low. From the global point of view the trend is constant (the occurrence is not higher than 16%).

The average values of the endomorphic component in all groups can be evaluated as optimal (they are not higher than 2.50 points). However, the average values of the mesomorphic component significantly fall behind the optimal values.

The optimal somatotype for PE students (women) is supposed to be the kind of somatotype whose values of endomorphic component are <3.5, while the mesomorphic component is dominant (or equals the endomorphic component within the limits of 3.5–4) and the ectomorphic component is not higher than 4 points.

TABLE 2b
Occurrence of optimal somatotype regarding PE study within the group of women

Year of study	Frequency of optimal somatotype occurrence	Occurrence of optimal somatotype (%)
2001 (n = 19)	3	15.78
2002 (n = 19)	4	21.05
2003 (n = 15)	2	13.33
2004 (n = 46)	7	15.21

TABLE 2b presents the number of women students whose optimal somatotype was found and proved. Obviously, the number of these women students concerning all groups is very low. From the global point of view the trend is constant (the occurrence is not higher than 16%). The only exception was in 2002 when an optimal somatotype had been noticed with 21% of the women students. The results concerning the women students correspond with the results concerning the male students (in whom the occurrence of optimal somatotype was not higher than 16%). The average somatotype values can be assessed as optimal in all groups (with values not higher than 3.5 points). However, the average values of the mesomorphic component are, in all monitored groups, not dominant, which is unsuitable in terms of the optimal somatotype. The only exception was in 2002. The average values of the ectomorphic components can be assessed as optimal (values not higher than 4 points). The results concerning average values of individual somatotype components with regard to optimal somatotypes for PE students correspond with the results concerning PE male students.

Here we are comparing the average values of somatotype components regarding our PE students with the results carried out by other authors.

TABLE 3a
PE male students

Monitored group	Endomorphic component	Mesomorphic component	Ectomorphic component
Pedagogical Faculty, Ostrava 2001	**2.50**	**3.70**	**3.00**
Pedagogical Faculty, Ostrava 2002	**2.50**	**3.60**	**3.10**
Pedagogical Faculty, Ostrava 2003	**2.20**	**3.80**	**3.00**
Pedagogical Faculty, Ostrava 2004	**2.10**	**4.10**	**3.00**
Pedagogical Faculty, Brno (Pavlík, 1999)	2.30	5.20	2.80
Faculty of Physical Culture, Olomouc (Riegerová et al., 1995)	2.20	5.10	3.20

The comparison of our results with the results carried out by Riegerová et al. (1995) and Pavlík (1999) leads us to a statement that the values of the endomorphic and the ectomorphic components do not differ distinctively. However, there were significant differences concerning the mesomorphic component. The values were by 1–1.5 points higher regarding the students from Olomouc and by 1.1–1.6 points higher regarding the students from Brno.

TABLE 3b
PE women students

Monitored group	Endomorphic component	Mesomorphic component	Ectomorphic component
Pedagogical Faculty, Ostrava 2001	**3.40**	**2.90**	**2.80**
Pedagogical Faculty, Ostrava 2002	**3.20**	**3.60**	**2.80**
Pedagogical Faculty, Ostrava 2003	**3.40**	**2.80**	**3.10**
Pedagogical Faculty, Ostrava 2004	**3.30**	**3.10**	**2.90**
Faculty of Physical Culture, Olomouc (Riegerová et al., 1995)	3.50	3.50	3.10

The values of the endomorphic and the ectomorphic components applied to our women students from Ostrava are almost identical with the values of women students from Olomouc. More significant differences were found within the mesomorphic component. The values concerning the women students from Ostrava were by 0.4–0.7 points lower (the only exception was in 2002).

The comparison of our results with the results carried out by Riegerová et al. (1995) and Pavlík (1999) leads us to a statement that the values of the endomorphic and the ectomorphic components do not differ distinctively. However, there were differences concerning the mesomorphic component. The students from Olomouc show a gain in values (men had higher values by 1.5 points and women had higher values by 0.5 points).

CONCLUSION

As for average somatotypes, no significant differences concerning PE students were noted during the consequent years of research and neither was any development trend proven.

PE students can be regarded as a group of the population with a large volume of physical activity, therefore a significant development of their physical build was observed, as well as a somatotype reaching an optimum for PE women students (Riegerová, 1994). However, the measurements proved that students fell behind especially in the mesomorphic component, which shows in the comparing with gymnasts (of the healthy population) who had taken an active part in the Czechoslovak spartakiada. The physical build of our students (students from the Ostrava University) is weaker. The occurrence frequency of students with an optimal somatotype can be characterized as very low in relation to all groups.

We do assume that our findings and results may prove a decreasing physical level and a related somatic development of our population as well as our students. The significantly lower value of the mesomorphic component of our students can be caused by the increased number of admitted students to university who do not enter their studies. This trend leads to a shift towards weaker students (see the introduction).

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SOMATICKÁ ANALÝZA POSLUCHAČŮ TĚLESNÉ VÝCHOVY VE ČTYŘLETÉM SLEDOVANÉM OBDOBÍ

(Souhrn anglického textu)

Moderní pojetí interpretuje sportovní výkon jako vymezený systém prvků, které jsou označovány jako komponenty, determinanty, faktory apod. Velmi důležitou skupinou faktorů jsou faktory somatické, které se týkají podpůrného systému. Za somatické faktory považujeme tělesnou výšku, hmotnost, délkové, šířkové a obvodové

rozměry a z nich tedy plynoucí tělesnou stavbu (velmi často vyjádřenou somatotypem).

