STUDIES IN MODERN COMPETITIVE FENCING

Edited by
MACIEJ ŁUCZAK AND MATEUSZ WITKOWSKI

WYDAWNICTWO NAUKOWE UAM

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UNIWERSYTET IM. ADAMA MICKIEWICZA W POZNANIU

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WYDAWNICTWO NAUKOWE

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INTRODUCTION

Fencing is a multidimensional part of our culture. In its utilitarian dimension it has been known since time immemorial. Over time fencing duels gave way to recreational, competitive and stage fencing. The development of sports requires the rationalization of training and more effective preparation participants and in the sphere of fencing, this concerns all participants, be they male or female, foil, epee or saber fencers.

The study areas covered by the present publication are not only related to fencing but also border on other sports. The following articles are of theoretical, empirical and sociological nature. Their authors do not intend to exhaust all the issues related to fencing, but rather emphasize problems of special concern to fencers, fencing coaches and all enthusiasts of this elite combat sport. The present edited collection aimsto inspire further development of fencing theory and practice. The authors do not give straightforward solutions to be implemented on the piste, but aim to encourage the readers to think and experiment with some ideas fromfencing and other combat sports.

Studies in modern competitive fencing is a collection of several original and review papers written by authors from five Polish academic centers. The constituent articles include reflections and observations by fencing masters, coaches and academic lecturers with extensive teaching experience in anthropology, human motor function, history of physical culture, methodology of physical education, sport psychology and sport and fencing theory. The contributors are not only renowned fencing theorists but also experienced coaches of fencing, team games, golf, riding, rowing and skiing as well as athletes and activists with no links to professional sport.

The 8 articles in the volume are grouped into three thematic parts: Part I: *Historical and theoretical aspects of fencing* (2 articles); Part II: *Psychology in fencing* (1 articles); and Part III: *Body build and motor training in fencing* (6 articles). All of them tackle various issues related to motor function as well as theory, history, and psychology of sport – in particular motivation in sport. I am convinced these contributions will shed light on the nature of fencing training and acquaint the reader with determinants of effectiveness in fencing.

Readers of the book have a great opportunity to learn about the current research conducted by Polish scholars and scientists dealing with various fencing issues. The readers will also find literature studies on symmetric fencing training as well as reflections that human behavior cannot be verified in an experimental way and that progress in the field of motor control appears impossible.

Fencers, as practitioners of an anaerobic sport, must display excellent coordination skills and explosive force, adequate reaction and movement times (especially in response to the opponent's actions), movement precision and spatial orientation. Within the limited space of the piste concentration of attention is also crucial in choosing appropriate actions in a bout.

Success in fencing is also determined by motivation and arousal, both during training and championship matches. It depends on the coach's instruction, but first of all, on the fencer's attitudes, behavior, personal commitment and many other various factors. An important role in the realization of goal orientations is played by task orientation, e.g. perseverance and conviction of the effects of one's own efforts on the result. That is, the awareness that significant engagement in a sporting activity increases one's opportunities to attain better outcomes. On the other hand, a high level of ego orientation focused on winning, and confronting one's sports level with others is not conducive to the optimal use of one's own sport potential.

An important development in fencing training is the improvement of running speed as it correlates with the fencer's tactical and specialist skills. Also the fencer's build and physical training affect his or her achievements. For example, young female fencers examined in one of the studies featured a robust body build, whereas young male fencers a slim body build. The greater percentage of body fat in girls results, however, from the genetic dominance of this particular body component.

It should be noted than in recent years the general level of physical fitness of young people has deteriorated, which can be explained by regressive inter-generational population changes, changes in the weight-length proportions in young people, reduction of strength capabilities of young people in overcoming the resistance of their bodies as well as endurance abilities so crucial in fencing.

With a view to fencers' health and fitness, fencing coaches should monitor fencers systematically and properly apply teaching loads at various stages of young people's development – especially in pubescent girls – to avoid spinal and articular overloads and apply appropriate preventive and therapeutic procedures.

According the famous American swimmer, coach, psychologist, scientist and author, James Counsilman, thanks to intelligence and hard work anyone can attain the best results. This is the standard used for measuring oneself and others.

The quality of competitive sports in the world, and fencing in particular, has levelled out in recent years. Therefore, medals at major events are won by representatives from increasingly more countries with a comparable degree of technical training and fitness. Training systems in individual countries make use of the achievements of various scientific disciplines. In their monograph, representatives of leading Polish scientific centres make an attempt to arrange the knowledge of fencing. It is an in-depth introduction to research entitled "The application of multi-faceted coordination training to improve precision and visual perception among fencers", conducted at the Adam Mickiewicz University in Poznań as part of the programme "The Development of College Sports" funded by the Ministry of Science and Higher Education in 2015–2017 (project no. N RSA3 04253).

Maciej Łuczak, Mateusz Witkowski

A REVIEW OF SELECTED POLISH RESEARCH STUDIES ON COMPETITIVE FENCING

Maciej Łuczak

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Fencing theory in Poland before 1945

Swordsmanship was historically an important component of military education of the Polish youth. By the late 16th century the saber had become the Polish national weapon. With its curved blade it turned out to be a more effective weapon than the sword. Further developments in saber fencing led to the emergence of the Polish saber fencing school in the 17th century and to the establishment of fencing as the most popular sport in Polish schools at the turn of the 18th century. Fencing was practiced in the famous Krzemieniec Lyceum (1805–1832) and at Kraków and Lviv universities. In the 19th century saber fencing was also taught in fencing and gymnastic schools in Warsaw and Lviv, in Sokół societies in Lviv (est. 1867), Kraków (est. 1884) and others, as well as in fencing circles in Vilnius (1868), Lviv (1867), Kraków (1900) and in the Society of Movement Games in Lviv (1904) (Łuczak, 2002: 7–8).

Despite its popularity, very few Poles contributed at that time to fencing theory. The most prominent Polish authors included Michał Franciszek Starzewski, who in his monumental treatise *O szermierce* (On Fencing) stated that "fencing is a science" (Starzewski, 1932), and Karol Bernolak who, in his work *Podręcznik szermierczy i krótki opis szabli polskiej* (Fencing manual with a short description of the Polish saber), observed that "fencing training is one of the most wholesome and beautiful physical exercises" (Bernolak, 1898: 11–13).

The interest in fencing theory started to grow after Poland regained independence in 1918. The most renowned authors of fencing training manuals published between 1919 and 1939 were Wiktoria J. Goryńska – *Szermierka* (Fencing) (1935), Władysław Sobolewski – *Szermierka na szable* (Saber fencing) (1920), and Włodzimierz Mańkowski – *Szermierka na szable* (Saber fencing) (1929).

Fencing classes were held in various types of schools, in the military and fencing sections of sports clubs and student organizations (academic fencing). Fencing was also part of the curriculum of the Central Military School of Gymnastics and Sports in Poznań, the Central Institute of Physical Education in Warsaw and the Academy of Physical Education in Warsaw. However, very few fencing enthusiasts published on fencing theory or wrote fencing training manuals.

Attempts to propagate competitive fencing among secondary school students in Poland in the late 1930s, especially in the aftermath of the Berlin Olympics of 1936, were not successful and by the outbreak of World War II fencing had failed to become a mass sport in Poland (Łuczak, 2001: 65–66).

Fencing theory and practice in Poland after World War II

After WWII, research on professional sport and competitive fencing was taken up by higher schools of physical education (established in 1950), the Academy of Physical Education in Warsaw (from 1945) and the National Institute of Physical Culture in Warsaw (from 1953) (Łuczak, 2002: 125). Initially, some interesting studies on sport theory, training methodology and application of research in sport were carried out by Otton Fiński, who in one of his works evaluated the contemporary advances in fencing (Fiński, 1952: 880–887). Most of these studies, however, merely touched upon the subject of competitive fencing (Demel, 1964: 12).

In the early 1950s studies on theoretical and practical aspects of competitive fencing were published by Zbigniew Czajkowski. His main contribution was *Nowa szermierka* (New Fencing) and its enlarged and revised version "for all fencers, mostly those who take the first steps at fencing and have not yet come to appreciate the beauty of this sport". His works proved tremendously useful for fencing beginners as well as for fencing coaches in clubs and national associations (Czajkowski, 1954a: 187). Czajkowski's other fencing books included *Szermierka na florety* (Foil fencing) (1954b: 137–138) and *Teoria i metodyka współczesnej szermierki* (Theory and methodology of modern fencing, 1968) (Czajkowski, 1968: 315; 1977: 19–20; 1987: 32; 1996).

In the 1960s, in particular before the 1968 Summer Olympics in Mexico City (elevation 2400 m), a long-term research project began in Poland on the so-called Problem 105 (Gaj, 1999: 182) aimed at finding solutions to the problem of sports rivalry at high altitudes featuring atmospheric hypoxia. Other studies from the period concerned nutrition of fencers, personality and reaction times. It should be emphasized that in the 1970s the knowledge about fencing specifics was still rather rudimentary. Training loads, for example, were adopted selectively in fencing training, mostly on the basis of coaches' intuition rather than research results (Celejowa, 1975: 70; Olszewska, 1975: 190, 194; Borysiuk, 2006: 11). A small number of fencing coaches, e.g. Adam Medyński or Zbigniew Czajkowski, were, however, seeking new training methods using biorhythm charts and reaction times (Zawadzki, & Skiba, 2009: 9, 18, 20).

In the 1980s and 1990s fencing research was conducted as part of the ministerial programme "Training, sport competition and regeneration". The reports from the 2nd Scientific Congress on Physical Culture in Gdańsk in 1986 included criteria of assessment of fencing training loads (Wit, Buczek, Fidelus, Kakietek, Starosta, & Wolf, 1987: 315, 336) and, in particular, indicated the relationship between the development of attitudes towards high performance sport and fencing practice (Pawlak, 1978: 211–232). Within the 3rd ministerial programme research was conducted on the optimization of the training process, especially on training loads in fencing (Wit, Wit, Krogulski, Składanowska, & Składanowski, 1987: 49–57). A psychological study carried out by J. Kłodecka-Różalska in 1986 revealed an improvement in mood and comfort and a reduction in the anxiety level among elite fencers. These results had no application in general population studies though (Kłodecka-Różalska, 1987: 68). The need for a broader application of psychological training, endurance fitness exercises and training individualization in fencing was also indicated by Zbigniew Czajkowski (Czajkowski, 2000: 112–117).

Research theories in fencing

A great improvement in the quality and quantity of Polish studies on training theory, psychology of sport combat and fencing history can be noted in the first fifteen years of the 21st century. The main contributors to this improvement were Zbigniew Czajkowski, Maciej Tomczak, Zbigniew Borysiuk, Maciej Łuczak, and Gabriel Szajna, affiliated with university schools of physical education in Katowice, Poznań and Opole.

