# Physical activity in science & practice

Conference Proceedings | In celebration of the 60th anniversary of the establishment of the Faculty of Physical Education and Sport, Charles University in Prague [Prague, 19–21 June 2013]

KAROLINUM

Libor Flemr, Jiří Němec, Kateřina Kudláčková [eds.]

**Physical Activity in Science and Practice**
Conference Proceedings

In celebration of the 60th anniversary of the establishment of the Faculty of Physical Education and Sport, Charles University in Prague
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**Libor Flemr, Jiří Němec, Ondřej Novotný (eds.)**

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# SPORT, EXERCISE AND PHYSICAL EDUCATION IN THE SOCIAL SCIENCES

CHARLES UNIVERSITY IN PRAGUE
FACULTY OF PHYSICAL EDUCATION AND SPORT
DEPARTMENT OF KINANTHROPOLOGY AND HUMANITIES

# THE PROBLEM OF SAFETY IN MARTIAL ARTS AND MARTIAL SPORTS

IRENA MARTÍNKOVÁ

## ABSTRACT

On the basis of the differentiation of martial activities according to their meaning for the participants (i.e. close combat, martial arts, martial paths and martial sports) (Martínková & Vágner 2010), I shall distinguish a lethal kind of combat (close combat) from several combat kinds that are not supposed to be lethal (especially martial arts and martial sports). I have three main aims: (1) I shall introduce the reasons and strategies for enabling combat to be peaceful; (2) I shall discuss the role of safety in the two main contemporary kinds of peaceful martial activities (martial arts and martial sports); (3) I shall present the problems that might arise in martial arts and martial sports due to safety concerns. The main focus of enquiry is on the difficulty of maintaining the martial character of these activities whilst restricting the effects of danger.

**Key words:** close combat, martial arts, martial sports, safety, danger, ethics

## INTRODUCTION

Combat has developed over a long period of time, and it is possible to distinguish different kinds of combat according to different criteria. In our earlier work (Martínková & Vágner 2010), we distinguished four main contemporary kinds of combat according to the meaning it has for practitioners. These distinctions were based on the different kinds of combat in Japanese culture (partly inspired by Donohue 2005, who draws on Draeger 1973a, 1973b, 1974), which influenced the mode of combat in the Euro-American cultural context to a great degree. We distinguished the terms 'close combat', 'martial arts', 'martial paths' and 'martial sports'[1] (though there obviously exist also other kinds of combat according to the same criterion, e.g. see Martínková, Peliš & Veselý 2013, regarding different kinds of combat in Chinese cultural context).

[1] 'Martial paths' can also be called 'martial ways' and 'martial sports' are often referred to as 'combat sports'.

The aim of these articles was not just to describe modes of combat in specific regions, but to lay the foundations for various kinds of combat according to their meaning for participants – and, indeed, we can find most of these kinds of combat not only in Japan, but also in many other regions, Europe and the Americas not excepted. But even if not all kinds of combat are manifested in all regions, this does not mean that they cannot appear later – so our previous work is a basis for categories that are of an eidetic character, rather than descriptions of the empirical.

Whilst we still have some examples of close combat in our safe societies (mainly in the military sector), I shall examine the two main contemporary kinds of 'peaceful' combat (martial arts and martial sports) that have developed out of close combat.[2] I shall focus mainly on the diminishing of the level of danger to life or of causing serious injury to the participants, and on strategies and consequences of this change.

## LETHAL AND PEACEFUL MARTIAL ACTIVITIES

The most basic function of combat is to defeat opponents or to defend oneself from them – this is a kind of combat that we called 'close combat' (Martínková & Vágner 2010). This kind of combat is pragmatic and efficient and therefore dangerous – the outcome is often the death or serious injury of one or more of the combatants. Such a necessity to defeat others and/or defend oneself is a basic kind of combat that is to be found in most societies and that is to some extent present even in the relatively peaceful Western societies of post-war times, and we can still find lethal combat for example in the army environment or in street fights and individual attacks on people. These street encounters are often, at least for one participant, involuntary and surprising, and they can be very unequal (e.g. the individual concerned may have had no previous martial training).

However, close combat is not the only kind of combat. There are also other – peaceful – kinds of combat that are supposed to be non-lethal. The change of lethal combat into these non-lethal kinds brings about a change in combat itself. These non-lethal kinds of combat have a different aim – combat here is more educative, voluntary, equal, restricted and therefore much safer; it belongs mainly to free time activities and entertainment. In the next section I shall discuss the change of close combat to martial arts and martial sports, which I shall call 'safetification'.

## SAFETIFICATION OF MARTIAL ACTIVITIES

Historically, the development of various non-lethal kinds of combat flourished especially at the end of the 19th and beginning of the 20th centuries, after the introduction of more efficient means of fighting and killing (tanks, fighting airplanes, nuclear weap-

2 However, not every martial art or martial sport necessarily originates directly from close combat.

ons) and with the gradual development of safer societies, in which death as an outcome of fighting is usually justifiable only in self-defence or war. In these circumstances lethal combat becomes relatively redundant, as its use becomes less and less necessary. However, combat can still be recognized as valuable, even without the necessity to defend or kill people, for example, as a means of education – since development through the process of training and the acquisition of martial techniques could have various benefits for people, even in safer societies. But to serve this purpose, combat needs to become non-lethal, i.e. peaceful.

Presently we can recognize two prevailing kinds of such non-lethal (peaceful) combat that are to be found in many societies – martial arts and martial sports (Martínková & Vágner 2010) – even though it is possible to distinguish other peaceful kinds of combat too, such as, for example, martial paths[3] (Martínková & Vágner 2010, p. 33), martial shows[4] (see e.g. Martínková, Peliš & Veselý 2013, p. 17), etc. While it may look illogical to talk about martial arts and martial sports at the same time since they differ in many aspects, it is possible to do so on a general level with respect to the topic of safety, since the relationship of both to safety is very similar – these activities are supposed to use martial techniques, while they are supposed to be educative or developmental, and therefore safe. Let us now distinguish these two kinds of combat in more detail.

Martial arts can be described as martial activities undertaken with the aim of developing oneself in various aspects while learning combat techniques (development of motor skills, character, moral virtues, insights into principles of combat, qualities such as perseverance, patience, etc.), and all this without lethal consequences. So the combat here is relatively safe, and while the practitioners do learn to fight against an opponent, the main aim is self-improvement. Donohue (2005, p. 10) suggests that: "'martial arts' are rather 'martially inspired arts' with little or no realistic combat utility in the modern world."

Another popular kind of peaceful combat is called 'martial sports' (or sometimes 'combat sports'). These sports are competitive rule-governed contests that use martial techniques as the activity in which athletes are compared one against another. The aim here is 'to fight to win', which requires the overcoming of an opponent in a way that is not proscribed by the rules. The rules of martial sports seek to ensure that the participants are not severely hurt or killed within the bout, and that the competition is balanced and fair. Similarly as all sports, martial sports have their intrinsic values, such as competition values, ascetic values, interpersonal values, self-improvement, moral values, etc. – for which sports are valuable in education – in Physical Education (Pezdek 2012) as well as in Olympic Education (Hadjistephanou, Pigozzi & McNamee 2012).

[3] The term 'martial paths' highlights the connection of combat to religious, educational and philosophical systems. An example of a martial path is the practice of martial techniques within the context of Zen Buddhism. The aim here is enlightenment (*satori*) – the acquisition of martial techniques is supposed to help with improvement of one's balance, breathing, flexibility, being in the 'here and now', readiness for the unexpected, etc. (See e.g. Herrigel 1971)

[4] The term 'martial shows' denotes the usage of martial techniques for the purpose of presenting symbolic meanings to the audience, such as, for example, in the Chinese 'lion dance'.

However, martial sports place higher emphasis on competition, which is not of so high value in martial arts. This is one of the reasons why in some cases martial arts practitioners (e.g. in kendo) try to preserve their 'arts' from a change into martial sports, which changes their character (see Honda 2007).