Příspěvek se zabývá tělesnou stavbou studentů oboru TV 1. ročníku, které můžeme považovat za selektovanou skupinu populace s poměrně velkým objemem pohybové aktivity. Šetření bylo prováděno v letech 2001–2004 a bylo do něj zařazeno 265 studentů (166 mužů a 99 žen). Pro zjištění tělesné stavby byl určován somatotyp podle metodiky Heath-Certer (Riegerová & Ulbrichová, 1993).

Při srovnání průměrných somatotypů studentů tělesné výchovy v jednotlivých letech jsme nezaznamenali významné rozdíly. Za výjimku můžeme považovat snad jen endomorfní komponentu u mužů, která měla výrazně klesající trend (hodnota se blížila k hranici statistické významnosti $\alpha = 0,05$).

Vzhledem k tomu, že považujeme studenty tělesné výchovy za selektovanou populaci s velkým objemem pohybové aktivity, předpokládali jsme u nich výrazný rozvoj habitu a typ somatotypu, kterým se většina přiblíží optimálnímu somatotypu pro studenty TV (Riegerová & Ulbrichová, 1993). Měření však ukázala, že studenti výrazně zaostávají především v oblasti mezomorfie, což ukazuje také srovnání s populačním normativem.

Domníváme se, že zjištěné hodnoty mohou vypovídat o klesající úrovni fyzického a s tím souvisejícího somatického rozvoje naší populace.

Klíčová slova: studenti TV, somatotyp, optimální somatotyp, sportující jedinci, TV.

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RELATIONSHIP BETWEEN CHILDREN'S SUCCESSFULNESS IN PRE-SWIMMING EDUCATION, THEIR TEMPERAMENT CHARACTERISTICS AND STIMULATION TO PHYSICAL ACTIVITIES

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The main aim of this inquiry was to review and evaluate possibilities of relations of preschool children's successfulness in a pre-swimming course to some outer and inner factors. We concentrated on a level of stimulation to physical activities from family and school and on temperament characteristics of monitored children. Our sample consisted of 83 children (non-swimmers) attending kindergartens. Complete results were obtained from 58 of them (30 girls and 28 boys). The mean age of the sample was 5.87 years. A degree of successfulness of a child in the pre-swimming education course, concentrated on teaching swimming fundamentals, was evaluated by a standardized 5 item set of tests (Řehoř, 1969). The sample was divided into three groups according to a total achieved test score as follows: U1 – very successful, U2 – successful, and U3 – unsuccessful. Temperament characteristics (temperament type and character dimensions) were assessed by the Eysenck questionnaire (Eysenck & Eysenck, 1994). The ESPA questionnaire (Renson & Vanreusel, 1990) was used to evaluate environmental stimulation to physical activities. A relationship between children's successfulness in pre-swimming education, their temperament type and character dimensions was evaluated by analysis of variance or the Kruskal-Walis test, respectively. The Mann-Whitney test was used to evaluate associations between stimulation to physical activities and successfulness in the pre-swimming education course. When comparing stimulation to physical activities between groups with different levels of successfulness in pre-swimming education (between groups U1 and U3 or U2 and U3, respectively), a significant difference was found ($p < 0.01$) in one of the stimuli of social participation. A comparison between the U1, U2, and U3 groups confirmed a statistically significant difference in the dimension of extroversion between the U1 and U3 groups ($p < 0.01$) and also between the U1 and U2 groups ($p < 0.05$). The worst group in the tests of the swimming successfulness (U3) significantly differs from the U1 group also in the occurrence of temperament types ($p < 0.05$). Within the assessed sample, a statistically significant dependence was found between the successfulness of a child in the pre-swimming education and temperament type ($p < 0.05$).

Keywords: Preschool age, pre-swimming education, temperament, stimulation to physical activities.

INTRODUCTION

Teaching swimming fundamentals to preschool children serves many specific functions. In addition to the well-known positive health outcome, swimming also ensures motor stimulation and physical self-realization of a child, contributes to the development of physical abilities and enhances a child's knowledge about new physical skills performed in an atypical environment. It also helps develop basic hygienic routines, leads to the hardiness of a child's organism and contributes to the advancement of some positive psychological attributes (such as will, self-confidence, and overcoming uneasiness) through its requirements of the adaptability of the organism to the new environment, and is involved in the development of mental resistance. Also the enjoyment of movements in the aquatic environment plays an important role (Hochová & Čechovská, 1989; Srdečný & Srdečná, 1990; etc.).

Despite the positives mentioned above, only some authors deal with factors of child's successfulness in pre-swimming education concentrated on teaching swimming fundamentals. That is why we target at least some of the factors in our partial inquiry: stimulation to physical activity from family members and temperament characteristics – dimensions of character and temperament type.

Stimulation to physical activity within the family

Family is the first social group from which a child receives plenty of integrating and differentiating processes. The more consistent and immediate emotional attitudes in a family, the stronger influence on the development of a child's personality can be found when observing familial environments. Many experts agree that familial education is a determinant of an individual's way of life and management of leisure time in future (e.g. Snyder & Purdy, 1982; Kučera, 1990; Matějček & Dytrych, 1994; etc.). Families where parents pursue physical activities together with their children, are typical in their active attitudes to exploitation of leisure time. Relationships in such families are more proximate, typically with lots of mutual understanding, cooperation and confidence in the abilities of a child. These relationships consequently flow into the growing self-confidence of a child and favor a gradual development of his/her social adaptability. A parent as a role model presents a nonviolent stimulation; the child is challenged to mime the adult ("adult play"), which is found to be motivating for youngsters (Matějček & Langmeier, 1981; etc.).

When orientating interests to physical activities, it is not possible to rely on a natural child's longing for movement. It is necessary to stimulate this need actively in the family environment.