An important landmark was the publication of Zbigniew Czajkowski's *Understanding Fencing. The Unity of Theory and Practice* in the United States in 2005 and 2006. Its first edition earned the distinction of the best American book on fencing. It was also published in Germany in 2011 as *Fechten Verstehen – in die Einheit von Theorie und Praxis* (Czajkowski 2010).

Czajkowski's third monograph *Taktyka i psychologia w szermierce* (Tactics and psychology in fencing) (Czajkowski, 2007) was an expanded volume combining *Teoria i psychologia szermierki* from 1984 and *Understanding Fenc-*

ing. The Unity of Theory and Practice from 2005 and 2006. It was thoroughly revised with new chapters and sections added on premeditation, motivation and stimulation during a fencing duel as well as on the learning and application of fencing techniques and tactics at particular training stages. *Taktyka i psychologia w szermierce* is a comprehensive summary of Czajkowski's sixty years of research. The readers could learn about a variety of issues such as motor habits and sensorimotor responses; tactical and technical fencing skills; psychological processes in fencing; choice of actions and premeditation; motivation and stimulation in sport; cognition and performance factors in fencing, their classification, tactical significance, application and effectiveness; basic tactical skills as reflected in preparatory actions; the nature of combat tactics accompanied with general and specific tactical hints for training duels; tactical preparation; changes in modern fencing tactics and styles; training individualization; fencers' attitudes towards the fencing match, training, opponent and results; psychological and tactical types of fencers; learning and using fencing tactics and techniques; shaping motor fitness in particular training stages; leadership theories, coaching skills and abilities and management styles; effects of psychology and social relations on training effectiveness; educational values of sport; and the importance of interpersonal relations in coach's work.

Z. Czajkowski stresses that the directions, content and significance of particular training components as well as the choice of training methods, forms and means must be fencing-specific. Although fencing shares a number of characteristics with other combat sports, e.g. a high significance of open habits and their various uses with regard to the ever changing tactical situations, it is a unique speed sport in which the main determinant of success is the psychological-tactical direction of training.

The above theoretical and methodological considerations reveal the immense value of *Taktyka i psychologia w szermierce* by Czajkowski (2007), who is a former bronze medalist from the 1953 saber fencing world championships, and the author of a classification of sensori-motor responses (simple, complex, choice, intuitive, foreseen and unforeseen, etc).

Other authors of fencing studies belong to the younger generation of researchers. One of them is Zbigniew Borysiuk from the Faculty of Physical Education and Physiotherapy of the University of Technology in Opole, a former fencer and fencing coach, whose most famous pupil was Dariusz Gilman – a gold and silver medalist at the saber world championships. Borysiuk has published[1] several monographs and articles, e.g. *Psychomoto-*

[1] Borysiuk published papers in such indexed journals as *Journal of Human Movement Studies, Biology of Sport, Człowiek i Ruch/ Human Movement, Journal of Human Kinetics, Brazilian Journal of Kinanthropometry* and many others.

ryczne i osobowościowe uwarunkowania poziomu mistrzowskiego w szermierce (Psychomotor determinants of eleite fencing level) (Borysiuk 2002); *Modern Saber Fencing* (Borysiuk, 2005); *Struktura czasowa procesów informacyjnych w wybranych sportach walki* (Temporal structure of information processes in selected combat sports) (Borysiuk, 2006b); and *Movement and Health* (Borysiuk, 2006a).

His seminal work is *Modern Saber Fencing* published in 2009 and accompanied by a DVD entitled *Saber Technique and Tactics*. The book is aimed at fencing academics and enthusiasts in Poland and abroad, and draws extensively on Borysiuk' observations and analyses of various fencing competitions and his coaching experience in the Zryw Sports Club, the Society of Fencing Enthusiasts and the Academic Sport Union of the Opole University of Technology, his comprehensive notes and video recordings.

In his monograph Borysiuk analyzes the historical evolution of all types of fencing weapons, the tenets of the Polish saber fencing school in the 19th and 20th century, fighting styles of world's elite saber fencers in the late 20th century, techniques and modern training forms of modern sabreurs, outlines of saber feing lessons, the nutrition of fencers, and basic forms of saber training, e.g. pair and queue exercises. Furthermore, he discusses studies on the psychomotor abilities of fencers – unique in Polish fencing literature –, diagnostic fencing tools useful for selection of fencers and determination of their level of advancement, practical applications, tools for assessment of fencing predispositions, assessment of psychomotor reactions, novice and expert training of simple and complex reactions to visual, tactile and acoustic stimuli and application of research results in coaching practice with regard to psychological types of fencers. Borysiuk's monograph can be a useful aid for all saber fencing coaches who train fencers at various levels of tactical and technical advancement. The book is richly illustrated and comes with a DVD with videos recordings of technical and tactical actions performed by elite saber fencers (Borysiuk, 2009).

In 2002 Borysiuk published Psychomotoryczne i osobowościowe uwarunkowania poziomu mistrzowskiego w szermierce (Psychomotor and personality determinants of elite fencers) (Borysiuk, 2002).[2] The work is a thorough analysis of psychomotor and personality variables affecting sports results, and proposes ways in which non-significant determinants of fencers' level can be identified. It also discussed very interesting somatic indices and components of fencing-specific predispositions.

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[2] In his work he touches on the following issues: systemic and praxeological concept of sport training; training as an organizational cycle, determinants of success in sport competition; data resources as the fundamental paradigm of diagnosis of sport success criteria; research questions in literature; research material, methods and tools; research results.

Movement and Health Conference Proceedings (Borysiuk, 2006) consists of articles peer-reviewed by renowned experts and conference contributors. The monograph was also published on a CD. It is an updated review of the state of fencing research, current trends and prospects. It contains 86 articles: 56 written by contributors to the scientific session of the conference, 12 by invited speakers (professors representing Polish and foreign academic centers) and 24 by authors of conference posters. An article dealing with combat sports entitled *The influence of coordination training on technical skills and effectiveness of sports competition in wrestling* was contributed by Zbigniew Borysiuk, Dariusz Gierczuk, Jerzy Sadowski. They noted that an increase in coordination loads in wrestling training has a positive influence on wrestlers' performance of the majority of technical elements. Borysiuk's other contributions to the volume were co-written with Teresa Socha and Michał Morys, i.e. *Analysis of the age of the world elite women fencers* and *Preparation of coordination of female saber fencers*.

Borysiuk as the Head of the Chair of Anthropomotorics of the Faculty of Physical Education and Physiotherapy conducts his research using a 16-channel Noraxon sEMG system equipped with high-speed cameras enabling comprehensive biomechanical analyses of motor patterns and quality of movement technique in various sports. Thanks to the sEMG system athletes and coaches can monitor and adjust their motor patterns, while injured athletes can test the progress of their recovery (personal communication with Zbigniew Borysiuk, February 13, 2014).

Another Polish fencing researcher is Maciej Tomczak from the Department of Psychology of the University School of Physical Education in Poznań (Tomczak, 2000; 2002; 2005; 2008).[3] His monograph *Psychospołeczne uwarunkowania rozwoju sportowego w okresie dorastania na przykładzie szermierki* (Psychosocial determinants of athletic development in adolescents: The case of fencing) (Tomczak, 2010) is aimed at anyone interested in getting to know

[3] M. Tomczak initially focused on the history of fencing in his BA thesis on the development of wheelchair fencing in Poland, 1991–1999 (Konin 2000). He also completed two MA theses: one on Zbigniew Czajkowski's life, scientific and sports career, defended at the Faculty of Physical Education of the University School of Physical Education in Poznań (Tomczak, 2002); and the other on psychological determinants of successes in fencing in adolescents, defended at the Faculty of Social Sciences of Adam Mickiewicz University in Poznań (Poznań 2008). In the latter work Tomczak revealed that the majority of adolescents practicing fencing fulfill their essential needs both during fencing training and fencing competition. A trainer should facilitate the development of life skills in his athletes using properly selected stimulation. He also observed that the degree of difficulty of tasks assigned to an athlete must be slightly higher than the degree of a task an athlete can accomplish on one's own. Tomczak also defended his doctoral dissertation entitled *Psychospołeczne i motoryczne uwarunkowania efektywności działania w szermierce* (Psychosocial and motor determinants of effectiveness in fencing) (Tomczak, 2005).

the psychological mechanisms of human activity. His analysis of results of studies on adolescent athletes encourages reflection on the mental "state" of young fencers. The book is both an analytical enquiry and a practical manual. In his discourse with the readers the author attempts to find answers to a number of questions including: How significant is the sports environment for the psychosocial development of athletes, in particular, athletes' identity? How can young people be guided to attain high sports results? How to ensure an appropriate selection process in fencing? Particularly noteworthy is the chapter "Wybrane właściwości psychiczne jako czynniki istotne dla rozwoju oraz wyniku sportowego szermierzy w okresie dorastania" (Selected psychological traits as factors affecting the sport development and successes of adolescent fencers), in which Tomczak stresses the importance of emotional reactivity, agility, motivation and thinking abilities in the athletic development of fencers.[4]

Tomczak's top-level research and statistical analysis, so unique in studies on sport psychology, is based on the correlation-regression model allowing for a thorough testing of hypotheses on correlations between variables. He successfully applies such statistical tools as matrices of correlations for independent and dependent variables, regression analysis, multifactor analysis of variance, canonical correlations, cluster analysis, and analysis of regression remainders. The elaborate statistical material gathered by the author reflects his mastery of mathematics and developmental psychology, in particular sport psychology, is most definitely the greatest asset of this book.

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[4] Maciej Tomczak's monograph consists of six chapters. Its main objective is to define determinants of sports success in adolescents practicing fencing. The practical aim of his work is to offer results of research on adolescent athletes to coaches. In the first chapter Tomczak makes a general discussion of fencing origins and rules. In the second part he presents psychosocial aspects of development of adolescent athletes. Tomczak points to changes in the physical, cognitive, and socio-emotional development in adolescence. He also indicates relationships between development and sports results and motivations of young athletes as well as hazards of high performance sports. Tomczak duly notes that the existing correlations between selected psychological traits (emotional reactivity, agility, achievement motivation, thinking ability) not only affect the sports development and results, but also human development in general and success in one's social life. In other chapters Tomczak decribes his research model focusing on the research problem, methods, hypotheses, variables and their structure, research tools and characteristics of subjects. In the final chapter he concentrates on the practical application of his research in fencing training. He stresses, however, that his study does not provide ready made solutions to all problems of adolescent athletes or problems related to psychological sport selection of adolescents, but it only offers certain guidelines.