Martial arts and martial sports are more or less connected to education and the striving of humans to improve themselves. Both of them are contests, and the interaction is direct, without any barriers between the opponents, while the participants are supposed to engage with each other. The aim is to defeat the opponent – but not in such a way as to defeat him absolutely (to kill him), but rather to give him the opportunity to learn about his/her weak spots that need to be improved. Participants let each other live so that they can further improve and compare their performances again. Martial arts and martial sports necessarily require this 'con-testing' (testing oneself against others) and therefore it would not make sense to kill one's opponents – for there would soon be no more possibility to participate and improve (see 'sporting families' in Kretchmar 1975, p. 28). This is a very different aim from the pragmatic aim of close combat, which is to overcome someone with the aim of gaining a benefit or, at least, not losing something, and in which self-improvement is a means to this end.

In both of these non-lethal kinds of combat, the pragmatic aim of combat itself is changed and vastly differs from the real-life fighting of close combat. Aims determine legitimate means and thus also the character of the activity itself. One important aspect of this change (of close combat into more peaceful kinds) lies in making combat more safe. I shall call this the 'safetification' of combat. This safetification is brought about by different strategies:

- introduction of rules,
- regulation of techniques,
- regulation of weapons and equipment.

Now, I shall discuss strategies of safetification of combat in more detail – taking the examples of martial arts and martial sports.

## STRATEGIES OF SAFETIFICATION OF MARTIAL ARTS AND MARTIAL SPORTS

Close combat is supposed to be efficient with respect to defeating an opponent or defending oneself from him/her, and so it is inherently dangerous. If there are some limits to constrain it, they are represented predominantly by the legal system of the given society and possibly the general approach to human beings (ethos), but the martial activity itself is not limited. Close combat has to be as efficient as possible – as Anglo (2000, p. 35) said: "The only rule that mattered was self-preservation. A man had to be ready to kill his adversary as quickly as possible."

However, if combat is to be a part of education within a peaceful society, it is important to make sure that its efficiency is limited and therefore modified in various ways. To begin with, for making sure that nobody dies, the creation, application and adherence to rules is necessary. Often, the rules specify conditions of time, place, eligibility and procedure. That is, the rules limit the conditions *when* and *where* martial arts and martial sports can be practised and *who* are the eligible participants, and *how* the fighting is performed. Rules are observed by coaches, referees, judges and timekeepers.

So, the rules about time prescribe an agreed and definite *time* for the contest; and the fight itself is limited by time, or if one of the contestants sustains a severe injury, or is certain to lose. Also, club rules often prescribe for participants certain legitimate times for practice, and institutional rules set the times of contests.

Similarly, the rules set a specific *place* for the contest, so that combat is assured to be safe. While close combat can occur virtually anywhere, the place for martial arts and sports is usually indoors – for example, a gymnasium (or '*dojo*' in the context of Japanese martial arts). The environment of the gymnasium itself is relatively danger-free, with a stable homogeneous surface on which the contestants move without any potentially dangerous objects surrounding them. Martial arts and martial sports practitioners are allowed to use their techniques in these specific conditions, but not in a public space and not against non-trained people.

It is not only *time* and *place* but also *eligibility* – who can participate? Martial arts and martial sports that are part of education are theoretically accessible for everyone. However, not everyone can take part in an actual contest – only those who are relatively equal competitors are permitted to fight against each other. For many martial arts and martial sports, age and weight categories are introduced to make sure that relatively equal fighters fight against each other, and that the fight is fair.

Eligibility sometimes also depends on the state of health of participants. For example, in many martial sports medical approval prior to competition is necessary, to certify that the fighter is eligible to fight. For example, the International Boxing Association (2013, p. 5) requires that: "A Boxer will not be allowed to compete in an international competition unless such Boxer possesses a valid up-to-date Boxer's AIBA Competition Record Book in which such Boxer must be certified as fit to box by a qualified Medical Doctor as approved by the presiding AIBA Medical Jury Member." And there are further rules that ensure the medical approval as valid.

And finally, as to *procedure*, it is the technical rules of martial arts and martial sports that ensure how the martial activity is conducted. The main focus is on making sure that fighters do not inflict serious injuries or lethal blows on each other. Thus, another aspect of the safetification of combat is the limitation of various dangerous techniques. This can be done in various ways, such as, for example, removing lethal techniques altogether, or limiting them – stopping one's blows in front of the opponent, restricting areas of the body where the blows may be placed, etc. Technical rules make the simplicity of efficient fighting more complicated – it is determined with precision what the fighter must or must not do. Rather than learning to use absolutely the most efficient technique for the given circumstances to defeat an opponent, martial arts and martial sports are restrictive systems of permitted techniques. And a fighter knows that it is only permitted techniques that can be used by and against him or her.

For example, the International Boxing Association (2013, p. 13) determines different kinds of fouls:

> "*6.1. Types of Fouls*
> 6.1.1. Hitting below the belt, holding, tripping, kicking, and butting with foot or knee;
> 6.1.2. Hits or blows with head, shoulder, forearm, elbow, throttling of the opponent, and pressing with arm or elbow in opponent's face, pressing the head of the opponent back over the ropes;
> 6.1.3. Hitting with open glove, the inside of the glove, wrist or side of the hand; …"

However, even the permitted manoeuvres are safetified – various pieces of protective equipment, such as mouthpiece, belt, box, gloves, etc., make sure that the fight is even safer. And the same is true for weapons – only rebated weapons are allowed for use within martial arts and martial sports (e.g. the introduction of flexible materials for fencing, removal of sharp edges, substitution of a stick for a sword, etc.)

These changes affect the character of the combat. Consider an example from the martial art *kendo*, presented by Donohue (2005, p. 10): "Although popularly understood as the art of Japanese fencing, kendo is not the same art that was practiced by the feudal swordsmen of Japan, the *bushi* or *samurai*. It is a modern system which developed out of the arts of these feudal warriors, but it is very different. Kendo has rules, combat does not. The restriction of kendo blows to eight areas has made a noticeable change in *kendo bogu* (armor) when compared to the war armor of the samurai. The *shinai*, the bamboo foil utilized in kendo, is used differently from a real sword, is shaped and balanced differently from the *katana*, and is (a most important consideration) not a lethal weapon. Kendo's stance and movements have been conditioned by the fact that *kendoka* (kendo practitioners) typically train indoors on a hardwood floor. Feudal warriors fought on battlefields."

With respect to martial sports, even more rules are introduced – some changing the sport so that it is more interesting for the audience (e.g. specific clothing or other restrictions are prescribed). Also, anti-doping rules are a part of martial sports rules, one reason for which is to ensure that the athletes do not use harming substances. Finally, in both martial arts and martial sports we find codes of conduct that regulate the acts of participants, in such a way as to enabling them to fight (and live) in a moral way.

While having rules is important for safety concerns, safety does not arise only through *having* rules, but also about *strictly adhering to* them, as studies of injuries in this area suggest (e.g. Critchley et al. 1999). This applies not only to the participants, but also to coaches and others, and it is also strongly supported by strict refereeing conventions.

## PROBLEMS ARISING FROM THE SAFETIFICATION OF MARTIAL ACTIVITIES

Changing the lethal forms of close combat into peaceful kinds brings with it various consequences. If, within education, people do not want to cause death or serious injuries to those who are striving to improve, martial activities that are meant for a safe society have indeed to be safe. However, this is in contradiction to what combat is, and some of the consequences are problematic – too much safety can mean a loss of the martial character of martial arts and martial sports altogether.

I shall now discuss three consequences of the safetification of martial arts and martial sports:

1. gradual diminishing of dangerousness,
2. inefficiency of skills and techniques for combat purposes,
3. re-emergence of 'dangerous combat' as a result of 'de-sportization'.

1. Of course, because of the direct interaction of opponents, injuries can happen in both martial arts and martial sports. However, if an injury should occur, it is not because it is an aim of martial arts and martial sports, but rather it is an accident. In the case of a very serious accident, rules are often changed for future participants, in order to avoid a similar accident in the future. Discussions of studies on injuries in combat sports point in this direction. For example, Shirani's et al. (2010) survey of injuries that occur in combat sports "[…] points out and documents the dangers involved in taking up such sports and stresses the need for safer rules and regulation, and also for better protective gear. These issues may be reflected to influence the Chairman of the Olympic Committee or the Martial Arts Federation."