Results of foreign research focused on the tracking of relations between the sports engagement of parents and children confirmed positive relationships between sports activity of parents and their children. Studies of Greenhofer and Lewko (1978), Freedson and Everson (1991), Bartík (1995) and others registered the significant influence of parents on children's attitudes towards physical activities and also a certain conjunction with one of the parent's sex or education. Kučera (1990) talks about adequacy of physical activity in children, which is set by genetic predispositions, living conditions and environments, nutrition, history of early ontogenetic phases, the type of a child in relation to certain types of physical activity; etc.

Temperament characteristics and physical activity

The environment of a child's growth and educational impingement on him or her has often crucial influence upon the configuration of his or her personality (Brierley, 1996; Čáp, 1996; Matějček, 2003; Špaňhelová, 2004; etc.). The more frequent stimuli to learn miscellaneous physical activities and the more positive experience with these activities, the easier it is to learn to cope with the stress caused by an unknown environment (Klusová, 2006; Řehulková et al., 1995; etc.). When directing a child to physical activities, Bouchalová (1987) remarks not only on another possibility of the development of his or her psychomotor fund, but also the development of the social component of a child's personality. He or she acquires the ability to adopt a role in a group, so it can be facilitating for other social roles in an individual's future life.

Many authors (e.g. Godin & Shepard, 1986; Řehulková, Fraňková, & Osecká, 1995; Slepičková, 2001; etc.) have dealt with problems of relationships between physical activity and some aspects of human personality. In particular, e.g. Semiginovský (1988), Motyčka (1991), Zapletalová (2003) and others have dealt with attributes of temperament in relation to sports activity in children, youth and adults.

PROBLEM QUESTIONS

The main aim of this inquiry was to review and evaluate possibilities of relations of preschool children's successfulness in a pre-swimming course to some outer and inner factors. We concentrated on a level of stimulation to physical activities from family and on temperament characteristics of the monitored children.

Based on a literature review and our main aim, we determined these problem questions:

1. Will any relationship be found between factors of stimulation to physical activities and children's successfulness in pre-swimming education?
2. Will children with different successfulness in pre-swimming education differ also in dimensions of their character?
3. Will any relationship be found between successfulness in pre-swimming education and temperament type?

METHODS

The sample consisted of 83 children (non-swimmers) attending kindergartens. Complete results were obtained from 58 of them (30 girls and 28 boys). The mean age of the sample was 5.87 years.

The degree of successfulness of a child in a pre-swimming education course, concentrated on teaching swimming fundamentals, was evaluated by a standardized 5 item set of tests (Řehoř, 1969). This set consists of five partial tests: T1 – repeated expirations to water, T2 – streamlining on one's back, T3 – streamlining on the abdomen, T4 – jumping into the water, T5 – immersion under the surface. The evaluation of the test scores was executed by three independent qualified raters who used a 4 point ordinal scale (1 point = the best, 4 points = the worst). The quality of their ratings was evaluated via a concordance rate between their measures by Wilcoxon ordinal test (Kovář & Blahuš, 1989). The tests were realized in the first, third, fifth, seventh, and ninth lesson, always close to its end. The children were challenged to do the item demonstrated by their teacher. If the children were not able to do the item even with help, they were neither forced nor reasoned with to do so. In the case of the thirty-percent or greater absence of a child, his or her results were not included into our analyses, although he or she also took part in these tests for pedagogical and psychological reasons. The sample was divided into three groups according to the total achieved test score as follows: U1 group (very successful) – achieved mean 1.00–1.99 points, U2 group (successful) – achieved mean 2.00–2.99 points, and the U3 group (unsuccessful) – achieved mean 3.00–3.99 points.

For the investigating of temperament characteristics (dimensions of character and temperament type), the Eysenck questionnaire B – J. E. P. I. (1994) was used. Score frequencies of the P dimension (psychoticism), the N dimension (neuroticism), and the E dimension (extraversion – introversion) of the sample as well as the score frequency of the monitored dimensions and temperament types in groups divided according to their successfulness in pre-swimming education was evaluated in percentages. We used values from the questionnaire also for a determination of the complementary temperament typology of the children (phlegmatic, sanguine, choleric, and melancholic). The results were processed according to Vilímová's method (1993). Pearson's coefficient of rank correlation was used to point out the possible interdependence of single dimensions and the successfulness of children in pre-swimming education. Assumed differences in the dimensions between groups with different successfulness in pre-swimming education were evaluated by the Mann-Whitney test. A relationship between the successfulness of children in pre-swimming education and temperament type was also evaluated by the analysis of variance or the Kruskal-Walis test.

For the evaluation of environmental stimulation to physical activities, we used the English version of the "Environmental stimulus for physical activity" questionnaire by Renson and Vanreusel (1990). This questionnaire assesses the material, spatial and social stimulation of a child to physical activities as pursued by family and school. The authors have confirmed in their previous research that the level of physical fitness and its main components in youth differs according to the cultural and social situation of the examined persons (Renson, 1980). The questionnaire registers the following aspects to investigate differences between the stimulation levels to physical activities:

- Place and opportunities for informal physical activities and also more formal participation in sports activities in the family.
- Place and opportunities for informal physical activities and also more formal participation in sports activities in school.

A resultant score of 47 points or less means a very low level of stimulation, 48–60 points means a low level of stimulation, 61–73 points means a lower average, 74–86 points means a higher average, 87–99 points means a high level, and more than 99 points means a very high level of stimulation to physical activities. When assessing results of the ESPA questionnaire, U1, U2, and U3 groups were evaluated by a frequency rate of incidence. An evaluation of the statistical significance of differences in results obtained by the ESPA questionnaire between the groups of children divided according to their successfulness in the pre-swimming education was pursued by the Mann-Whitney test.