Maciej Tomczak is also a fencing coach, a youth, individual and team world champion, as well as a silver and bronze medalist at the European fencing championships and multiple Polish national saber champion in various age categories. In his academic career Tomczak focuses on sport psychology, and fencing psychology in particular. He has published in such indexed journals as *Journal of Human Kinetics* and *Human Movement.*

Tomczak also discusses the effectiveness of actions in elite fencing in *Profile właściwości temperamentalnych a wyniki sportowe szermierzy w kategorii wiekowej juniora* (Profiles of temperamental traits and sports results of junior fencers) (Łuczak, 2013). He notes that determination of inter-group differences in fencers' profiles of temperamental traits with the use of K-means clustering algorithm had a higher degree of predictability than determination techniques using simple correlations.

Another of Tomczak's studies, on psychosocial determinants of effectiveness in elite sports, with a particular emphasis on combat sports, is *Styl rywalizacji a efektywność działania w sportach walki – analiza psychologiczna* (Competitive styles and effectiveness of actions in combat sports: A psychological analysis). The most significant outcome of this study is the thorough analysis of competitive styles in combat sports as a significant, indirect factor that might explain the relationships between psychological traits and effectiveness of actions in sport. Tomczak's monograph contains a special questionnaire form on the competitive styles in combat sports as well as its analysis. Another book by Tomczak demonstrates the possibility of application of methodology and statistics in anticipation of sports results (Tomczak, 2012).

Tomczak's methodological achievements, demonstrated in his publications and conference contributions, include designing of a tool for assessment of competitive styles in combat sports, adapting two tools measuring motivation in sport activity and applying methodology and statistics in physical culture sciences.

In 2009, a work titled *Współczesne problemy badawcze w szermierce* (Contemporary research problems in fencing) was published on the initiative of Teresa Socha from the University School of Physical Education in Katowice. The contributors to the publication were renowned fencing theorists and practitioners such as Zbigniew Czajkowski (Czajkowski, 2009a). The research issues tackled by the authors of particular articles included *Information processing during sensorimotor activities; Analysis of hits by elite female epee fencers during the Polish championships; The age of world elite fencers; Talent identification in sports with open motor habits; Sports results and the age of Olympic finalists; Contemporary research problems in fencing; Aerobic and anaerobic fitness of female foil fencers at different ages and training levels; Individualization of training of fencing-specific skills based on responses;* and *Fencing literature in Polish.* The publication with such a great thematic diversity can be of immense help to all fencing trainers and practitioners.

Fencing history has been the main area of research carried out for many years by Maciej Łuczak from the University School of Physical Education in Poznań. Initially, Łuczak was concerned with the history of fencing on a regional level and with biographies. His monograph *Szermierka w Polsce w latach 1945–1989* (Fencing in Poland, 1945–1989) is a synthetic study of history of competitive fencing in Poland. Łuczak discusses in his monograph such issues as the history of Polish fencing organizations, training and competitions; activities of the national and regional fencing associations, clubs and sections; fencing successes on the local, national and international levels; links between fencing, literature and art; fencing techniques and tactics, evolution of fencing combat and dress; fencing as part of other sport disciplines, fencing for the disabled; fencing in modern knightly tournaments military fencing – especially bayonet fighting –; and fencing in schools and academies (Łuczak, 2002).

Maciej Łuczak was also the editor of the volume *Szermierka we współczesnych badaniach naukowych* (Fencing in contemporary research) which contained contributions from authors representing both the humanities and sciences. All the articles in the publication combined theory with practice. Their subjects included fencing methodology as well as sport psychology, philosophy, pedagogy, history, laws and biomechanics. Theoretical themes tackled by the contributors were concerned with the evolution of fencing research, application of genetic research and talent identification in fencing. Some authors focused on the issues of law regulations in fencing, ethics and fair play. In other articles, the authors recommend implementing the training process accounting for an appropriate sequence of training stages and coordination abilities leading to the development of motor potential and sports skills. Research also found that application of training loads must account for temperamental differences of fencers (e.g. strength of stimulation and mobility of nervous processes), psychological support (e.g. relaxation, visualization, biofeedback) and high quality nutrition. Fencers' general fitness can be determined with the use of biochemical analysis (blood levels of iron, testosterone, cortisol, creatine kinase and complete blood count). Also training control using tests or test batteries can be an effective measure of the quality and scope of sport training. In the training process coaches should constantly expand their theoretical knowledge and practical skills to avoid moving in a rut.

A regional history of combat sports is the subject of Gabriel Szajna's book *Sporty walki na Podkarpaciu w latach 1945–1989* (Combat sports in the Podkarpacie region, 1945–1989). The author describes there the development of fencing in the Podkarpacie region of Poland, activities of the Regional Fencing Association in Rzeszów and sports achievements of fencers from fencing sections from various regional sports clubs. Szajna also briefly discusses the figures of Olympic fencers from the region (Szajna, 2011).

In 2013 Mateusz Witkowski published an interesting doctoral dissertation entitled *Morphological, physical and social determinants of the level of foil-*

specific skills in the youth category (Witkowski, 2011). Nutrition of children and adolescents practicing fencing was the subject of articles and conference papers by Monika Radzimirska-Graczyk and Włodzimierz Chalcarz (Radzimirska-Graczyk, Chalcarz, 2004; 2006; 2009).

Studies on fencing as a combat sport published in numerous monographs and articles were not only of interest to fencing coaches (Kalina, Stusiński, 2004), but also to trainers of other martial arts and sports (Giermasiński, Magiera, 2001; Topisz-Starzewska, Mleczko, Ryczek, 2002).

Many famous coaches have used specialist fencing manuals such as *Theory and methodology of contemporary fencing* or *Fencing tactics*. For example, Bruce Lee in his famous book *Tao of Jeet Kune Do* published posthumously quoted extensively from well-known fencing manuals by Julio Martinez, James and Hugo Castello, Charles L. De Beaumont, Roger Crosinier, as well as from textbooks on physical therapy, philosophy and boxing. He merely replaced the term 'fencer' with 'warrior', 'blade' with 'arm' and 'fencing' with "Jeet Kune Do" (Czajkowski, 1985).

Finally, fencing has been the subject of numerous MA theses completed by students of University Schools of Physical Education in Warsaw, Poznań, Katowice, Gdańsk and Wrocław. The areas of MA seminars included anthropology and anthropomotorics (Fajkis, 2001; Walotek, 2008), biochemistry (Górski, 2011), history (Tomczak, 2002; Wojciechowski, 2003; Jeż, 2006; Marczak, 2008), physiology (Rosińska-Szromek, 2007), psychology (Górniak, 1989; Żurek, 2005), and sport theory (Szewczyk, 2002). The topics of MA projects have been related to analyses of fencing duels (Kościucha, 2006[5]); methodology of technical training (Dominik, 2010; Rostek, 2004; Wrotny, 2005, 2007; Hetman, 2007, Malerczyk, 2007), fencers' reaction times (Piguła, 2003) and many others.

Conclusion

The studies on fencing and other combat sports in Poland in the first decade of the 21st century conducted by experts in physical culture sciences have greatly contributed to the improvement of knowledge of fencing training, methodology, motor coordination, simple and complex reaction times, biochemistry and physiology. The most important Polish fencing theorists and

[5] Kościucha in her study of saber fencing matches during the 2004 Polish National Championships noted that female fencers on the piste preferred mostly offensive actions (64%). Most often they performed feinted attacks (89%), usually ending in hits to the head. However, they were more effective in defensive actions (58%) than in offensive actions. The most effective defensive actions were stop-hits (38%).

practitioners who have written extensively on various areas of fencing research have been Zbigniew Czajkowski (who has published numerous works on fencing methodology, pedagogy, psychology and training in Poland and abroad), Zbigniew Borysiuk on fencing anthropomotorics and Maciej Tomczak on fencing psychology. Thanks to the growing interest in fencing of researchers from faculties of physical education, who represent diverse areas of science, fencing theory and practice will be continue to be further explored in Poland.

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SYMMETRISATION TRAINING IN FENCING RESEARCH

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1. Introduction

The idea for this work derived from the author's own observations of competitors who participated in sports where symmetrical motion was important. Athletes of symmetrical sports disciplines often mentioned about their better or worse side. The author's own observations enhanced the theory that particular body asymmetries may influence functional body symmetry and therefore have an impact on the laterality of particular coordinative skills. The author himself had the possibility to make a self assessment on this subject, since he was competing in an asymmetric sport, tennis, that neccesitated a vast increase of strength in his right arm and shoulder in comparison to the left side. While playing tennis, he did not feel any decrease in his motor potential. It was, on the other hand, very different in two other sports the author competed in: alpine skiing and windsurfing. In the first discipline, alpine skiing, his asymmetric body structure caused differences in technique while executing left and right turns. In windsurfing the asymmetry caused problems in execution of a turn, when the sail shift was led by the non-dominant arm. These observations and ideas made the author take up the scientific question of the influence of the symmetrisation training in sports, in particular in asymmetric sports, on the motor potential of athletes competing in such disciplines (Maćkała, Michalski, & Čoh, 2012).

A pilot study about asymmetric sport was undertaken. It was made on a group fencers and on a group of skiers. The aim of this study was to show the differences between athletes competing in symmetric and asymmetric sport disciplines. The athletes from the asymmetric sports discipline, fencing, had an asymmetry in their lower limb structure mass. On average the dominant, or leading leg, had a greater muscle mass, hence it inhibits forward movement of a fencer while a fencer lunges (Table 1).

Table 1. Results of the pilot study. Structure mass: Fat Mass – FM, Mass of Non Specific Structure – MNSS, Muscle Mass – MM [kg]

	FM	MNSS	MM	Ó
Leading leg	2.1	6.5	6.2	14.81
Standard deviation +/–	0.65	1.54	1.47	3.40
Back leg	2.1	6.3	6.0	14.39
Standard deviation +/–	0.65	1.52	1.44	3.38

Additionally a further survey was undertaken among the athletes that showed the athletes' vulnerability towards injuries in their leading lower extremity (which was exposed to higher loads). Well trained and functioning muscles are the basis for omitting postural disorders and other ailments that derive from daily insufficient body motion. Therefore, overall training becomes very important. Such training provides the right development of a young body in the process of ontogeny. Professional sports training should prepare the body for a "controlled loss of health", in other words, for competition in sports. At the same time it should not disturb the growth and development process of the body. Moreover, the training should enhance the body and correct possible disturbances in the body's development. Asymmetric sport disciplines bare the hazard of disturbances in the body's structural development, therefore there is a need for conducting symmetrisation training (Trzaskoma, 2003).

Both the author's own observations and scientific research claim that all athletes who have a better functional body symmetry, regardless of the discipline they competed in, had a greater variety of technical and tactical capability. At the same time, those athletes who where under asymmetric (one sided) load, suffered more often injuries of their dominant limbs. Symmetrisation undoubtedly enhances the athlete's motor potential which results from the alignment of such an asymmetry (Lamcha, 2009; Starosta, 2003; Witkowski, 2007). This appears to be the reason for the improvement in motor skills, which are validated by the results of IPFT and EUROFIT tests. The enhancement and improvement of overall motor skills has a positive influence on the development of special motor skills and their better trainability (Talaga, 2004).