However, any change of rules must be done with caution so that martial arts and martial sports keep a certain level of danger, in order that the martial aspect is retained. We should remember that close combat, being the most basic kind of combat, is the almost-forgotten basis of the peaceful kinds of combat, and that some level of danger must remain. Thus the rules have to make sure that a correct tension is kept, so that both martial arts and martial sports retain their martial character whilst, on the other hand, they do not present too much risk and danger to participants. So, safetification should be only partial, and whilst martial arts and martial sports should not be considered lethal, neither should they be considered safe. Participants (and coaches and parents, etc.) should be aware that they are consenting to the possibility of a certain degree of risk and danger. We should see these activities as 'partially dangerous'.

2. Safetifying martial arts and martial sports makes them artificial and sophisticated systems (especially because of all the rules that have to be followed), and this means also making them less effective, and sometimes even virtually ineffective as real martial systems. Furthermore, they tend to stagnate and can become rigid, since they are not tested in real martial encounters. Also, unlike in close combat, in which

people usually learn more systems, and are taught to be flexible with techniques, martial arts and martial sports are codified systems, and the adherence to one system limits the practitioners, making them less flexible and less ready for any dangerous combat situation that might occur. Therefore, practitioners should not have too high expectations about the combat effectiveness of their martial skills. Participants and masters or coaches should be clear about this and, if they ever find themselves in a really dangerous situation, they should remember that their opponent(s) will not necessarily adhere to the rules of some martial art or sport. Even boxing skills may not be much use in a close-combat bar fight. In these circumstances, one must be flexible, and not to stick to one (possibly ineffective) system. Sometimes just to run away as fast as possible is the best strategy, rather than to rely on a set of acquired sophisticated techniques.

3. The high levels of safetification in martial arts and martial sports have had a possibly unforeseen consequence – the process of the de-sportization of martial sports. The reason for this is that there are those who do not want to be constrained by these safe kinds of combat, but prefer rather to fight outside of any one system, under much simplified rules that permit 'dangerous combat', in which a common outcome is injury (e.g. cage fighting, UFC, NHB, MMA). In these cases, rules are reduced, sometimes to minimum – for example, Van Bottenburg & Heilbron (2006) describe the first Ultimate Fighting Championship (UFC) as follows: "With the exception of biting and eye gouging, anything was permissible in the first few UFCs … The only possible ending was knockout or submission, the latter being signalled by 'tapping out' or by the coach throwing a towel into the mesh-rimmed ring" (ibid., p. 260), and the fighting was advertised with phrases such as: "THERE ARE NO RULES" and "THEY FIGHT TO SURVIVE" (ibid., p. 260).

These fights stem from commercial interests and offer the audience fights that resemble close combat. However, the aim here is not a purely pragmatic one (defeat someone or defend oneself), but also to be spectacular and to attract an audience, while manifesting high levels of violence to which both sides agree. So it seems that our safety-conscious society and the safetification of close combat have brought about a new kind of combat, a fight that is very close to a real fight – which is motivated by financial and personal motives, while putting the fighter into dangerous situations. The interest in these fights is high, but authorities have continued to monitor them and control them, and their pressure has led to changes in these combat practices, by which some of them underwent the processes of 're-sportization' and spectacularization to allow these fights to happen, while some did not change and moved underground (Van Bottenburg & Heilbron 2006, pp. 276 f.). However, further de-sportization is still possible, permitting "displays of behaviour and feelings that have been banished from everyday life and social conventions" (ibid., p. 279).

So, in conclusion, it becomes clear that knowing about the problems of the safetification of combat can help those who make the rules of these peaceful martial activities more sensitive to changes, while it may help participants to be clearer about the nature of what they are doing.


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# DEXTERITY AND THE LEVEL OF PHYSICAL FITNESS AND MOTOR SKILLS IN 6-YEAR-OLD POLISH CHILDREN

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## ABSTRACT

Children's level of fitness and motor skills are significant elements of school maturity assessment. This problem becomes particularly important for left-handed children, whose lateralisation process and, in this way, also the motor development process, can be delayed.

The aim of this article is to determine the level of children fitness and motor skills at the age of 6 depending on the hand's preference.

The research involved examination of 1251 schoolchildren at the age of 6, including 586 girls and 665 boys living in the area of lubelskie voivodeship (province). The programme was realized in a period from April to May and from October to November in 2006. It anticipated an identification of the level of motor development with the use of selected trials of the European Test of Physical Efficiency EUROFIT. Additionally, children's motor skills were assessed by means of ball throwing and griping, jumping, kicking and proper running. Hand preference was evaluated by means of two trials: a throw and a grip. The research material was statistically analysed. Mann–Whitney U tests were used. The accepted level of significance amounted $p \leq 0.05$.

9.92% of the children were found to be left-handed, 10.53% of the boys and 9.22% of the girls. Statistically insignificant differences were observed in the level of physical fitness in girls, depending on the preferred hand. The right-handed boys, on the other hand, demonstrated a better level of physical fitness in a majority of tests. Statistically significant results were obtained among right-handed boys for total balance ($p = 0.017$) and functional strength of arms ($p = 0.030$). Among boys, left-handedness proved to be a factor reducing a majority of motor skills. Statistically significant differences were obtained for throwing ($p = 0.000$) and catching ($p = 0.002$) with the right hand and for throws both hands ($p = 0.020$) and for kicking a ball with the right foot ($p = 0.004$). Left-handed girls, on the other hand, obtained statistically worse results

only for throws right hand (p = 0.049) and they were statistically better at catches left hand (p = 0.009).

**Key words:** Handedness, motor abilities, Eurofit Test, preschool children.

## INTRODUCTION

Handedness is the tendency to use the dexterous dominant hand, which is developed during ontogenesis. The foundations for the future lateralisation are formed already in the prenatal period. This is the time when the fastest development of the nervous system occurs in the entire ontogenesis. Ultrasound examinations show that approx. 90% of children prefer to suck their right thumb in the intrauterine life. Thus, this is consistent with the proportions of right- and left-handed people in the adult population (Hassler & Birbaumer, 1988). There are various views on the age of handedness determination. Some authors assume that it begins to be determined between the second and the fourth years of life and the one-sided lateralisation is ultimately developed already in the majority of children completing their preschool education. Other authors have a similar opinion, i.e. that the most significant changes in this process occur at 6–7 years of age (McManus et al., 1988). However, lateralisation is ultimately formed at 12–14 years of age. At this time, the dominance of one of the hands is established (Marlow et al., 2007).

The dominance of the right- or left-hand is a biological characteristic conditioned by multiple factors. Numerous theories account for the handedness aetiology in various ways, dividing it into 3 broad categories: pathological handedness, (acquired as a result neurological insult), natura handedness (predetermined handedneess due to prenatal adrogenic or Genesis influeces) and learned handednees (aquired trough the influence of external presures (Medland et al., 2004; Perelle & Ehrman, 1982). No unambiguous reason for handedness has been recognised so far. There are reports implying genetic foundations of handedness (Öztürk et al., 1997). Numerous authors also emphasise its environmental conditions, such as educational experiments, family pressure (Medland et al., 2004). The influence of the cultural factor is also emphasised, especially in eastern communities (Zverev & Mipando, 2007).

Endo- and exogenous theories are not mutually exclusive. It indicates the fact that left-handedness results from numerous factors. The issue of left-handedness is inseparably connected with the phenomenon of lateralisation, i.e. the advantage of one side of the body over the other side.

The estimation of the handedness frequency, depending on the gender, shows that there are usually slightly more left-handed boys than girls (Annett & Manning, 1990). There are theories, that explain these relations between frequency of sinistrality and gender by hormones activity. The most prevailing is the one of Geschwind (1987).