RESULTS AND DISCUSSION

Successfulness in pre-swimming education and stimulation to physical activities

It is possible to note that 50 percent of children achieving high successfulness in the course of pre-swimming education (group U1) are stimulated to physical activities on an above average level (score 74 to 86). Children from the U2 and U3 groups scored less in this category (40 percent) and, on the contrary, they scored better in the group achieving a lower average level (TABLE 1).

When comparing the stimulation to physical activities between the groups with different successfulness in pre-swimming education (between the groups U1 and U3 or U2 and U3, respectively), a significant difference was found ($p < 0.01$) in some stimuli of social participation, particularly in the factor "participation in children's and sports organizations" (TABLE 2). Of the studied children, 90% in the U3 group, 40% in the U2 group, and 32.14% in the most successful U1 group, respectively, are not members of any association or organization. No children's camp, neither sports and non-sports oriented, was ever attended by 70% of the children in the U3 group (55% in the U2 group and 39.29% in the U1). These results are similar to the findings of some authors (e. g. Bouchalová, 1987; Řehulková et al., 1995; Klusová, 2006 etc.), that the participation of a child in sports or other organizations or associations probably affects a child's personality in the sense of enhancing his or her self-reliance and adaptability to various (including unpleasant) environments. A child must be able to be absent from his or her family members for some time and should be active and self-confident even without their support. Strengthening of these abilities allows a young non-swimmer to cope with the "weirdness" of movements in an aquatic environment more quickly and easily. This should be manifested by more successful managing of swimming fundamentals as a whole.

Successfulness in pre-swimming education and temperament characteristics

In the P and N dimensions, a majority of the participants were placed in the category score frequencies of 0–10 points in all the three groups: U1 – P dimension 96.43% and N dimension 96.42%, U2 – P dimension

100.00% and N dimension 100.00%, U3 – P dimension 100.00% and N dimension 100.00%. Different results can be observed in the E dimension: 60.71% of the participants from the U1 group, but only 50.00% participants from the U2 and U3 scored in the category of 15 or more points. On the other hand, only 17.85% of participants from the U1 group scored in the 0 to 10 points category, while the matching score in the U2 and U3 groups was 50%. A mutual comparison between all the three groups confirmed a statistically significant difference between the U1 and U3 groups ($p < 0.01$) and also between the U1 and U2 groups ($p < 0.05$) in the E dimension (TABLE 3).

When considering the frequency of occurrence of the temperament types, there is a much lower number of sanguine children (71.43%) in the U1 group than in the U2 (50%) or U3 (30%). On the other hand, there is lower share of phlegmatic children in the most successful group (14.29%), compared to U2 (50%) and U3 (70%), (TABLE 4). A statistically significant difference was found between the U1 and U2 groups ($p < 0.05$) and the U1 and U3 groups ($p < 0.01$), respectively, in the phlegmatic type. A statistically significant difference was confirmed between the U1 and U3 groups ($p < 0.05$) in the sanguine type (TABLE 5). The worst group in the tests of swimming successfulness (U3) significantly differs from the U1 group also in the occurrence of the temperament types ($p < 0.05$). These results correspond to findings of relationships between temperament characteristics in some other inquiries dealing with similar problems (e.g. Vilímová, 1993; Řehulková, Fraňková, & Osecká, 1995; Suchomel, 2002; Zapletalová, 2003; etc.). In this sample, a statistically significant dependence between the successfulness of a child in pre-swimming education and temperament type was confirmed ($p < 0.05$) (TABLE 6).

TABLE 1
Score frequency points of stimulation for physical activities between groups with different successfulness in pre-swimming education U1, U2 and U3

Group U1	**n = 28**					
Category	**Frequency**	**Cumul. %**	**%**	**Category**	**Frequency**	**Cumul. %**
47	0	.00	.00	86	14	50.00
60	0	.00	.00	73	13	96.43
73	13	46.43	46.43	99	1	100.00
86	14	96.43	50.0	47	0	100.00
99	1	100.00	3.6	60	0	100.00
Others	0	100.00	0.0	Others	0	100.00
Group U2	**n = 20**					
Category	**Frequency**	**Cumul. %**	**%**	**Category**	**Frequency**	**Cumul. %**
47	0	.00	.00	73	11	55.00
60	1	5.00	5.00	86	8	95.00
73	11	60.00	55.00	60	1	100.00
86	8	100.00	40.00	47	0	100.00
99	0	100.00	0.00	99	0	100.00
Others	0	100.00	0.00	Others	0	100.00
Group U3	**n = 10**					
Category	**Frequency**	**Cumul. %**	**%**	**Category**	**Frequency**	**Cumul. %**
47	0	.00	.00	73	6	60.00
60	0	.00	.00	86	4	100.00
73	6	60.00	60.00	47	0	100.00
86	4	100.00	40.0	60	0	100.00
99	0	100.00	0.0	99	0	100.00
Others	0	100.00	0.0	Others	0	100.00

Legend:
Category — max. points of the questionnaire ESPA
Frequency — number of children in the category
Cumulative % — cumulative frequency %
% — % number of children in the group

TABLE 2
Significant influences in stimuli to physical activities between groups with different successfulness in pre-swimming education U1, U2 and U3

Groups	U1–U2	Sign.	U2–U3	Sign.	U1–U3	Sign.
MATERSk	–1.0075		1.6009		1.2461	
	0.3136		0.10938		0.2127	
MATERRod	–1. 9364		1.1813		–0.3874	
	0.0528		0.2374		0.6984	
KDESk	1.0343		1.0796		1.7436	
	0.3009		0.2802		0.0812	
KDERod	0.7591		–0.8631		–0.4178	
	0.4477		0.3880		0.6760	
CESTA	–1.2948		1.0099		0.1163	
	0.1953		0.3125		0.9073	
KAMAR	0.1936		–2.6549		–3.0672	
	0.8464		0.0079	XX	0.0021	XX
TABOR	–1.1288		–0.8207		–1.7373	
	0.2589		0.4117		0.0823	