Analysis of the development of a particular sports discipline allows prediction of the athlete's future results. This is mainly possible in measurable sports disciplines, such as athletics, where motor skills are better reflection in the results. In fencing the results are thus more difficult to predict, but it is possible to assess the development of motor skills required by the fencer in order to achieve high results (Ważny, 1989).

The pursuit of top prizes in any sport is a process that lasts many years. A foil fencer reaches their peak sports level at the age of about 26–28 years (Lukovich, 1986). This is a typical age for many sports disciplines, except a few disciplines, where early age professional training is normal (for example figure skating and gymnastics) (Prusik, Dudycz, & Trzaskoma, 2003; Sachnowski, Iskra, Ozimek, & Skóra, 2006). If foil fencer reaches their peak level much beyond this age, (they are not subsidized by the ministry of sports and the federation. Generally, only athletes of the age of 21 and younger are subsidized in Poland), the coach has to put a lot of effort, despite the unfavorable financial circumstances, not to accelerate the training process and prevent early specialization. Under such circumstances an athlete will be able to compete at the average peak sports level age, fully prepared and in good health, and therefore able to achieve the highest results.

2. Review of the literature

The subject of symmetrisation and lateralization has for many years interested numerous scientists from all over the world. There are many aspects of this issue which have been widely discussed and researched. However, there is one facet that has not been sufficiently covered yet, namely the problem of symmetrisation in an asymmetric sports disciplines. Scientists have undertaken a lot of research on similar subjects and this allowed for the presentation of symmetrisation training as a part of overall fitness training programs for an athlete, which protects the athlete's health from the results of lateral training load on their body.

Laterality and symmetrisation – Laterality is a state of lateral differences either functional or structural. Symmetrisation therefore is the process of reduction of the lateral differences.

Considering the human body, people are almost symmetrical. Nevertheless humanity is divided into right handed, left handed and bilateral people. People prefer to conduct their motion by one of their sides. This is the so called motion asymmetry or in other words laterality. Laterality may occur as one-sided or mixed dominance, also known as cross laterality (Raczek, 2003).

The division of motor skills into lateral and multilateral skills leads to the question of symmetrisation. Symmetrisation is needed to widen the coordinative skills and to enhance sporting potential. Starosta's (2003) publications take up this subject. Theauthor describes the symmetrisation process in many disciplines. Among them, figure skating is of key interest. Starosta finds that figure skaters bear a hidden motor potential in their asymmetry. This asymmetry may be the basis of their further motor development.

Along with Lamcha, the same author describes the better skilled multilateral volleyball players (Lamcha, & Starosta, 2009; Starosta, 2003). Witkowski (2007) comes to similar conclusions in his research on association football players. In his work he emphasizes the tactical and technical advantage of players, who are functionally symmetrical skilled. Therefore a football player should train both sides to develop symmetrical skills from an early age.

Even in symmetrical sports disciplines such as running sport, scientists have discovered asymmetry and the need for its symmetrisation (Maćkała, Michalski, & Čoh, 2012). An asymmetry in the stride length has been discovered among many short track runners. Their results were improved after implementation of special symmetrisation exercises.

The assessment of laterality as important has been ascertained by scientists from Australia in a study about swimmers' track start. They have noticed the importance of this assessment for the training progress and the progress of the start, which is a very important part of competitive swimming (Hardt, Benjanuvatra, & Blanksby, 2007).

2.1. Is there a need for training adaptation in asymmetric sports?

There are scientific theories saying, that asymmetric sports require particular adaptation therefore asymmetric body structure and the functional asymmetry, to meet the demands of asymmetric loads in these disciplines (Wojtkowiak, 2013). Overall development is considered as less important because the asymmetric adaptation to an asymmetric discipline is not considered as having a negative impact on the athlete's body and therefore their sporting potential. Even among fencers, scientists have found an overall increase in strength, but have not found any considerable difference in strength in their legs, even though asymmetric ground reaction has been stressed. No research on the difference in leg structure has yet been undertaken (Poulis, Chatzis, & Christopoulou, 2009). In research on artistic gymnasts no difference in their one legged balance has been found, even though one leg is clearly dominant. Also no structural difference could be discovered (Sobera, & Siedlecka, 2009).

In this research though incorrect methods and instruments were used or the data collected from the athletes has been misinterpreted. Proof for this claim can be seen in the great number of articles that concern the changes in functional and structural symmetry of the body. Therefore a question arises: is body asymmetry a good thing? Most of the research that deals with this subject say that this asymmetry has a constrictive influence. Therefore research has been undertaken to construct a training system in which symmetrisation training takes an important part.

2.2. The influence of asymmetric load on the body

One useful study about the training in an asymmetric sport, fencing, was carried out by Tsolakis and Tsiganos (2008). They proved that among professional Greek fencers, the structural difference in legs caused by training loads reached 10–15%, while non-professionals had a difference of about 8%. Thesedifferences were reflected by the results in the explosive strength tests of the legs.

The subject of symmetrisation has been considered by a number of authors with regards to the health of athletes competing in fencing. In their book: “Fechttraining” (in the chapter: “Sport-medical aspects of the fencing sport”) Beck and Barth, both very good German fencing coaches, emphasize the risk of overloading of the leading leg during a typical fencing lunge. The front leg is under a greater load because of its function in the lunge and because of the forward motion of the armed hand over this leg. A fencing lunge begins with the on-guard position, then the front foot makes a leap in the attack direction. During this motion the foot bends dorsally, and the heel is moved close to the ground, while the knee is being stretched. The front foot lands first on the heel and the leg bends at the knee and the hip. That lowers the body’s position and stops the forward motion (Lukovich, 1986). During the preparation for an attack, the fencer keeps their weight on both legs equally, but the upper body is kept sideways to present the smallest possible target area. This results in a forward rotated pelvis. The rotation is the reason for the spine’s excessive inward curve, or lordosis (Beck, & Barth, 2000).

Fink (1996) has also discovered structural and functional differences in the legs that resulted from different loads on them caused by the fencing lunge. Fink emphasised the importance of this asymmetry and the combined risk of overload. He concentrated his research on the forces that had impact on particular joints in the front leg during a fencing lunge. The forces reached 3.5G, therefore on each kilogram of body mass there was an impact force of 34.335N. In comparison to a running stride, the lunge had a ground reaction of about 1G more.

More precise research on ground reaction forces has been conducted by a research team from Taiwan. Wen-Lan, Jia-Hroung, Hwai-Ting, Gwo-Jaw (2003) did research on ground reaction during double-legged leaps. Forces during leaps were measured. Measurements were taken for starting knee angles of 45° and 90°. The research showed that when the starting knee angle was 45°, the force was greater and reached about 2G.Thuson each kilogram of body mass, there was an impact force of 19.62N. At an angle of 90° there was an impact force of 14.715N. However, the force for the forward motion while the knee was at an angle of 90° lasted longer, therefore people jumping from this position reached longer distances. Regardless of these results, in conducting a one legged jump, the rule of the bilateral deficit must be taken into consideration. Therefore the result of a one legged jump is more than the half of the double legged jump. The results of a Croatian research team (Bračič et al., 2010) show that if bilateral deficit is around 40%, then the ground reaction force should be:1.8G + (1.8Gx40%) = 2.62G, and on each kilogram of body mass there would be an impact force of 25.7022N. This is around 1/3 less on the back leg, than on the front leg. Additionally it ought to be mentioned, that the front leg also takes greater load because of the greater joint angle and the eccentric motion of the muscle (Trzaskoma, 2003). That is why the front leg in comparison to the back leg takes a greater load in fencing.

2.3. Symmetrical motion and the essence of symmetrisation training

In encyclopaedias, the term symmetry is a characteristic of structures and affects the placement towards points in space that are the centre of symmetry, straight lines, that are the axis of symmetry or planes, that are the planes of symmetry. Bilateral symmetry, which is represented by the human body, is not perfect. The lack of this symmetry means asymmetry.

It is commonly though that there is a need for perfect symmetry in the body. However perfect symmetry is not always the best solution and we should instead look for optimum symmetry (Kunysz, & Sabat, 2010). Starosta writes: "(...) asymmetrical exercises lead to the overload of the dominant limbs (for example the arm of throwers or tennis players) and may cause injuries. Therefore we should protect athletes from such overload and injuries resulting out of this fact. Otherwise the careers of the athletes will come to an abrupt end."

The implementation of symmetrisation training leads to better results in both left and right-legged long jump regardless of time of the training period. Moreover, according to Starosta (2010), they learned new exercises faster and if there was an injury, they quickly learned how to jump from the non-dominant leg. Along with the progress in jumps from the non-dominant leg, faster progress and also better results on the dominant leg were observed" (Starosta, 2010).

Scientists from Wrocław have also emphasized the importance of symmetrisation. Their research proves that asymmetric sports disciplines, and their asymmetric loads, lead to structural and functional asymmetries. The main reason here is the early specialisation in such asymmetric sports disciplines (Sławińska, Rożek, & Ignasiak, 2006).

Sobera and Witkowski (2012) claim that lateralisation is trainable. This has been proved in research on Capoeira participants. Regardless of their footedness, after some time of training, their dominant leg became their left, because this is the main support leg in the discipline. This could be the basis for the symmetrisation theory in which the less loaded leg could be trained to result in better functional and structural symmetry (Sobera, & Witkowski, 2012).

The newest research from Italy shows that fencing, as an asymmetric sport also causes neurological asymmetry. They argue that strength and coordination of the legs is not sufficient to do a perfect fencing lunge. As a remedy, they advise special training to reduce asymmetry and the enhancement of the overall fitness (Sannicandro, Piccinno, Cataleta, Maffione, & De Pascalis, 2010).

Rynkiewicz (2003) argues that the expression of functional symmetry are the motor skills of informative nature. Therefore, coordination in overall motion, and research on its symmetry, is vital. Those motor skills that may be symmetrised are all the skills that reflect a potential body asymmetry. As well as coordination, such lateralisation is represented by strength. The rest of the motor skills are of an energetic nature and affect the body as a whole and do not emphasize lateralisation. In his research, Stefaniak (2008) took the same approach that strength is a skill that is subject to lateralisation. Moreover, the author emphasised endurance as a motor skill that also greatly influences the precision of movement. Many contemporary studies are aimed at investigating the laterality of strength and the influence of symmetrisation training on lateral strength, i.e. comparing the strength of the left and right leg before and after the training. Such research has already been undertaken by Wojtkowiak (2013), who assessed strength asymmetry. This asymmetry reached 15% among boys and 20% among girls. The author claims that an asymmetry of up to 20% is a normally a neccessary trained adaptation to meet the demands of fencing. The greater difference among girls could be related to less additional sports undertaken by girls.