Issues connected with motor development problems among left-handed children are quite broadly documented with reference to manual skills; however, other components of motor skills or physical fitness have been researched less frequently. In addition, available research studies mostly pertain to children and adolescents as well as to adults. Few of them focus on preschool children and differentiated research methodology does not allow for looking at the phenomenon from a broader perspective. It is not known either at what point of the child's ontogenesis, a change in the level of motor skills and physical fitness may reveal itself, depending on the child's handedness. Especially in view of the fact that the process of the spontaneous learning of motor tasks in children primarily involves observation and high frequency of repetition. This leads to a situation, in which the learner shows proficiency in performing motor activities (Rudel et al., 1984). It is believed that in left-handed children, the performance of tasks at a varying complexity level may involve a slightly higher level of difficulty. The process of learning such tasks may be influenced by various external factors. One of them seems to be the unconscious pressure exerted by the closest persons, who are mostly peers, siblings and adults. Attempts of visual analysis of motor tasks shown with the other hand and next repeating it in an appropriate way may take a left-handed child a bit more time than a right-handed peer. As a result, this may lead to certain disproportions as regards the level of quality of the performance of such a task. When a left-handed child tries to master the task correctly, their left-handed peer can achieve perfection in the same movement. It should also be emphasised that there may be children, for whom attempts were made to switch them to be right-handed. Thus, the time needed to master motor activities may be extended and it may influence the lower level of motor skills in six-year-olds. Moreover, left-handed children may avoid motor games with peers, and this fact does not promote physical fitness. It is worth emphasising that motor skills and the achieved level of physical fitness are some of the symptoms of the child's competences, which should be achieved during school education.

This article is aimed at defining the level of six-year-old children's physical fitness and motor skills, depending on their hand preference.

## METHODS

A group of 1251 six-year-olds including 586 girls and 665 boys were recruited into the research conducted in two stages in 2006, respectively in April–May and October–November. Sampling was representative for the lubelskie voivodeship and the following criteria were taken into account: division into voivodeships, type of school a six year-old attended and environment: countryside vs. city (villages, towns and rural areas in urban-rural municipalities). Thus, it was stratified and cluster sampling. Average age: $\overline{x} = 6.6512$ with a standard deviation $s_d = 0.194$.

Motor fitness was assessed by means of the following tests of the European Test of Physical Fitness (EUROFIT): total balance, arm moment speed, flexibility, trunk strength, explosive leg power, running speed and agility (Grabowski, 1987). Additionally, bent arm hang test was done, however with straight arms due to children inability to perform this task in its original form. The order of tests was in accordance with the test guidelines. Notions of H-RF were taken into consideration while choosing trials and tests to assess six-year-olds' motor fitness, which allows them to function in a defined environment. Differences stemming from the sizes of schools and kindergartens in Poland were also taken into account.

Additionally, basic motor skills were assessed. The following tests were performed: one hand ball throws and catches, both hands ball throws and catches, one leg jumps, both legs jumps, right and left leg kicks at a selected goal, as well as abilities to perform correct run and coordination while doing exercises. The hand throw and catch tests were performed by children and a research leader three times. The measurements and assessments in relation to fitness and motor skills were made at a particular child's school by teachers of PE, who were trained and equipped with guidelines (DVD's and printed training materials). To assess motor skills 'competent judges' method with a four-degree scale was used: 1 – very well performed, 2 – well performed, 3 – averagely performed, 4 – unable to perform. This must be clearly stated that the teachers assessing the tests followed the guidelines in reference to a number and sort of mistakes made. Final assessment was averaged. Lower values on the scale in case of motor skills and lower average results in speed tests (arm moment speed and running speed) as well as in total balance meant higher level of these abilities and skills.

Children laterality was identified on the basis of one hand ball throw and catch test. Children were asked to take a ball or sack and to throw it or catch. They chose either right or left hand to perform the task on their own. If they chose the same hand three times, it meant that hand was a preferred one. Additionally, to assess dextrality a 'plate tapping' test was used, in which a child chose a better hand to perform the task, as well as a pedagogue's observation while the child was writing or painting. If these two matched, the child was qualified into a group of dextral or sinistral children. All other cases were qualified into other groups not being a subject of this analysis.

The results were statistically analysed. The examinees were divided according to their age, gender and hand preference. The definition of normal (Gaussian) distribution was the basis of the test choice to analyse the material and it was done by means of Kolmogorov–Smirnov test as well as Shapiro–Wilk test. All the variables in the subgroups proved to be statistically significant and different from the shape of the normal curve. Furthermore, bearing in mind the fact, that some part of analysed data was approximate not quantitative, non-parametric tests were introduced. A series of Mann–Whitney U tests was performed. All calculations adopted a level of significance $p \leq 0.05$ and used statistical package Statistica 10.0.

## RESULTS

The research group comprised of 1251 children. There were 124 sinistral found (9.92%) – 70 boys (10.53%) and 54 girls (9.22%). Statistically insignificant differences were observed in the level of physical fitness in girls, depending on the preferred hand. On the basis of the median values, it was found that left-handed girls obtained slightly worse results in the leg strength, abdominal muscle strength and functional strength of arms. However, left-handed girls obtained slightly better results in total balance and arm speed movement. It can also be noticed that the variability range between the 25 and 75 percentile is slightly lower in left-handed girls as compared with right-handed girls (functional strength of arms, abdominal muscle strength, explosive strength of lower limb, agility and balance), (Table 1).

The right-handed boys demonstrated a better level of physical fitness in a majority of tests. In two cases, i.e. fo total balance and functional strength of arms, the differences proved to be statistically significant ($p = 0.017$ – total balance, $p = 0.030$ – functional strength of arms). Abdominal muscle strength as well as running speed and agility were slightly better in left-handed boys (Table 2).

Despite similar median values obtained in the groups and right- and left-handed children, two statistically significant differences were observed in the group of girls and four such differences were observed in the group of boys as regards the number of points the children received from PE teachers for various motor tasks (Tables 1 and 2).

In the group of girls, the statistically significant differences included throwing a bean bag with the right hand ($p = 0.049$) and catching a bean bag with the left hand ($p = 0.009$). In both cases, better results were obtained by children using their leading hand (right-handed girls in throwing and left-handed girls in catching). Left-handed girls obtained slightly higher scores for left leg kicks (Table 1).

Left-handed boys, as compared with their right-handed peers, received statistically significant lower scores for throwing ($p = 0.000$) and catching ($p = 0.002$) with the right hand and for throws both hands ($p = 0.020$) and for kicking a ball with the right foot ($p = 0.004$). In addition, they did slightly worse at left leg kicks and right leg jumps. The calculated median values reveal higher scores only for left leg jumps for these boys (Table 2).

## DISCUSSION

The incidence of left-handedness varies widely throughout the world depending partially on the social permissiveness toward left-handedness. Thus, in cultures in which left-handedness is not repressed, the occurrence of left- handedness is between 8 and 10% (Illingworth, 1974; Markou, 1993; Rigal, 1992).The results obtained show that the extent of the left-handedness phenomenon among 6 year-old children in Poland amounts to 9.92%. The observed slightly higher frequency of left-handed boys, as compared to girls, is consistent with the popular, however, not commonly confirmed notion that men exhibit a greater tendency towards left-handedness. The size of the sex difference was significantly moderated by the way in which handedness was assessed (by writing hand or by other means), the location of testing, and the year of publication of the study, implicating additional influences on its development (Papadatou-Pastou et al., 2008).