Legend:

Sign.	statistically significant difference
MATERSk	material play stimulus at school
MATERRod	material play stimulus in the family
KDESk	spatial play stimulus at school
KDERod	spatial play stimulus in the family
CESTA	transportation stimulus
KAMAR	social participation stimulus (organizational context of sport involvement)
TABOR	participation (in camps)
XX	statistically significant difference between groups ($p < 0.01$)

TABLE 3
Significant influences in dimension P (psychoticism), the N dimension (neuroticism), and the E dimension (extraversion–introversion) between groups U1, U2 and U3

Dim.	U1–U2	Sign.	U2–U3	Sign.	U1–U3	Sign.
P	–0.6234		0.6314		0.1356	
	0.5305		0.5277		0.8921	
E	–1.9732		–1.127		–2.6424	
	0.0484	X	0.2597		0.0082	XX
A	0.6266		0.5145		0.9038	
	0.5308		0.6068		0.3660	

Legend:

Dim.	dimension
Sign.	statistically significant difference
X	statistically significant difference $p < 0.05$
XX	statistically significant diference $p < 0.01$

TABLE 4
Score frequency of temperament types in groups U1, U2, and U3

TU1						
Category	**Frequency**	**Cumul. %**	**%**	**Frequency**	**Cumul. %**	**%**
1	4	14.29	14.29	2	20	71.43
2	20	85.71	71.43	1	4	85.71
3	0	85.71	.00	4	1	89.29
4	1	89.29	3.57	5	1	92.86
5	1	92.86	3.57	6	1	96.43
6	1	96.43	3.57	7	1	100.00
7	1	100.00	3.57	3	0	100.00
Others	0	100.00	.00	Others	0	100.00
TU2						
Category	**Frequency**	**Cumul. %**	**%**	**Frequency**	**Cumul. %**	**%**
1	10	50.00	50.00	1	10	50.00
2	10	100.00	50.00	2	10	100.00
3	0	100.00	.00	3	0	100.00
4	0	100.00	.00	4	0	100.00
5	0	100.00	.00	5	0	100.00
6	0	100.00	.00	6	0	100.00
7	0	100.00	.00	7	0	100.00
Others	0	100.00	.00	Others	0	100.00
TU3						
Category	**Frequency**	**Cumul. %**	**%**	**Frequency**	**Cumul. %**	**%**
1	7	70.00	70.00	1	7	70.00
2	3	100.00	30.00	2	3	100.00
3	0	100.00	.00	3	0	100.00
4	0	100.00	.00	4	0	100.00
5	0	100.00	.00	5	0	100.00
6	0	100.00	.00	6	0	100.00
7	0	100.00	.00	7	0	100.00
Others	0	100.00	.00	Others	0	100.00

Legend:
TU1 temperament types in the group U1
TU2 temperament types in the group U2
TU3 temperament types in the group U3
1 phlegmatic type
2 sanguine
3 choleric
4 melancholic
5 line phlegmatic-sanguine
6 line sanguine-choleric
7 crossing centre extraversion-introversion
n = 58

TABLE 5
Statistically significant differences in temperament types between groups with different successfulness in pre-swimming education U1, U2 and U3

TYPE	U1–U2	Sign.	U2–U3	Sign.	U1–U3	Sign.
1	–2.6838	X	–1.0421		–3.3347	XX
2	1.5119		1.0421		2.3007	X
3						
4	0.8541				0.6056	
5	0.8541				0.6056	
6	0.8541				0.6056	
7	0.8541				0.6056	
Others						

Legend:

Sign.	statistically significant difference
X	$p < 0.05$
XX	$p < 0.01$
TYPE	temperament types
1	phlegmatic type
2	sanguine
3	choleric
4	melancholic
5	line phlegmatic–sanguine
6	line sanguine–choleric
7	crossing centre extraversion–introversion

n = 58

TABLE 6
Relationship between childrens' successfullness in pre-swimming education and temperament type and dimension of character, n = 58

Dim.	Pears	Sign.
P	–0.0445	
E	–0.4492	
A	0.2005	
TYPE (ANOVA)	7.5999 0.0139	X
TYPE (Krus-Wal)	13.9331 0.0160	X

Legend:

Sign.	statistically significant difference
Dim.	dimension
P	dimension P (psychoticism)
E	dimension E (extraversion–introversion)
N	dimension N (neuroticism)
Pears	Pearson's coefficient
TYPE (ANOVA)	relationship between childrens' successfullness in pre-swimming education and temperament type as evaluated by analysis of variance
TYPE (Krus-Wal)	relationship between of children's success in pre-swimming education and temperament type as evaluated by the Kruskal-Walis test

CONCLUSIONS

1. Within the examined sample, the stimulation of a child to physical activities by family members influences only partially successfulness in pre-swimming education. The significant difference ($p < 0.01$) between the groups U1 and U3 in one stimulus of social participation (area of a child's participation in sports or children's organizations) refers to the possible affecting of a child's personality in the point of enhancing of his or her self-reliance and adaptability to various environments.
2. Statistically significant differences were confirmed when comparing the E dimension in all three groups of children mutually. It was also gathered that the majority of children scoring highly in the N dimension (neuroticism) were positioned in the lowest successful group. These children probably need a slower tempo and an individual adaptation of methods, in agreement with theoretical knowledge in this field. Within the examined sample, more extrovert children had a higher degree of successfulness in pre-swimming education.
3. The highest incidence of sanguine type (71.43%) and the lowest share of phlegmatic type (14.29%) was found in the U1 group, while the phlegmatic type predominates in the least successful group in pre-swimming education, when evaluating the frequency of incidence of the temperament types in each of the three groups. A statistically significant dependence was also found between the successfulness of a child in pre-swimming education and the temperament type ($p < 0.05$).