Wojtkowiak found that bilateral deficit decreased with aging among both sexes. Unfortunately though, the author did not mention whether the decrease had something in common with symmetry or not.

Due to these research results indicated above, it can be argued that the main impact on body symmetry, both functional and structural, come from motor skills of an informative character, i.e. coordination. The only motor energetic motor skill that underlies symmetrisation is strength. Taking this as a starting point, an original training program, combining strength and coordinative skills, was invented for fencers, to estimate the impact of it on the fencer's motor skills.

Table 2. Original symmetrisation training project for fencers

Symmetrisation exercises	Overall training in the control group
1. Non-dominant leg lunge onto stability platform, 10x. The athlete stands in front of the stability platform at a distance that allows them to perform a lunge by landing the non-dominant leg on the stability platform. After that, they return to the initial position. During this exercise, the hands are placed on the hips	1. Squats on stability platform, 20x. The athlete does squats while standing on a stability platform.
2. Single leg squats on the non-dominant leg with a stability ball under the shin of the dominant leg. The ball is placed behind the athlete, 10x. The athlete stands in front of a stability ball. Their dominant leg is bent at the knee at a 90° angle and placed with the shin on the stability ball. The ball is behind the athlete on the sagittal plane. The athlete does a squat and simultaneously puts their arms to the front. At the same time the athlete stretches the leg placed on the ball to the back, rolling the ball back. After that, they return to the initial position.	2. Alternate lunges onto a stability platform 20x. The athlete stands in front of a stability platform at a distance that allows them to do a lunge with landing one of the legs on the stability platform. After that, they return to the initial position and alters the leg for the next turn. During this exercise, the hands are placed on the hips.
3. Single leg squats on the non-dominant leg with a stability ball under the calf of the dominant leg. The ball is placed beside the athlete, 10x. The athlete stands beside a stability ball. Their dominant leg is bent at the knee at a 90° angle and placed with the foot on the stability ball. The ball is beside the athlete. The athlete does a squat and simultaneously puts their arm s to both	3. Squat jumps on stability platform. Starting position: high squat, the arms close to the body and bent. Jump to spread legs position, the feet landing left and right from the stability platform. The arms also spread alike the legs but pointing upwards. After that, return to the initial position, 20x.

sides. At the same time the athlete stretches the leg placed on the ball to the side, rolling the ball aside in coronal plane. After that, they return to the initial position.	
4. Single leg squats on the non-dominant leg with a stability ball under the shin of the dominant leg and the stability platform under the non-dominant leg, 10x. The exercise is executed as inPt.2 but with the stability platform under the non-dominant leg. To correctly execute this exercise, the athlete may hold their arms on a stabilizing device such as a wall.	4. Alternate side lunges onto a stability platform 20x. The athlete stands on one side of the stability platform at a distance that allows them to do a side lunge by landing one of the legs on the stability platform with proper vertical knee alignment. After that, they return to the initial position and alter the leg for the next turn, (rotating through 180°). During this exercise the hands are initially on the hips and spread to the sides while performing the lunge.
5. Single leg squats on the non-dominant leg with a stability ball under the shin of the dominant leg. The ball is placed beside the athlete and the stability platform under the non-dominant leg, 10x. The exercise is executed as in Pt.2, but with the stability platform under the non-dominant leg. To correct execute this exercise, the athlete may hold their arm on a stabilizing device such as a wall.	5. Alternate one leg stand on a stability platform. The stance is performed for 10 seconds 2x for each leg.
6. Lying on their back, both legs bent. The non-dominant leg is placed on a stability platform. From this initial position the athlete lifts their hips and does kick-up with the dominant leg a then returns to the initial position 10x.	6. Lying on their back, both legs bent. Both legs are placed on a stability platform. From this initial position the athlete lifts their hips and does a kick-up with one leg then returns to the initial position and alters the leg, 20x.

All exercises are performed at the fifth level of intensity, thus the exercises are repeated in two sets with one minute recovery before each exercise (interval method). The recovery between the two sets is 10 minutes. That means that the exercises will have a major impact on strength and coordination due to the recruitment of deep stabilizing muscles. Hence a complex mix of motor skills is trained.

This is an ongoing experiment and initial survey has shown a greater coordinative skill in the non-dominant leg but little change in the muscle mass when both legs are compared. Nevertheless, fencers who did more training on the weaker leg performed more precise and explicit movement while fencing.

3. Summary

The research mentioned above led the present author to take up the subject of symmetrisation, and specifically to design symmetrisation training that could reduce fencers' functional and structural leg asymmetry and therefore have an indirect, but strong, influence on a fencer's level.

All the research referenced above agrees that symmetrisation improves overall health, but does it also improve the skills of participants in an asymmetric sport such as fencing? Ongoing research aims to show how far symmetrisation should go to reach the optimum level of symmetrisation and whether effective symmetrisation training should combine coordinative skills with strength, and therefore if the original training is appropriate. In the case of successful studies and training experiments, overall symmetrisation guidelines could be implemented. Those could then be adjusted accordingly to fit particular asymmetric sport disciplines.

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ACHIEVEMENT MOTIVATION IN REFERENCE TO GOAL ORIENTATION IN FENCING

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The chapter discusses the concept of achievement motivation in reference to two fundamental types of goal orientation: task orientation and ego orientation. Task orientation refers to the perception of achievement through development of one's own skills. Highly task-oriented individuals are persistent in action and are convinced their sports results depend on their own efforts. They can become intensely involved in sport activities and thus greatly improve their chances of high scores. Ego orientation is related to the perception of one's own achievements in the context of having an advantage over the opponent. Ego-oriented individuals focus on winning and testing their skill level against others. It is more difficult for them to take full advantage of their own potential since they tend to develop their skills to equal or surpass the skills of other competitors (Duda, 1993; Roberts, 2001).

The present chapter discusses the concept of achievement motivation in view of its application in fencing. The authors point to potential problems related to the development of task orientation in fencers, which is an important determinant of the level of fencing skills.

Goal achievement motivation in the context of general theories of motivation

In general, motivation refers to factors that stimulate individuals to act and affect the direction and intensity of their actions. The reasons and causes of human actions are highly significant in terms of involving their initiation, directions, level of engagement in pursuing the goal, and performing and finishing the task (Franken, 2006). Different approaches to motivation are important components of psychological systems of human activity. The differences between the approaches have depended on different psychological paradigms dominant in particular periods. Madsen (1980) categorized and placed general theories of motivation within psychological constructs of human activity. He distinguished four basic motivation models: homeostatic, incentive, humanistic and cognitive.

The homeostatic model of motivation assumes that a disturbance of homeostasis is the primary source of motivation, while cognitive and energetic factors trigger action. A reaction may, in turn, restore homeostasis and cause the completion of action, or it may have no significant effects on homeostasis. In the case of the latter the action must be continued. The homeostatic model involves psychoanalytic theory and evolutionary theory. Psychoanalytic theory assumes that motivation was related to a reduction of tension by instincts called drives. Each drive is associated with a specific source of energy deriving from one common source, i.e. libido or sex drive, being the fundamental determinant of human behavior outside one's consciousness (Freud, 2004). In the general psychodynamic sense of motivation, psychoanalytic theory involves such factors as the biological energy of the body, behaviors triggered by drives, self-control and motivation related to the necessity of tension reduction (Cofer, & Appley, 1972; Horney, 2004). In turn, the evolutionary theory in the homeostatic model is associated with two approaches: etiological and socio-biological. In the etiological approach motivation is associated with the readiness to follow an established behavior pattern. The socio-biological approach assumes that the main motivation controlling the behavior of living organisms is to spread genes using related strategies.

The incentive model of motivation considers the stimulus to be the source of motivation to act. It assumes that stimulation triggers energy processes. If a reaction to a given stimulus leads to the ignorance of the stimulus, the behavior pattern is not followed. When a reaction does not affect the stimulation the behavior continues. This approach to the motivational process is related to behaviorist theories assuming the presence of drives, incentives and reinforcement (Łukaszewski, 2000). Drive is regarded here as the amount of deficit of a positive factor significant to the body, or as the strength of a negative factor. An incentive is an object or a state that leads to a reduction of the strength of the drive through action. Reinforcement is an object or a state leading to a repetition of a reaction induced by a stimulus (Hull, 1943).

The humanistic model of motivation assumes the presence of internal sources of human behavior in which a specific behavior takes place without stimulation and one's reactions result from internal energy and cognitive processes (Rogers, 1951). These theories assume humans possess biological self-actualization dispositions to develop and mature. According to Rogers (2002) humans have a natural tendency to realize, maintain and perfect their identity. This approach encompasses Abraham Maslow's hierarchy of needs (1990) as the fundamental motivating mechanisms, comprising two broad groups of needs: deficit needs and growth needs.

The cognitive model assumes that motivation is associated with information processing in the contexts of information abundance and deficit, conformity, conflict and cognitive dissonance (Łukaszewski, 2000). Actions are triggered by tensions in the cognitive system, which are experienced as unpleasant. Such behaviors lead to the narrowing of discrepancies. The cognitive approach assumes that individuals create cognitive representations of their surroundings and use them in the process of behavior management. The main theoretical frameworks of this model include theory of cognitive dissonance (Festinger, 1957) and balance theory (Heider, 1958).

The aforementioned general models of motivation include more specific motivation theories developed for decades. Within the variety of approaches to motivation an important construct is achievement motivation. The need of achievement is part of Murray's system of needs. It is defined as the readiness and desire to overcome obstacles and solve challenging tasks in the fastest and best ways possible. Murray, on the basis of the psychoanalytic approach, assumed that needs are to a large degree of an unconscious character and examined them using projective tests. The need of achievement was included in the esteem category of needs in Maslow's hierarchy. Further research on achievement needs was carried out by McClelland, who defined achievement motivation as a tendency to keep up with and improve standards of perfection and experience positive emotions in fulfilling challenging tasks (McClelland, 1995). These aspects were further explored by John Atkinson, who together with McClelland and with reference to Murray's theory, developed appropriate projective tests (McClelland et al., 1953). In general, Atkinson claimed individuals display a tendency to achieve success, which was manifested in human actions as the strength of motivation to achieve goals and expectations of outcomes of one's own actions. The tendency to achieve success was the product of subjective probability of success attainment and the value of reward: the easier the task, the smaller the reward. Moreover, success-oriented action is according to Atkinson a resultant of two opposed tendencies: to achieve success and to avoid failure. Then, with the development of the cognitive model in psychology, issues related to the perception of self-efficacy, depending of a variety of criteria, and perception and interpretation of one's own success became more pronounced. The analysis of self-efficacy according to Bandura (1990) is strongly associated with the effects of action. Self-assessment of one's own competences increases as a result of experienced achievements.