**Table 1.** Statistical characteristics for physical fitness components and motor skills in the group of girls, depending on the choice of hand.

| Physical fitness components | Hand preference | $\bar{x}$ | $s_d$ | centyle | | | U–W | z | p |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 25 | 50 | 75 | | | |
| Total balance* | Right | 14.00 | 8.07 | 7.00 | 12.00 | 20.00 | 1814.00 | –0.946 | 0.344 |
| | Left | 12.28 | 8.14 | 6.57 | 8.50 | 18.75 | | | |
| Arm speed movement* | Right | 26.47 | 6.15 | 23.00 | 25.00 | 28.00 | 7903.00 | –0.123 | 0.902 |
| | Left | 26.36 | 6.94 | 23.00 | 24.50 | 29.00 | | | |
| Flexibility | Right | 1.16 | 4.94 | –3.00 | 2.00 | 5.00 | 7956.00 | –0.055 | 0.956 |
| | Left | 0.86 | 5.05 | –2.75 | 2.00 | 4.00 | | | |
| Explosive strength o lower limb | Right | 91.57 | 21.02 | 78.00 | 93.00 | 106.00 | 7931.00 | –0.014 | 0.989 |
| | Left | 92.27 | 17.16 | 82.00 | 92.50 | 105.50 | | | |
| Trunk stregth | Right | 9.70 | 4.56 | 6.00 | 10.00 | 13.00 | 4319.50 | –1.114 | 0.265 |
| | Left | 8.63 | 4.66 | 5.00 | 8.00 | 11.25 | | | |
| Functional strength of arms | Right | 24.42 | 17.13 | 13.00 | 20.00 | 31.00 | 6163.00 | –1.842 | 0.066 |
| | Left | 18.05 | 12.67 | 6.75 | 16.50 | 27.25 | | | |
| Running speed and agility* | Right | 29.64 | 5.84 | 26.00 | 29.00 | 31.00 | 7406.50 | –0.404 | 0.686 |
| | Left | 29.08 | 4.64 | 26.00 | 29.00 | 32.00 | | | |
| Throws right hand* | Right | 1.98 | 0.79 | 1.00 | 2.00 | 2.00 | 6565.00 | –1.966 | 0.049 |
| | Left | 2.19 | 0.78 | 2.00 | 2.00 | 3.00 | | | |
| Throws left hand* | Right | 2.33 | 0.82 | 2.00 | 2.00 | 3.00 | 6615.50 | –1.899 | 0.058 |
| | Left | 2.06 | 0.75 | 2.00 | 2.00 | 2.00 | | | |
| Catches right hand* | Right | 2.33 | 0.96 | 2.00 | 2.00 | 3.00 | 7431.00 | –0.757 | 0.449 |
| | Left | 2.42 | 1.08 | 1.75 | 2.00 | 3.00 | | | |
| Catches left hand* | Right | 2.60 | 0.95 | 2.00 | 3.00 | 3.00 | 6051.00 | –2.597 | 0.009 |
| | Left | 2.14 | 1.46 | 1.00 | 2.00 | 2.00 | | | |
| Throws both hands* | Right | 1.86 | 0.78 | 2.00 | 2.00 | 3.00 | 7909.50 | –0.123 | 0.902 |
| | Left | 1.83 | 0.84 | 1.00 | 2.00 | 2.00 | | | |
| Cathes both hands* | Right | 2.11 | 0.86 | 2.00 | 2.00 | 3.00 | 7055.50 | –1.293 | 0.196 |
| | Left | 1.89 | 0.78 | 1.00 | 2.00 | 2.00 | | | |
| Right leg kicks* | Right | 2.16 | 0.77 | 2.00 | 2.00 | 3.00 | 7904.50 | –0.131 | 0.896 |
| | Left | 2.14 | 0.83 | 1.25 | 2.00 | 3.00 | | | |
| Left leg kicks* | Right | 2.54 | 0.78 | 2.00 | 3.00 | 3.00 | 6975.00 | –1.414 | 0.157 |
| | Left | 2.31 | 0.75 | 2.00 | 2.00 | 3.00 | | | |
| Right leg jumps* | Right | 2.15 | 0.77 | 2.00 | 2.00 | 3.00 | 7849.00 | –0.180 | 0.857 |
| | Left | 2.19 | 0.95 | 1.00 | 2.00 | 3.00 | | | |
| Left leg jumps* | Right | 2.23 | 0.77 | 2.00 | 2.00 | 3.00 | 6643.00 | –1.864 | 0.062 |
| | Left | 2.00 | 0.72 | 1.25 | 2.00 | 2.75 | | | |
| Both legs jumps* | Right | 2.27 | 0.80 | 2.00 | 2.00 | 3.00 | 7603.50 | –0.465 | 0.642 |
| | Left | 2.28 | 0.85 | 2.00 | 2.00 | 3.00 | | | |
| Running* | Right | 2.03 | 0.67 | 2.00 | 2.00 | 3.00 | 7118.00 | –1.263 | 0.207 |
| | Left | 2.19 | 0.85 | 2.00 | 2.00 | 3.00 | | | |
| Total coordination during excercising* | Right | 2.11 | 0.71 | 2.00 | 2.00 | 3.00 | 7731.00 | –0.303 | 0.762 |
| | Left | 2.06 | 0.63 | 2.00 | 2.00 | 2.00 | | | |

* the lower average ranges, the higher level of advancement in defined motor skills and abilities

**Table 2.** Statistical characteristics for physical fitness components and motor skills in the group of boys, depending on the choice of hand.

| Physical fitness components | Hand preference | $\overline{x}$ | $s_d$ | centyle | | | U–W | z | p |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 25 | 50 | 75 | | | |
| Total balance* | Right | 12.62 | 7.58 | 6.50 | 10.00 | 18.50 | 516.50 | –2.388 | 0.017 |
| | Left | 17.90 | 7.59 | 13.75 | 16.50 | 23.00 | | | |
| Arm speed movement* | Right | 20.76 | 6.95 | 22.00 | 25.00 | 29.00 | 9724.00 | –0.123 | 0.902 |
| | Left | 25.21 | 4.96 | 22.75 | 26.00 | 27.25 | | | |
| Flexibility | Right | –0.309 | 5.09 | –4.00 | 0.00 | 3.00 | 9647.50 | –0.256 | 0.798 |
| | Left | –0.705 | 5.74 | –4.75 | 0.00 | 3.75 | | | |
| Explosive strength o lower limb | Right | 97.03 | 21.39 | 84.00 | 100.00 | 112.00 | 8129.00 | –1.899 | 0.058 |
| | Left | 91.50 | 22.26 | 82.00 | 88.50 | 102.50 | | | |
| Trunk stregth | Right | 9.47 | 4.78 | 6.00 | 10.00 | 13.00 | 4765.00 | –1.922 | 0.055 |
| | Left | 10.85 | 4.14 | 8.75 | 11.00 | 14.00 | | | |
| Functional strength of arms | Right | 26.00 | 17.94 | 15.00 | 22.00 | 32.75 | 7621.50 | –2.165 | 0.030 |
| | Left | 22.95 | 19.97 | 12.00 | 18.00 | 24.00 | | | |
| Running speed and agility* | Right | 29.87 | 6.46 | 2.00 | 29.00 | 32.00 | 8557.00 | –1.361 | 0.174 |
| | Left | 27.90 | 19.97 | 25.00 | 28.00 | 30.00 | | | |
| Throws right hand* | Right | 2.04 | 0.79 | 1.00 | 2.00 | 3.00 | 6934.50 | –3.513 | 0.000 |
| | Left | 2.48 | 0.82 | 2.00 | 2.50 | 3.00 | | | |
| Throws left hand* | Right | 2.35 | 0.78 | 2.00 | 2.00 | 3.00 | 9612.00 | –0.319 | 0.750 |
| | Left | 2.27 | 0.84 | 2.00 | 2.00 | 3.00 | | | |
| Catches right hand* | Right | 2.34 | 0.96 | 2.00 | 2.00 | 3.00 | 7228.50 | –3.079 | 0.002 |
| | Left | 2.80 | 0.93 | 2.00 | 3.00 | 3.75 | | | |
| Catches left hand* | Right | 2.20 | 0.96 | 2.00 | 2.00 | 3.00 | 9667.00 | –0.245 | 0.807 |
| | Left | 2.59 | 0.95 | 2.00 | 2.00 | 3.00 | | | |
| Throws both hands* | Right | 1.90 | 0.97 | 1.00 | 2.00 | 2.00 | 7535.50 | –2.320 | 0.020 |
| | Left | 2.21 | 0.90 | 2.00 | 2.00 | 3.00 | | | |
| Cathes both hands* | Right | 2.16 | 0.83 | 2.00 | 2.00 | 3.00 | 9147.00 | –0.845 | 0.398 |
| | Left | 2.30 | 0.93 | 2.00 | 2.00 | 3.00 | | | |
| Right leg kicks* | Right | 2.09 | 0.73 | 1.00 | 2.00 | 2.00 | 7521.50 | –2.851 | 0.004 |
| | Left | 2.39 | 0.62 | 2.00 | 2.00 | 3.00 | | | |
| Left leg kicks* | Right | 2.45 | 0.75 | 2.00 | 2.00 | 3.00 | 9572.00 | –0.341 | 0.733 |
| | Left | 2.48 | 0.88 | 2.00 | 2.50 | 3.00 | | | |
| Right leg jumps* | Right | 2.33 | 0.76 | 2.00 | 2.00 | 3.00 | 9011.00 | –1.038 | 0.299 |
| | Left | 2.43 | 0.76 | 2.00 | 2.50 | 3.00 | | | |
| Left leg jumps* | Right | 2.47 | 0.75 | 2.00 | 3.00 | 3.00 | 9713.00 | –0.199 | 0.843 |
| | Left | 2.45 | 0.66 | 2.00 | 2.00 | 3.00 | | | |
| Both legs jumps* | Right | 2.50 | 0.83 | 2.00 | 3.00 | 3.00 | 8718.50 | –1.371 | 0.170 |
| | Left | 2.66 | 0.83 | 2.00 | 3.00 | 3.00 | | | |
| Running* | Right | 2.09 | 0.69 | 2.00 | 2.00 | 3.00 | 9358.50 | –0.608 | 0.543 |
| | Left | 2.14 | 0.73 | 2.00 | 2.00 | 3.00 | | | |
| Total coordination during excercising* | Right | 2.16 | 0.65 | 2.00 | 2.00 | 3.00 | 8335.00 | –1.932 | 0.053 |
| | Left | 2.34 | 0.57 | 2.00 | 2.00 | 3.00 | | | |