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VZTAH MEZI ÚSPĚŠNOSTÍ DĚTÍ V PŘEDPLAVECKÉ VÝCHOVĚ, JEJICH TEMPERAMENTOVÝMI CHARAKTERISTIKAMI A STIMULACÍ K POHYBOVÝM AKTIVITÁM

(Souhrn anglického textu)

Cílem studie bylo posoudit a zhodnotit možnost ovlivnění úspěšnosti dětí předškolního věku v kurzu předplavecké výchovy některými vnějšími a vnitřními faktory. Zaměřili jsme se na úroveň environmentální stimulace k pohybovým aktivitám ze strany rodiny a školy a na rysy temperamentu sledovaných dětí. Do výzkumného souboru bylo zahrnuto 83 dětí – neplavců z mateřských škol, úplné výsledky se podařilo získat u 58 dětí (30 dívek a 28 chlapců). Průměrný věk sledovaného souboru byl 5.87 roku. Míra úspěšnosti dítěte v kurzu předplavecké výchovy, zaměřeném na výuku základních plaveckých dovedností, byla hodnocena pomocí standardizované pětisložkové testové baterie (Řehoř, 1969). Na základě výsledků byly děti zařazeny do tří skupin: U1 – velmi úspěšní, U2 – úspěšní, U3 – neúspěšní. Rysy temperamentu byly zjištěny prostřednictvím Eysenckova dotazníku (Müllner & Senka, 1987). Pro posouzení environmentální stimulace k pohybovým aktivitám jsme užili dotazníku ESPA (Renson & Vanreusel, 1990; Miklánková, 2005). Hodnocení souvislosti mezi stimulací k pohybovým aktivitám a úspěšností dětí v kurzu předplavecké výchovy bylo provedeno Mann-Whitney testem. Vztah mezi úspěšností probandů v předplavecké výchově a jejich typem temperamentu byl hodnocen analýzou variance, případně metodou Kruskal-Walis. Při porovnání stimulace k pohybovým aktivitám mezi skupinami s rozdílnou úspěšností v předplavecké výchově (mezi skupinami U1 a U2, U2 a U3) byl nalezen signifikantní rozdíl ($p < 0.01$) u jednoho ze stimulů sociální participace. Srovnání mezi skupinami U1, U2 a U3 potvrdilo statisticky významný rozdíl v dimenzi extraverze mezi skupinou U1 a U3 ($p < 0.01$) a mezi skupinou U1 a U2 ($p < 0.05$). Skupina U3, která dosáhla v testech plavecké úspěšnosti nejhorších výsledků, se signifikantně odlišuje od skupiny U1 také v typu temperamentu ($p < 0.05$). U sledovaného souboru byla prokázána statisticky významná závislost mezi úspěšností dítěte v předplavecké výchově a typem temperamentu ($p < 0.05$).

Klíčová slova: předškolní věk, předplavecká výchova, temperament, stimulace k pohybovým aktivitám.

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CENTILE CHARTS OF MOTOR DEVELOPMENT IN GIRLS AGED BETWEEN 7.5–19.5 FROM THE KUJAWSKO-POMORSKIE DISTRICT

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Submitted in May, 2006

The aim of the research was to present motor development with the help of centile charts, where the centile curves determine particular parts of the population: 3, 10, 25, 50, 75, 90 and 97 percentile.

The research was conducted in the spring of 2001. A survey of 11 803 girls aged between 7.5 and 19.5 years old, from various types of rural and urban schools of the Kujawsko-Pomorskie district, was conducted. Centile charts make it possible to observe the process of the development of the examined characteristic, to answer the question as to whether an individual is at the level which is characteristic of a certain age, and, in case of aberrations, to come to a conclusion that the process of growth is disturbed. While determining the centile position one can become familiar with the level of development of an individual against calendar individuals of the same age. The value of C50 determines the calendar age of an individual. The results of the empiric research shows that the curve of the individual development of a child “wanders” within some channels, which is quite normal and does not mean a distortion of development.

Keywords: Motor fitness of girls, centile charts.

INTRODUCTION

Political changes have brought about social and economical changes in Poland. This situation can influence the biological development of children and teenagers. In order to present individual development one can used centile charts, which are widely used by doctors and teachers. They are also being developed by the employees of the International Institute of Mothers and Children in Warsaw (Bożiłow et al., 2004).

The development of an individual at every stage is a function of genetic factors, environment and time. As a result of interaction between genotype and environment, development progresses in accordance with its specific developmental line (Stein & Julian, 2003).

METHOD

Motor development was presented with the help of centile charts, where the centile curves determine particular parts of the population: 3, 10, 25, 50, 75, 90 and 97 percentile (Stupnicki et al., 2003).

The research was conducted in the spring (at the turn of April and May) of 2001 and covered 11 803 girls aged between 7.5 and 19.5 from various types of rural and urban schools of the Kujawsko-Pomorskie district. The number of girls in particular age groups as well as the environment they lived in were similar.

The calendar groups were created in accordance with the terms generally used in tests of the developmental type (Malinowski, 1978; Kemper & Van Mechelen, 1996). It was assumed that a 7.5 year old child was one who, on the day the research was done, was age between 7 years and eight years without one day. Considering the 24 hour long biological rhythm, the research on motor activity was conducted between 10 a.m. and 1 p.m.

Both daytime and extramural students of the Academy of Bydgoszcz (now Kazimierz Wielki University in Bydgoszcz), as well as the teachers of physical education and the medical personnel from the examined schools proved very helpful. All examiners were trained in accordance with the research instructions.