Nicholls (1984) noted various perspectives of self-efficacy assessment. In his construct known as Achievement Goal Theory (AGT) individuals perceive the effectiveness of their own actions in reference to the effects and competences of others or in view of development of one's own competences regardless of others. According to J. G. Nicholls (1984) goal orientation is connected with a subjective interpretation of the concept of competence and understanding of the concept of achievement; and the structure and strength of motivational processes in fields involving pursuance of goals, e.g. in sport, depend on the characteristics of goals in particular fields (Duda, & Ntoumanis, 2003). Theory of goal orientation stipulates that achievement motivation involves two basic perceptions of achievement, and thus two types of goals. The first type involves learning a new task, skill and engaging in task execution. In this type individuals are task-oriented and focus on achievement of the task itself. Competence assessment is realized through self-reference. An individual experiences pleasure resulting from the involvement in one's own actions. This experience is not related to the perception of efforts and skill levels of others. The conviction of one's own capabilities is constructed through development and assessment of one's own standards. The feeling of competence results from self-analysis of skill development.

The other type of goals is associated with the assessment of one's own actions in reference to others. Goal achievement here is ego-oriented, i.e. individuals develop their competences as means to be shown to others. An important aspect is information about the level of performance of others. One's own performance is not the basis for self-development but rather a means of showing the performance to others. It can even be on an objectively lower level than others' performance, provided it is relatively better in comparison with the others' competences. The level of competence and success attainment are seen here through the prism of better abilities, better performance or faster development with a similar or even lower level of involvement. Highly ego-oriented individuals are exclusively oriented towards winning with others.

In practice task-oriented individuals reach a better level of performance of specific tasks than ego-oriented individuals (relative to their skill level). The latter attain desired results only at a higher perceived level of competence (see Table 1.1, below).

Table 1.1. Goal orientation determinants in reference to task- and ego-orientation of motivation (Nicholls, 1989; Tomczak, & Walczak, 2011)

Task-orientation of motivation	*Ego-orientation of motivation*
• Focus on personal development; • Conviction of one's own abilities on the basis of mastered motor skills; • Perception of achievement as depending mainly on one's own performance and persistence; • Choice of high standard tasks; • High level of persistence regardless of perceived skill levels.	• Normative reference to the level of one's own skills; • Perception of competences through manifesting greater capabilities, better performance than others, with less effort than others; • Focus on winning; • Persistence in implementing a task only until one's level of competence is sufficient in comparison with others.

Both orientation types (ego- and task-) are statistically viewed as orthogonal (Nicholls, 1989). This means that each individual displays both orientations, while one of them is dominant and affects the general pattern of motivation (task-oriented motivation or ego-oriented motivation), although its dominance is not of a permanent character. In each individual, also in each athlete, there is some level of orientation that renders an athlete's action meaningful while performing a task. This means that the mutual interaction between expectations of performance and expectations of outcome should be accounted for as much as the desired configuration of components of goal orientation of particular individuals to make their motivation optimal and further improve the performance level (Harackiewicz et al., 2002). Such an approach to goal achievement motivation enables a conventional classification of combinations of both types of motivation (see Table 1.2, below). High performance sport based on intense competition generates task-oriented behaviors within the framework of achievement motivation since it involves a self-assessment through the prism of displayed skills, and high self-evaluation is perceived as success. Some psychologists see the desire of achievement as innate, while some regard it as acquired (Jarvis, 2003). The analysis of motivational processes of athletes contributes to the achievement of the best sport results and to the proper understanding of success in sport, not simply as winning a competition but also as self-fulfillment enabling athletes to get involved in the attainment of designated goals, also despite of failure or injury, as well as after the completion of their sports careers (Duda et al., 1995).

Table 1.2. Motivational profiles on the basis of combinations of task and ego orientations within the framework of goal achievement theory (Hardy, 1997; White, 1998; Hanrahan, & Gross, 2005)

	STRONG EGO ORIENTATION	WEAK TASK ORIENTATION
STRONG TASK ORIENTATION	High level of general achievement motivation	Dominant intrinsic motivation (non-competitive individuals)
WEAK TASK ORIENTATION	Dominant extrinsic motivation (highly competitive individuals)	Low level of general achievement motivation

The aforementioned two types of goal orientation can be examined in the context of fencing as a combat sport in which direct rivalry is the essence.

Goal orientation in fencing as a combat sport

The primary aim of fencing as a combat sport involving weapons is to attempt to hit the opponent while avoiding being hit. In this context of direct confrontation between fencers, ego-orientation seems to be a natural component. This has been confirmed by a number of studies based on observations of experienced fencing coaches, who assessed the following determinants of a fencing situation characteristic of combat sports in general: maximization of performance, motor activity, rivalry, long-term training and social perception. The research results showed that fencing involves a much higher intensity of rivalry than any other component in the context of conflict of interests, sport competition, manifestation of the desire for victory, and reactions to the opponent's actions. This is clearly visible in sport practice where permanent confrontation is an integral part of the training process and where a large number of exercises are performed with a partner or an opponent. Such exercises include, for example, pair exercises being the basis for guided and specialist training or training duels. The nature of such training, i.e. permanent confrontation, strengthens one's ego-orientation. The essence of many fencing tasks is to perform them better than the opponent. The development of fencers' ego-oriented motivation based on their ego-involvement features:

- perception of one's performance through the prism of worse performance of the opponent. This is part of sport combat and training of various tasks together with the opponent, where the victory of one competitor is always the failure of the other (zero-sum game);
- focus on winning only – strengthened often by positive feedback from the coaches and managers after victories and by rewards;
- perfecting the performance of a task until its level is sufficient in comparison with others, involving the necessity of observation of performance of the same tasks by all competitors and feedback from trainers;

On the other hand, achievement of the maximal skill level by athletes, including fencers, requires a high level of task-orientation. Fencing research shows that high effectiveness of fencing performance is correlated with a high level of task orientation and intrinsic motivation (Gillet at al., 2009; Tomczak, 2013). Fencers with high task-orientation are characterized by:

- focusing on the development of their own skills, which alongside related task performance bring the sense of pleasure and satisfaction;
- perception of achievement as the result of development of one's own competences. Achievement depends here mainly on one's own efforts, persistence and time devoted to the mastery of particular skills;
- preference of relatively more difficult, high-standard tasks, often above an individual's level of abilities. Challenging tasks require the development of new skills;

An important consideration here is the theoretical and empirical relationship between ego- and task-orientation, where correlations between the two types of orientations are close to none. A configuration of levels of these orientations may determine the level of general achievement motivation of athletes. Simultaneously high task-orientation and ego-orientation indicate the athlete's high achievement motivation; whereas low levels of both orientation point to low achievement motivation. Furthermore, individuals with strong task orientation and weak ego orientation are intrinsically motivated, For whom rivalry is not the core of sport activity. In turn, persons with high ego orientation and low task orientation are extrinsically motivated mostly by factors related to rivalry. Therefore, while ego-orientation is mandatorily strengthened by fencers, fencers' task-orientation should be considered as well, in terms of its practical implementation in fencing training and combat.

Recommendations concerning development of task orientation in fencing

The development of task orientation in fencing training must involve the following components:

- fencers must realize that even while performing specialist tasks against the opponent, a high focus on rivalry is not conducive to the complete development of fencing skills. Individuals who are excessively rivalry-oriented may experience problems with behavior control and correct performance of a task, in particular, in early training stages. Excessive desire of victory may render the correct performance of a precise fencing task impossible;
- fencers must realize that it is worth concentrating on performing new tasks that lead to the development of new skills. Individuals who exclusively and to the maximum concentrate on winning during fencing combat may experience difficulties with performing new uncontrolled tasks. Maximal orientation towards winning can reduce the fencer's array of actions to only those he or she can do best.
- fencers must be rewarded mainly for the high level of involvement in implementing a given task. This leads to the development of persistence in performing tasks and shows that physical effort is a natural stage on the way to the attainment of high-level competences;
- fencers must be praised and rewarded for their participation in the training process;
- fencers must realize that the task goal precedes the achievable task, i.e. in order to win in combat (achievable goal) one must first perform specific tasks (task goal), and not the other way around. Thus fencers during combat must, first of all, grasp the present, i.e. "here" and "now" – which is necessary to perform a given fencing task – and then the future, i.e. the end of the match and winning the match.

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BODY BUILD AND BODY COMPOSITION OF FENCING COMPETITORS

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Introduction

Fencing is an open-skilled combat sport with an aerobic-anaerobic character, and is more technical than powerful (Tsolakis, & Vagenas, 2010). There are many intermittent acceleratory and decceleratory movements such as stopping, starting and changing direction rapidly to pursue or retreat from an opponent (Chang et al., 2009). Moreover, training volume and intensity is high in this sport (Ochoa et al., 2013) and so athletes should be very well prepared in order to achieve good performance.

Success in the sport is determined by an athlete's anthropometric dimensions, reflecting body shape, proportionally and composition (Carter, 1984; Battinelli, 1990). Reilly, Seecher, Small, and William (1997) have pointed out that individual physique and body proportion, or composition, either greatly limit or to some extent in one activity or the other. Lean, less fatty athletes with well-developed muscles are superior in performance in certain competitive sports (Karkare, 2011). Moreover, an appropriate level of body composition is important to prevent short- and long-term health risk connected with under- and over nutrition (Jonnalagadda et al., 2004). Fencing is a discipline which evaluated in athlete's body build (Rohrer Index and LBM) (Borysiuk, 2001). According to some authors, in fencing there are a number of morphological characteristics which are necessary for successful performance and which influence motor abilities specific for this discipline such as stature, arm span and leg length (Barth, & Beck, 2007).

Aim

Because there is a sparseness of data regarding anthropometric characteristics among fencers, the aim of the present study was to evaluate and determine somatotype and body composition of Polish young male and female fencers by anthropometry.

Methods

The study included 128 young Polish fencers (67 male and 61 female) with an average age of 14.3 and 13.3 respectively. All participants were recruited from local and regional fencing clubs in Poland. To assess certain body morphological characteristics all athletes were divided into three groups according to age: group 1 (n = 21, age 14), group 2 (n = 24, age 15) and group 3 (n = 22, age 16) in boys and group 1 (n = 16, age 14), group 2 (n = 28, age 15) and group 3 (n = 17, age 16) in girls.

Written informed consent was received from all athletes prior to participation. The study was approved by the institution's Human Ethics Committee.

Procedures

All fencers were measured for standing height using a moveable anthropometer to the nearest mm and body mass with an electronic scale to the nearest 0.1 kg. Then, body mass index (BMI) measurements were calculated as mass in kilograms divided by height in meters squared.