* the lower average ranges, the higher level of advancement in defined motor skills and abilities

The research results obtained show a significant reduction in left-handed boys' physical fitness as regards total balance and functional strenght of arms. An analysis of the remaining physical fitness components did not reveal any statistically significant differences to the advantage of left-handed or right-handed children. It was observed, however, that left-handedness in boys, more often than in girls, may be connected with lower scores on numerous physical fitness assessment tests. It results from the research results obtained so far that left-handed children have poorer scores on tests assessing gross motor skills. However, the differences observed are not usually statistically significant (Giagazoglou et al., 2001).

Similar results of the existing research results pertaining to children's motor skills, depending on the hand preferences, are not completely unambiguous. Giagazoglou et al. (2001) as well as Karapetsas & Vlachos (1997) found that left-handed children, as compared to right-handed ones, achieved statistically lower scores on fine motor skills. Similarly, Kastner – Koller et al. (2007) found that left-handed children aged 4–6 achieved lower scores than their right-handed peers on tasks requiring visual-motor coordination. However, in research conducted by Rudel et al. (1984), left-handed girls proved to be faster than left-handed boys and right-handed girls in a finger-to-thumb successive opposition test assessing motor coordination. However, left-handed children chose the preferred hand while undertaking a new task less frequently than their right-handed peers. Tan (1985), while assessing fine motor skills in 4-year-old boys and girls, found that there were no differences between right- and left-handed children. Only boys and girls with poorly marked hand preferences had a lower level of motor skills than right-handed children. Similarly, Rousson et al. 2009, while examining children and teenagers aged 5–18.5 using the Zurich Neuromotor Assessment, found there were no differences between left-handed and right-handed boys and girls. However, the authors found that lateralisation in left-handed children and teenagers is less advanced than in their right-handed peers, as they perform motor tasks motor quickly with the non-dominant hand than with the dominant one. Moreover, this result does not depend on the age and previous motor experience. It probably depends on the significant impact of the genetic factor. It was found in the present authors' own research that the scores of left-handed girls were significantly lower only for throws right hand. The statistical significance of boys' scores was lower in a larger number of tasks.

It cannot be unambiguously concluded from the research results presented and also from other authors' reports that left-handed children achieve a significantly lower level of development in the area of gross and fine motor skills than right-handed children (Giagazoglou et al. 2001, Goez & Zelnik 2008, Healey 2004, Karapetsas & Vlachos 1997, Raymond et al. 1996, Rousson et al. 2009, Springer & Deutsch 1998). It seems that left-sided children, who have undergone early and strong lateralisation, usually use their left legs in a similar manner to their right-sided peer use of their right legs and motor development disorders occur mostly in children, who are popularly regarded as left-handed, either exhibit a lower rate of the lateralization process or cross lateralization. These children perform all activities which require more precision in a clumsy or inaccurate manner. Movements of children with lateralization disorders often seem clumsy, awkward, inharmonious and imprecealready at first glance.

## CONCLUSION

The observed greater tendency among boys than among girls to receive lower scores on a majority of tests may indicate that the lateralisation process is slower in them, which has its consequences in the motor development. It can be supposed that left-handed children undertake various forms of motor activity less frequently, i.e. they are less willing to take part in motor games with other children. Moreover, boys are more ecosensitive. Hence, a higher level of motor activity has greater consequences for them than it does for girls. However, scant research in this research and different methodologies do not allow for drawing unambiguous conclusions and indicated the necessity for further research. These issues are particularly important for preschool children. Potential identification of developmental deficits in the area of motor development caused by left-handedness allows for taking actions aimed at providing early developmental support and allowing the child to achieve an optimal level of school maturity.

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# SOMATIC GROWTH AND MOTOR ABILITIES OF HEARING-IMPAIRED CHILDREN AND ADOLESCENTS

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## ABSTRACT

Introduction: Relations and interactions occurring between various features and factors are a part of studies of developmental potential of a human being; thus, morphological conditions impacting physical agility are frequently examined and the examination results have a wide range of empirical verification. Nevertheless, no references may be found that could verify developmental interrelations in hearing-impaired children and adolescents.
Aim: The presented study addresses relations occurring between somatic growth and selected motor abilities such as muscular endurance, explosive power and strength of hearing-impaired children and adolescents. It was assumed that deafness does not affect the relations between somatic features and motor abilities.
Materials and methods: A group of 56 hearing-impaired children and adolescents participated in a semi-longitudinal study. All subjects manifested hearing loss of a range of 80 dB and more, and were divided into 3 age-related subgroups. The somatic variables used in the study included body height (BH) [cm], body mass – (BM) [kg], body mass index – BMI, percentage of fat tissue of body mass – FAT [%] and fat free mass – FFM [%]. Not only were motor abilities measured with a use of "Eurofit" test battery (1989), but also the strength of basic muscle groups including abdomen, chest, arms, legs and hand muscles was examined as well. Each hearing-impaired child was provided with a clear instruction and details of the experiment by their school teachers by means of a sign language. What is more, the structure of the experiment enabled completion of the procedure on the same day it was initiated. Statistics: Statistical calculation was aided by STATISTICA v 7.1 software.
Results: Somatic features observed in hearing-impaired children and adolescents revealed a progressive trend similar to the one observable in their hearing peers. Somatic features and BMI index impacting only few muscle strength abilities were reported within a group of young males and females. A positive relation between height and body mass as well as functional strength (bent arm hang), static strength (hand grip), trunk strength (sit-ups) was observed in the group of 10-year-old and 13-year-old

boys. As far as girls are concerned, one reported a negative relation between functional strength (bent arm hang) and BM, BH and BMI within the youngest and the oldest groups.
Conclusions: Somatic changeability and its progressive character exert a significant influence on the level of motor skills. Among young females, the negative correlation index was more frequent, which resulted in a lower level of strength abilities. Furthermore, deafness does not affect somatic features and motor abilities.

**Key words:** Hearing-impaired children and young adults, correlations, somatic growth, motor abilities.

## INTRODUCTION

While studying the human developmental potential one should always consider interactions occurring between numerous factors. Studies of those interactions considerably contribute to further practical applications including, inter alia, stimulation of compensation processes in an oriented manner, which is of crucial importance particularly in the case of the disabled. Due to a number of interactions taking place between various features and factors, a developmental analysis of disabled individuals seems to be indispensable in order to determine their capacities.

Considering this aspect, one may argue that only an analysis carried out in a group of disabled individuals may become a significant source of relevant data. In addition, the focus must shift from medical perception of disability towards the developmental potential of the disabled children and young adults (adapted physical activity approach).