In the opinion of the author motor ability is mainly seen at the level of manifestation of abilities and motor skills of an individual during a particular act of movement, including fitness tests. Fitness as a characteristic was adopted as the ability to solve motor tasks and the level of the fitness of the population was expressed in average values obtained in motor tests.

In order to determine motor abilities, eight tests from the International Committee on the Standardisation of Physical Fitness were used. The test includes universal assessment of groups of muscles of the whole body. The technical elements are not aimed at any of the basic sports disciplines.

Before the tests, the examined parties did a warm-up typical for intensive physical training. The sports outfit used during research was to consist of a t-shirt and shorts (alternatively a light track-suit) and some sports shoes without spikes and pins, with a non-slippery sole. The tests of overhang and forward bend were to be done without any footwear. Instructions, helpful while doing particular tests, from the International Committee on the Standardisation of Physical Fitness, as described by Larson (1974) were adopted.

The centile charts were developed by the author on the basis of the obtained results.

RESULTS

The results are presented in graphic form, on centile charts, Figure 1–8.

Fig. 1
The centile chart of the girls' 50 m run

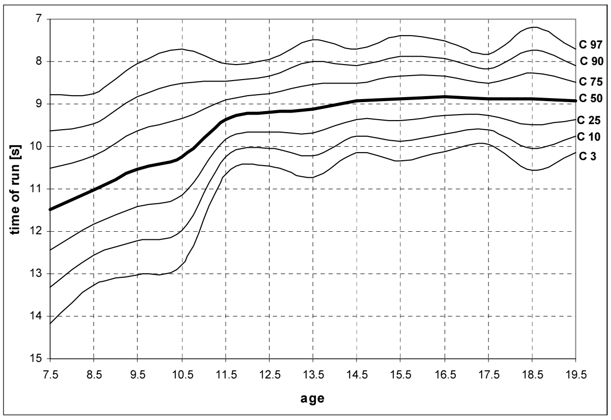


Fig. 2
The centile chart of the girls' 600 m for girls aged 7.5–11.5 and 800 m age 12.5–19.5 run

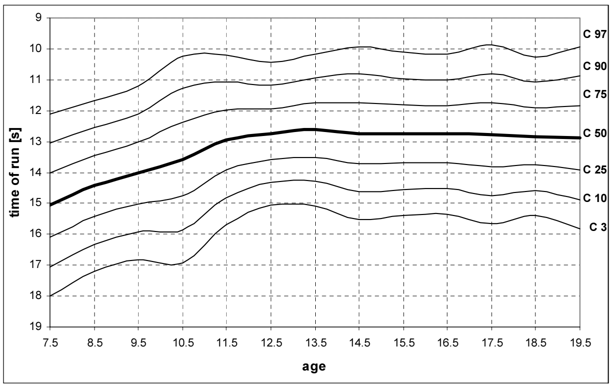


Fig. 3
The centile chart of the girls' 4 × 10 m shuttle run

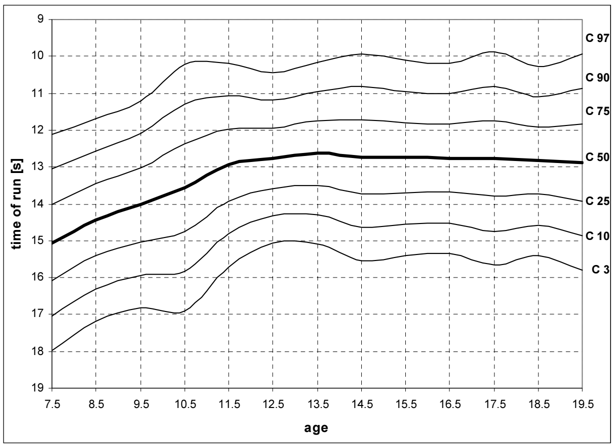


Fig. 4
The centile chart of the girls' forward bend of the trunk from the standing position

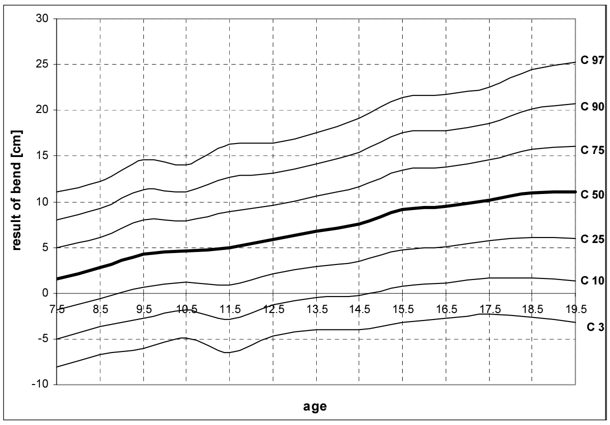


Fig. 5
The centile chart of the girls' – sit-ups within 30 sec.