Body circumferences were measured with anthropometric tape at the upper arm (relaxed), waist, hip, thigh and calf sites. Skinfold thicknesses were measured with Lange calipers at the triceps, forearm, subscapular, suprailiac, thigh and calf site. Humerus and femur bone breadths were taken with a sliding caliper. All anthropometric measurements were conducted on the left side of the body according to standard procedure (Martin, 1928). Measurements were taken in the morning and before training, with subjects dressed in light clothing. All measurements were taken by the same person to ensure consistency.

The bioelectric impedance method (BIA) was used to assess body composition levels (Lukaski et al., 1985) with an Akern-BIA101 device. This makes use of changes in values of the electric field surrounding the human body in the process of induction. Two basic measurements are required for this examination: height and body mass. It also requires that the age of the tested person be determined prior to measurement. A current of minimal intensity (0.8 µA) is run through the body, which is imperceptible. It measures changes in two parameters: resistance (index of overall water volume in an organism) and reactance (index of protein-lipid cell membranes) and informs provides information on mutual dependencies and levels of particular body mass components.

The following body mass components were evaluated: fat mass (FM), fat free mass (FFM) and total body water (TBW). Water, being a good electric conductor, points to fat and fat free mass levels. Large amounts of water is signalled by low resistance, which usually happens in slim bodies, thus low resistance indirectly points to high fat free mass – and the other way round. Therefore, simple equations treating body mass as a sum of fat and fat free mass provides information about body composition. Mutual proportions and intra- and extracellular mass of fat free are presented in changes of reactance. Interactions between resistance and reactance are established on the basis of phase relation equations. The reliability of the BIA method has been confirmed in numerous tests (Bolanowski et al., 2005; Bella et al., 1998; Lukasky et al., 1997; Sun et al., 2003). In this paper the percentage distribution of components in total body mass was taken into account.

In order to identify body build type, the graphic method of typological assessment, invented by W. H. Sheldon and modified by B. Heath and J. L. Carter, was used in the present study (Carter, & Heath, 1990). Formulating the principles of his typological method, Sheldon (1940) made an assumption that the body build of an individual is characterised by three factors (endomorphic, mesomorphic and ectomorphic) occurring with varied intensity. Depending on the domination of any factor, the phenotype of an individual takes the form approximating the extreme manifestation of this factor to a greater or lesser extent. Accomplishing an assessment of human body build using B. Heath and J. L. Carter's (1967) interpretation requires measuring ten somatic features in the given individual. The component of body fat deposition, called the endomorphic component, can be estimated by determining the thickness of four cutaneous folds. Measuring the height and weight of the body allows researchers to calculate the factor which determines the degree of slenderness of an individual. This factor is called ectomorphic. Next, measuring the width of long bone epiphyses and muscle perimeters of the arm and shin allows researchers to estimate the individual's degree of mass, called the mesomorphic factor. Determining the three factors allows researchers to establish two coordinates (x and y), by the use of which we present an individual as a point on a triangular somatocard depicting the diversity of the human population. The vertices of the triangle represent the extreme body build types: the endomorphic, mesomorphic and ectomorphic type. The closer to the middle of the figure, the more the intensity of each factor diminishes. An individual with a balanced share of all the elements is placed in the centre of the somatocard (Sheldon, 1940; Heath, Carter, 1967; Carter, & Heath, 1990; Carter, 2002).

Results

The results of the research on the body build type are presented in Figs 1–2. The statistical measures of the features employed in the analysis are presented in Tables 1–2, which contain the descriptive statistics of the material. The observation of individual results in typological analysis (presented in Fig. 1) indicates that the body build of the examined boys is marked by domination of the ectomorphic factor. The assessment of the changes in points distribution on the somatocards depicting the participants also indicates that the type of the fencers' body build shifts from the centre of the somatocard towards the vertex of ectomorphy. The statistical description of particular elements (endo-, meso-, and ectomorphic factors) confirms observations based on avisual assessment of a somatocard (Table 3). The predominant element of the body build is the ectomorphic factor and meso- and endomorphic factors have are relatively smaller.

Following the principles of Sheldon's typological method, it was concluded that a healthy young man is placed on the central axis of the somatocard, with a shift of the somatotype towards the mesomorphy vertex, occupying the upper central part of the panel. A healthy young woman, demonstrating a balanced intensity of endo- and ectomorphic elements, possesses a somatotype which is shifted lower along the mesomorphy axis in comparison to men – generally occupying the centre of the somatocard (the intersection point of the three axes). As is evident from Fig. 1, in the examined girls, a distinct dominance of the balanced and endo-ectomorphic types can be observed. While analysing the extent of particular components' formations, we noticed that endomorphy has the highest value (Table 3). However, it is perceptible that the development of the mesomorphic component is weaker in the examined girls in relation to boys, which confirms the genetic determination of a larger amount of fatty tissue in females.

Due to the results of the study, male Polish fencers (Fig. 2, Table 3) from age group 1 represented a balanced endomorphic ectomorph (somatotype = 3.6-2.9-3.8). The ectomorphic somatotype was characteristic of athletes from group 2 and group 3 (3.9 and 3.6, respectively). Among female fencers the endomorphic somatotype dominated in each age group. It was also observed that the older the group, the higher the value of this component. (4.8, 5.0 and 5.8, respectively).

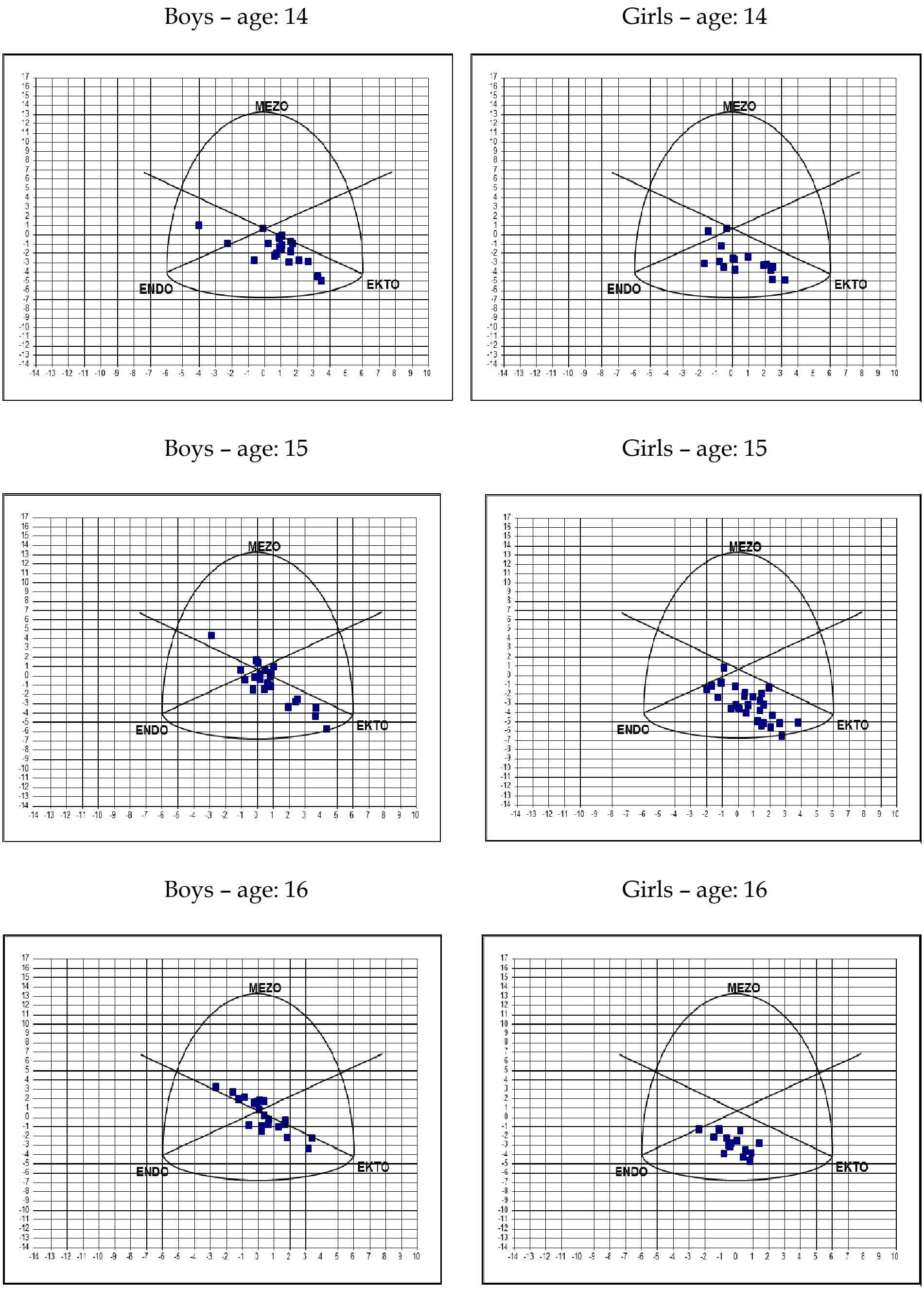

Fig. 1. The distribution of individual somatotypes of fencing competitors by sex and age group

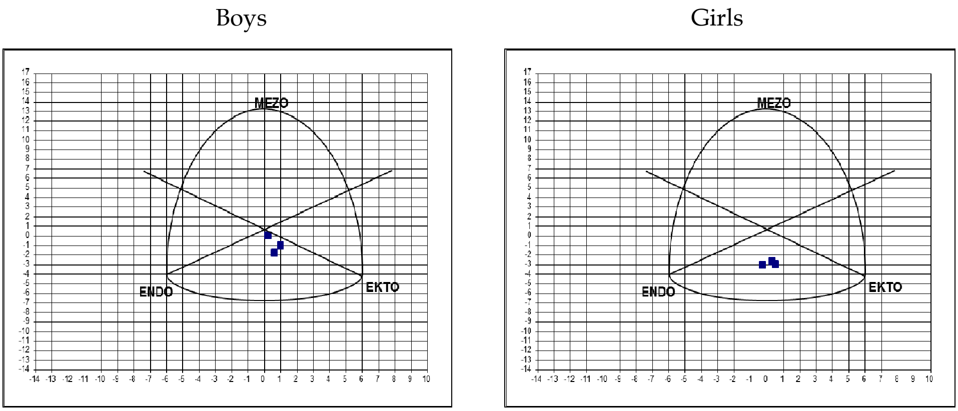

Fig. 2. The distribution of somatotypes in male and female fencing competitors

Table 1. Statistical description of somatic features of fencing competitors – boys