Relations between motor development and size, type and composition of the body, each resulting from the given genotype as well as environmental factors and cultural background receive a significant amount of scientific attention (Malina, 1995). Interrelations occurring between muscle strength, capacity and somatic features were indicated (Malina, 1997, 2004; Raudsepp, Jürimäe, 1996, 1997); greater somatic components correspond to higher parameters of motor abilities within the scope of these interrelations. Static strength results from body mass as well as fat free mass, and this relation is particularly emphasized during puberty (Szopa et al., 1999; Loovis, Butterfield, 1993; Jurimae, Jurimae, 2010). This study demonstrates that the developmental level of acquisition of motor abilities in prepubescents does not correspond to the quantitative measures of somatic growth and body composition (Puhl et al., 1990). Furthermore, body mass and height significantly contribute to static strength, however, this correlation gradually declines in the post- pubescence period (Szopa et al., 2000).

Hearing-impaired children and young adults compared with their hearing peers achieve worse (weaker) results in selected areas of motor development (coordination and gross motor abilities) as well as physical development (Zwierzchowska, 2004, 2005; Winnick, Short, 1986; Martens et al., 1996; Shephard, Lee, 1987). What is more, one also observes a different, diverse developmental rate and dynamics (Zwierzchowska, 2009). While the empirical publications on physical and motor development in deaf individuals focus mainly on comparative studies, the practical application of these studies not only boils down to deficiencies or limitations of a disabled child, but it also does not add to the knowledge on using compensation potential. The interpretation of a linear deterministic model of somatic growth processes is dominant in the science of physical education. Contemporary auxologists are critical of the model as it is believed that, at times, such an interpretation may lead to formulation of incorrect conclusions and, in consequence, inadequate guidelines regarding practical applications (Martin, Nicolaus, 1997).

While investigating developmental potential, possible interactions between a variety of factors should always be taken into consideration. Studies of such interactions constitute a considerable contribution to further applications; the results might, for instance, facilitate stimulation of compensation processes in an oriented manner, which plays a crucial role in the case of disabled individuals.

The introduced study emphasizes the influence of somatic components on the selected motor abilities and their variability in a given period of time in a group of hearing-impaired children and young adults. This study was also to address the differences in growth patterns and motor abilities (muscular endurance, explosive power and strength) in deaf girls and boys.

It was assumed that the relations between somatic features and motor abilities are identical in both deaf and hearing children and adolescents, and that deafness does not affect somatic features and motor abilities.

## PARTICIPANTS

A group of 56 deaf children and young adults participated in a semi-longitudinal study. All subjects were divided into 3 age subgroups: children (Gr 1 – up to the age of 10), children (Gr 2 – up to the age of 13), and adolescents (Gr 3 – up to the age of 16). The relations between somatic growth components and motor ability variables were analyzed considering age and sex differences. All variables were measured on three occasions between 2004–2006 (with yearly intervals) on the same subjects (Table 1). All of them were students of schools for individuals with impaired hearing, all were intellectually functional and had no dysfunctions of motor organs. Sampling of the subjects was deliberate and, due to specificity of the disability one adopted criteria used in contemporary audiology (Parving, 1995). The selection criteria included a severe hearing impairment diagnosed before the age of 3 (prelingual deafness), and a known cause of hearing impairment. It was assumed that all cases whereby the etiology of hearing loss remained undefined were eliminated.

All deaf subjects were characterized by a loss of hearing of a range of 80 dB and more. The group included 26.9% subjects with acquired hearing loss (e.g. resulting from meningitis occurrence before the age of 2), 17.7% subjects with inherited hearing loss, 55.4% subjects with congenital origin (e.g. idiopathic).

**Table 1.** Characteristic numbers and basic features of somatic deaf boys and girls in the study semi-longitudinale

| Year of study | Girls: Age Group/n | Girls: Age | Girls: Body Height | Girls: Body Mass | Boys: Age Group/n | Boys: Age | Boys: Body height | Boys: Body mass |
|---|---|---|---|---|---|---|---|---|
| 1 | Gr 1 n = 6 | 10.7 ± 1.2 | 137.5 ± 12 | 38.8 ± 12.7 | Gr 1 n = 16 | 10.9 ± 1.1 | 146.3 ± 9.1 | 40.0 ± 9.0 |
| 2 | | 11.4 ± 1.2 | 142.6 ± 11.8 | 41.7 ± 12.9 | | 11.5 ± 0.7 | 152.0 ± 8.0 | 42.7 ± 9.9 |
| 3 | | 12.4 ± 1.3 | 148.0 ± 11.1 | 47.1 ± 16.0 | | 12.8 ± 1.1 | 160.8 ± 10.9 | 50.1 ± 11.7 |
| 1 | Gr 2 n = 6 | 13.7 ± 1.1 | 158.2 ± 3.4 | 52.3 ± 7.6 | Gr 2 n = 6 | 13.3 ± 0.3 | 160.7 ± 10.4 | 48.2 ± 13.7 |
| 2 | | 14.6 ± 1.1 | 160.2 ± 2.7 | 54.8 ± 6.4 | | 14.3 ± 0.3 | 168.5 ± 11.9 | 51.8 ± 7.5 |
| 3 | | 15.6 ± 1.2 | 163.4 ± 6.5 | 59.3 ± 7.5 | | 15.3 ± 0.2 | 171.5 ± 9.3 | 52.7 ± 12.3 |
| 1 | Gr 3 n = 12 | 16.3 ± 0.2 | 159.2 ± 5.9 | 55.9 ± 7.6 | Gr 3 n = 10 | 16.4 ± 0.2 | 172.8 ± 6.7 | 61.1 ± 14.2 |
| 2 | | 17.3 ± 0.3 | 161.0 ± 5.3 | 53.1 ± 7.0 | | 17.4 ± 0.2 | 173.4 ± 6.6 | 59.6 ± 15.9 |
| 3 | | 18.3 ± 0.3 | 162.0 ± 5.2 | 55.3 ± 9.2 | | 18.4 ± 0.2 | 173.9 ± 7.1 | 63.1 ± 14.0 |

## PROCEDURES AND APPARATUS

The study data was obtained by means of direct observation, questionnaires, analysis of medical and pedagogical documents and measurements of somatic and motor abilities. Body height was measured using an anthropometer, whereas body weight and fat percentage were reported with a use of an electrical impedance analyzer. The somatic variables introduced in the study included body height (BH) [cm], body mass – (BM) [kg], body mass index – BMI, percentage of fat tissue in body mass – FAT [%] and fat free mass – FFM [%]. Motor abilities were measured with a use of "Eurofit" test battery (1989); the strength of basic muscle groups including abdomen, chest, arms, legs and hand muscles was examined as well. The "Eurofit" test verifies four motor abilities, i.e. standing broad jump (explosive strength – SB), hand grip (static strength – HGR), sit-ups (trunk stregth – SUP), bent arm hang (functional strength – BAH). Each hearing-impaired child received a clear instruction and details of the experiment procedures by their regular school teacher in a sign language; the experiment was completed on the same day it was commenced.

The study of hearing-impaired children and adolescents was approved and authorized by the Bioethical Commission of the Academy of Physical Education. Additionally, legal guardians of the subjects were provided with a set of comprehensive information on the methods applied during the experiment and gave their written consent enabling participation in the study.

## STATISTICS

Statistical calculations were made by means of STATISTICA v 7.1 software. The fundamental statistical parameters such as mean value ($\bar{x}$), median (Me), minimum and maximum, standard deviation (s), skewness (Sk) and curtosis (Ku) were calculated. The normality of distribution was validated using Shapiro-Wilk test. The ontogenetic variability of somatic and motor ability parameters observed in consecutive examinations were verified by means of an analysis of the variability indices for the changes in each parameter. The variability indices included coefficients of linear regression, where each dependent variable was a verified parameter, whereas the independent variables were formed during the first examination (the unit of a year was adopted). The indices of increments were subject to an analysis of variance. Interrelations between somatic and motor ability parameters as well as changes in their increments over a period of time were verified by means of Spearman's correlation analysis.

The results of the presented study were considered statistically significant at the level of $p < 0.05$. In this case, absence of statistical significance did not rule out a possibility of occurrence of obtained results.