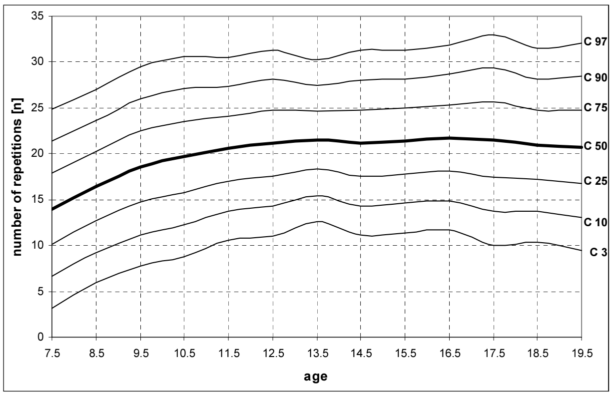


Fig. 6
The centile chart of the girls' horizontal bar bent arm hang

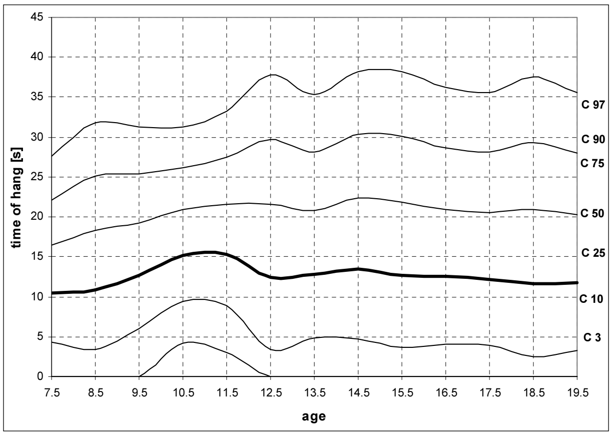


Fig. 7
The centile chart of the girls' dynamometer hand grip squeeze

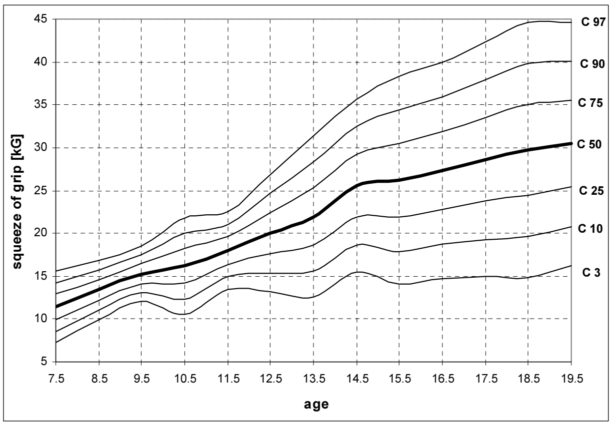
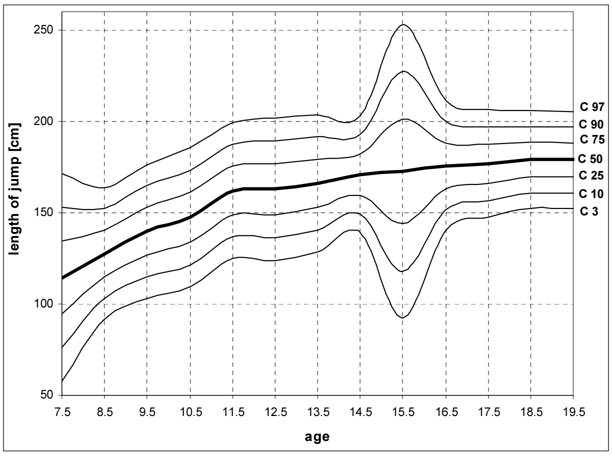


Fig. 8
The centile chart of the girls' standing long jump



DISCUSSION

The centile charts make it possible to observe the process of the development of the examined characteristic, to answer the question as to whether an individual is at the level which is characteristic of a certain age, and, in case of aberrations, to come to a conclusion that the process of growth is disturbed (Stupnicki et al., 2003).

While determining the centile position one can become familiar with the level of development of an individual against calendar individuals of the same age. The value of C50 determines the calendar age of an individual.

CONCLUSION

The results of the empiric research show that the curve of individual development of a child "wanders" within some channels, which is quite normal and does not mean a distortion of development (Cieślik et al., 1994). The developmental standard is a biological point of a reference which is used to determine the physical development of the population at the developmental age. The present evidence is a part of broader research into somatic and motor development of children and teenagers from the Kujawsko-Pomorskie district.

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CENTILOVÉ STUPNICE MOTORICKÉHO VÝVOJE U DÍVEK VE VĚKU 7,5–19,5 ROKU Z KUJAVSKO-POMOŘSKÉHO KRAJE

(Souhrn anglického textu)

Cílem výzkumů bylo představit motorický vývoj pomocí centilových stupnic, kdy centilové křivky určují jisté části populace: 3, 10, 25, 50, 75, 90 a 97 percentil.

Výzkumy byly prováděny na jaře roku 2001. Týkaly se 11 803 dívek ve věku mezi 7,5 a 19,5 lety z různých typů venkovských a městských škol kujavsko-pomořského kraje. Centilové stupnice umožňují sledovat proces vývoje zkoumaných charakteristik, zodpovědět na otázku, zda se jednotlivec nachází na úrovni charakteristické pro určitý věk a – v případě odchylek – dospět k závěru, že proces růstu je narušený. Při stanovování centilové pozice je možno poznat úroveň vývoje jednotlivce ve srovnání s jednotlivci téhož kalendářního věku. Kalendářní věk jednotlivce určuje hodnota C50. Výsledky empirických výzkumů ukazují, že křivka individuálního vývoje dítěte se klikatí v mezích určitých kanálů; to je však normální a neznamená to deformaci vývoje.

Klíčová slova: motorická zdatnost dívek, centilové stupnice.

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Dynamics of development of somatic and motor features of children and youth in Kujawy-Pomorze region and conditioning of the development; motor activity of children and youth and its influence on their health.

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The text of the contribution is in English. The contribution is not to exceed a maximum limit of 15 pages (including tables, pictures, summaries and appendices). A summary will be in the Czech language, and by rule 1 page at the most.

The text is to be presented in MS Word editor and also as a printout.

All contributions are reviewed anonymously.

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To be written on separate pages. A table is to be marked as TABLE 1 with its name below, write on the left margin above the table (the same applies for appendices). A picture is to be marked as Fig. 1, write from the left above the picture (the same applies for a graph).

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We look forward to our further cooperation!

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