## RESULTS

The analysis of obtained values of somatic features leads to a conclusion that the semi longitudinal study reveals a progressive trend in observed features, which is appropriate for this period of ontogenesis in the both groups of girls and boys. The findings were confirmed by multiple regression analyses, where the age variable produced results statistically significant for body height ($p < 0.01$ in girls, $p < 0.01$ in boys). Age was also statistically significant in the body mass analysis ($p < 0.01$ in girls and $p < 0.01$ in boys). Intersubject variability was reported for body height within one-year interval at the level of 3.6 cm in girls and 5.1 cm in boys, respectively. As far as body mass is concerned, these values were equal to 2.9 kg among girls, and 3.9 kg among boys (Table 2, Fig. 1, 2).

**Table 2.** The influence of age and gender on the values of somatic components in the first study and their growth during the two years of research into hearing-impaired girls and boys

| Somatic parameters | The effect of gender | | | | The effect of age | | | |
|---|---|---|---|---|---|---|---|---|
| | For first time | | For increment | | For first time | | For increment | |
| | f | p | f | p | f | p | f | p |
| BV | 1.3 | 0.01* | 5.9 | 0.01* | 1.3 | 0.02* | 19.9 | 0.01* |
| BM | 1.2 | 0.01* | 1.3 | 0.2 | 1.2 | 0.01* | 12.7 | 0.01* |
| BMI | 3.6 | 0.06 | 0.3 | 0.6 | 1.8 | 0.17 | 0.74 | 0.4 |
| FAT | 20.4 | 0.01* | 0.01 | 0.9 | 1.12 | 0.33 | 1.34 | 0.2 |
| FFM | 20.4 | 0.01* | 0.01 | 0.9 | 1.12 | 0.33 | 1.34 | 0.2 |

* indicates statistical significant

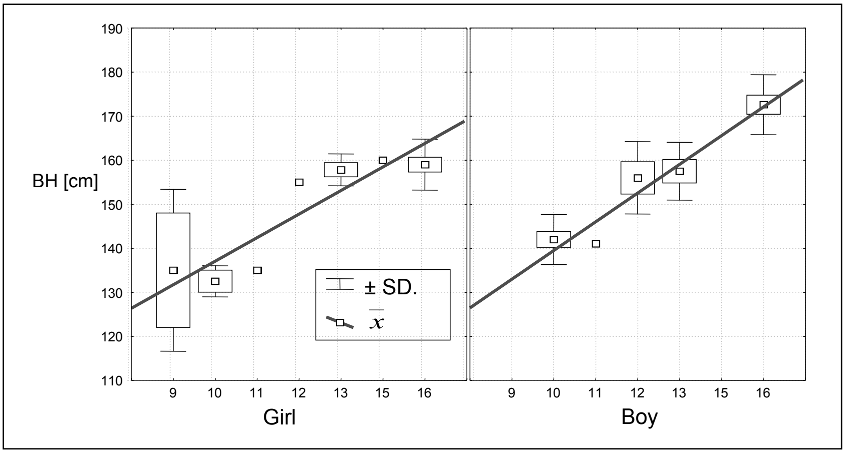


**Figure 1.** Variability of body height (BH) of boys and girls with age.

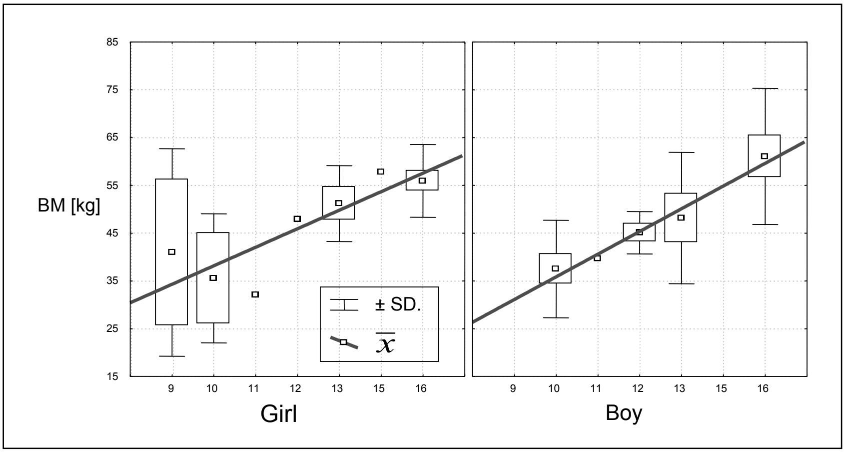


**Figure 2.** Variability of body mass (BM) of boys and girls with age.

A considerable influence of somatic components and BMI index on the level of only some strength abilities was reported in the group of boys solely (table 2). A positive relation between BH, BM and HGR ($r = 0.6$ to $0.8$, $p < 0.01$) as well as between BH and SUP ($r = 0.5$ to $0.9$, $p < 0.03$) was observed in the groups of 10-year-old and 13-year-old boys. This type of relation did not occur in the group of the oldest boys (16-year-olds), nevertheless, a positive correlation between BMI and SB ($r = 0.7$, $p < 0.01$) was revealed. A relation between FAT, FFM and motor abilities was not observed in any of the age groups of boys.

No statistically significant correlations were observed between motor abilities and somatic parameters in the group of girls in the first run of study (Table 3).

**Table 3.** Correlations between somatic components and motor abilities of deaf boys in the first run of study*

| Age boys | Somatic parameters vs. motor abilities | BH | | BM | | BMI | |
|---|---|---|---|---|---|---|---|
| | | R | p | R | p | R | p |
| 10.9 ± 1.1 | HGR | 0.8 | **0.01** | 0.6 | **0.01** | | |
| | SUP | 0.5 | **0.03** | | | | |
| 13.3 ± 0.3 | HGR | 0.9 | **0.01** | 0.8 | **0.03** | | |
| | SUP | 0.9 | **0.01** | | | | |
| 16.4 ± 0.2 | SB | | | | | 0.7 | **0.01** |

* indicates statistical significant p < 0.01; p < 0.05
Body height (BH) [cm], body mass – (BM) [kg], body mass index – BMI, [kg/m$^2$], static strength – HGR [KG/m$^2$], trunk strength – SUP [number/30 s], explosive strength – SB [cm].

In regards to boys aged 10–12, no statistically significant correlations between increment of somatic components and increment of motor abilities could be reported, while, in subsequent age categories of boys, significant correlations were observed between increased somatic components (BM, BMI, %FAT) and SUP, BAH and HGR. In the group of boys aged 13–15 – GR 2, the study revealed a negative correlation between increments BM, BMI and SUP ($r = -0.9$, $p < 0.03$), which denotes that the greatest increase in somatic components was associated with a smaller growth of muscular strength. No correlations between increment BH and motor abilities could be observed (Table 4).

**Table 4.** Correlations between increments in somatic components and motor abilities of deaf boys*

| Age group of boys | Increments of somatic parameters vs. motor abilities | BH | | BM | | BMI | | % FAT | | % FFM | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | R | p | R | p | R | p | R | p | R | p |
| GR 1 | | **No statistical significant correlations** | | | | | | | | | |
| GR 2 | SUP | | | –0.9 | **0.03** | –0.9 | **0.03** | | | | |
| | BAH | | | | | 0.9 | **0.03** | | | | |
| GR 3 | HGR | | | 0.7 | **0.03** | 0.8 | **0.01** | 0.7 | **0.01** | –0.7 | **0.01** |

* indicates statistical significant p < 0.01; p < 0.05
Body height (BH) [cm], body mass – (BM) [kg], body mass index – BMI, [kg/m$^2$], percentage of fat tissue in body mass – FAT [%] and fat free mass – FFM [%],trunk strength – SUP [number/30 s], functional strength – BAH [s], static strength – HGR [KG/m$^2$]

In all studied age groups of girls, one observed a negative relation between increments in functional strength (BAH) and increments in BM, BH and BMI. The strength of this relation was high and very high, respectively ($r = -0.7; -0.9$ for $p < 0.01$ or 0.03). The negative character of this correlation proves that the greater the values of BH and BM as well as BMI index, the lower functional strength may be observed. What is more, one reported improvement of somatic features (BH and BM) and BMI values negatively correlated to the functional and explosive strength. At the same time, girls