VARIABLES		BOYS – AGE GROUPS		
		14 years (n = 21)	**15 years** (n = 24)	**16 years** (n = 22)
Body height [cm]	x̄	**167.00**	**173.67**	**177.20**
	sd	8.25	7.44	6.21
	min	152.30	159.80	161.00
	max	184.20	190.00	186.70
Body weight [kg]	x̄	**54.53**	**60.23**	**65.39**
	sd	9.26	9.58	6.08
	min	41.00	47.30	52.20
	max	80.00	81.20	75.70
Humerus breadth [cm]	x̄	**6.72**	**6.72**	**6.88**
	sd	0.37	0.47	0.37
	min	6.10	5.80	6.30
	max	7.60	8.00	7.50
Femur breadth [cm]	x̄	**8.91**	**8.96**	**9.33**
	sd	0.52	0.51	0.44
	min	8.20	8.10	8.40
	max	10.20	10.30	10.00
Arm circumference [cm]	x̄	**25.71**	**26.44**	**28.30**
	sd	3.44	2.53	1.84
	min	20.00	23.00	24.50
	max	35.00	32.00	31.50
Calf circumference [cm]	x̄	**34.21**	**35.38**	**36.27**
	sd	3.09	3.00	2.11
	min	28.00	30.00	32.00
	max	42.00	43.00	39.00

4Σ skinfolds [mm] (subscapular, suprailiac, triceps, calf)	x̄	**45.60**	**37.42**	**35.41**
	sd	15.75	10.83	11.53
	min	29.00	17.00	20.00
	max	87.00	61.00	62.00
Fat free mass (FFM) (%)	x̄	**86.67**	**87.64**	**87.87**
	sd	6.69	5.60	5.56
	min	70.00	74.00	71.00
	max	97.00	96.00	98.00
Fat mass (FM) (%)	x̄	**13.33**	**12.36**	**12.13**
	sd	6.69	5.60	5.56
	min	3.00	4.00	3.00
	max	30.00	26.00	29.00
Total body water (TBW) (%)	x̄	**69.30**	**68.08**	**65.47**
	sd	6.24	4.50	4.53
	min	55.00	56.00	52.00
	max	74.00	75.00	72.00
BMI [kg/m²]	x̄	**19.53**	**19.97**	**20.89**
	sd	2.54	2.11	1.58
	min	16.60	16.00	16.90
	max	27.20	25.20	23.70

Table 2. Statistical description of somatic features of fencing competitors – girls

VARIABLES		**GIRLS – age groups**		
		14 years (n = 16)	**15 years** (n = 28)	**16 years** (n = 17)
Body height [cm]	x̄	**163.46**	**165.94**	**166.18**
	sd	4.54	5.36	6.79
	min	153.80	155.40	157.00
	max	170.10	177.40	178.00
Body weight [kg]	x̄	**53.16**	**55.67**	**60.24**
	sd	7.36	5.78	7.68
	min	42.40	47.30	48.50
	max	64.70	71.00	74.50
Humerus breadth [cm]	x̄	**6.15**	**6.12**	**6.18**
	sd	0.17	0.30	0.46
	min	5.90	5.60	5.50
	max	6.50	6.70	7.20
Femur breadth [cm]	x̄	**8.59**	**8.59**	**8.99**
	sd	0.62	0.47	0.45
	min	7.70	7.80	8.30
	max	10.00	9.70	9.90

Arm circumference [cm]	$\bar{x}$	**24.78**	**24.68**	**26.38**
	sd	2.10	1.85	2.07
	min	22.00	22.00	22.50
	max	29.00	31.00	30.50
Calf circumference [cm]	$\bar{x}$	**34.03**	**34.48**	**35.79**
	sd	1.96	1.68	2.02
	min	31.00	31.50	33.00
	max	38.00	38.50	39.00
4Σskinfolds [mm] (subscapular, suprailiac, triceps, calf)	$\bar{x}$	**62.31**	**64.64**	**75.68**
	sd	20.76	17.37	16.06
	min	29.00	17.00	20.00
	max	87.00	61.00	62.00
Fat free mass (FFM) (%)	$\bar{x}$	**81.86**	**78.53**	**73.99**
	sd	4.67	4.87	4.66
	min	74.00	65.00	65.00
	max	90.00	87.00	81.00
Fat mass (FM) (%)	$\bar{x}$	**18.14**	**21.48**	**26.01**
	sd	4.57	4.84	4.66
	min	10.00	13.00	19.00
	max	27.00	35.00	35.00
Total body water (TBW) (%)	$\bar{x}$	**60.58**	**57.70**	**54.19**
	sd	4.53	3.97	3.51
	min	53.00	47.00	48.00
	max	67.00	65.00	61.00
BMI [kg/m^2]	$\bar{x}$	**19.93**	**20.29**	**21.84**
	Sd	2.39	1.85	1.64
	min	17.10	17.60	19.30
	max	24.10	24.30	24.80

In the analysis of health potential in the tested group, morphological features (height, body mass and BMI) were taken into consideration. Subsequently, with use of BIA, body composition was determined (describing the percentage distribution of particular components in total body mass). Basic statistical characteristics were calculated for the analysed features (Tables 1–2). Fat mass results were compared to *Bodystat Ltd.* norms for girls and boys aged 10–17 (Table 7).

Most female and male fencers were characterized by an appropriate level of fat component. However it is worth noting that some number of them had too much body fat particularly the girls.

Table 3. The statistical assessment of the intensity of build type factors in fencing competitors

Factor	Endomorphy	Mesomorphy	Ectomorphy	Endomorphy	Mesomorphy	Ectomorphy
	BOYS			GIRLS		
Age: 14 $\bar{x} \pm sd$	3.6 ± 1.5	2.9 ± 0.6	3.8 ± 1.2	4.8 ± 1.4	2.6 ± 0.5	3.3 ± 1.2
Age: 15 $\bar{x} \pm sd$	3.0 ± 0.9	3.0 ± 0.5	3.9 ± 1.1	5.0 ± 1.3	2.5 ± 0.4	3.3 ± 1.0
Age: 16 $\bar{x} \pm sd$	2.8 ± 0.9	3.2 ± 0.5	3.6 ± 1.0	5.8 ± 0.9	2.7 ± 0.3	2.5 ± 0.7

Table 4. Fat mass categories in fencing competitors. Norms for fat mass according to *Bodystat Ltd.* for 10–17 age group

FAT MASS (%)	Girls		Boys	
	N	%	N	%
Low	56	92	29	46
Normal	5	8	27	43
High	0	0	7	11

Regular participation in training by young fencers is the sort of physical activity that influences development of their height and weight proportions. Mean BMI values of girls and boys were within standard ranges (according to WHO BMI = 18÷25). Boys' body components displayed a low mean content of fat mass (Table 1) which denotes a high level of fat free mass (FFM). Girls were characterized by a proper mean content of fat mass (Table 2) when referred to population norms, yet there is a significant variation in individual values of this component. Programmed physical activity in the form of systematic training favourably influences the level of the tested body components in both male and female young fencing competitors.

Discussion

In sports sciences, the body build type of the competitors practising various sports disciplines has been extensively analysed (Pietraszewska, 1998; Olszewska, 2002). It can be assessed by considering the criterion of two basic morphological features, namely body height and weight, through the proportions of various body parts and their main components.

Moreover, there are numerous methods of body build type assessment that have been acknowledged as useful tools. Among them, the most objective typology appears to be Heath and Carter's, being a modification of Sheldon's system, which has recently enjoyed great popularity in ontogenetical research and may be employed in sports research.

In the results of the present study male Polish fencers from group 1 represented a balanced endomorphic ectomorph (somatotype = 3.6-2.9-3.8). The ectomorphic somatotype was characteristic of athletes from group 2 and group 3 (3.9 and 3.6, respectively). Among female fencers, the endomorphic somatotype dominated in each age group. It was observed that the older the group, the higher value of this component would be (4.8, 5.0 and 5.8). Additionally female fencers had a higher percentage of body fat than male fencers. However, whilst in boys the value of this component was constant in every age group, in girls body fat gradually increased. As stated by Roi, and Bianchedi (2008), a high level of body fat and relative lower values of lean body mass in female fencers may hinder sporting performance.

Female fencers from present study seem to have similar somatotype as their counterparts from Greek (4.3-2.3-2.9) research (Tsolakis et al., 2006). Furthermore, Carter, and Heath's (1990) study showed that endomorph and mesomorph were equal among female fencers.

The body fat levels (connected with the endomorphic factor) of male Polish fencers was very similar in all three age groups (13.33, 12.36, and 12.13, respectively). According to Thomson et al. (2010), a typical fencer should, on average, have 8–12% body fat and thus the measurement values of this component obtained in the present study were very close to the reference range for other athletes. The adiposity level of female athletes was much higher and differences were noticed among the age groups with a growing tendency as age increased.

The finding of ectomorphic type domination, ascertained among the examined male competitors, does not correspond to the research by other authors dealing with similar issues (Carter, & Heath, 1990; Charzewski et al., 1991; Skład et al., 1993; Demuth et al., 2007). On the other hand, the substantial development of the endomorphic component observed among some girls in our research is not an exceptional phenomenon. Numerous studies have proven considerable body fat deposition among female competitors which exceeds the acknowledged sexual dimorphism of this feature (Skibińska, & Łaska-Mierzejewska, 1982; Pietraszewska, 1998; Krzykała et al., 2006).

A decrease in this component's share in the somatotype has been observed among girls with the highest sporting achievements (Carter, 2002). The dominance of the ectomorphic component over the endomorphic component ascertained in this work in a few female competitors also corroborates the results of other researchers (Matković et al., 1994).

Results of numerous research shows that physical activity plays a significant role in decreasing body mass and counteracts unfavourable effects caused by excessive fat tissue (Bensimhon et al., 2006; Jakcic, & Otto, 2005; Lee, & Skerrett, 2001; Wadden et al., 2007; Wessel et al., 2004). The body components of fencers who took part in this examination point to good proportions, which could have been influenced by long-term, regular training. Although some authors observed a relatively low influence of morphological, compared to physiological or tactical factors, in fencing (Steward et al., 1977), others have noticed that morphological adaptation in sport must be taken into account because of the intense training and selection procedures in this sport discipline (Norton, 2001).

Torun et al. (2012) have stated that body fat (%) is one of the basic factors effecting success in fencing. Furthermore, Vender et al. (1984) have observed that low body fat percentage can improve performance in fencers. Therefore, it seems to be important to undertake systematic morphological monitoring of such athletes with regards to their health and performance, in order to determine the proper magnitude of training loads according to various periods of physical growth.

Conclusion

The present study shows that Polish fencers had high ectomorphic levels and girls were characterized by endomorphy, regardless of age. This could be explained by the fact that the somatotype of girls changes significantly during puberty. This is reflected by an increase in the endomorphic component, which was also observed in our research. Moreover, the predominance of fatty tissue in girls confirmed the genetic domination of this body component. With regards to athletes' health and performance, systematic monitoring should be undertaken to determine the proper magnitude of training loads according to various periods of physical growth.

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MOTOR LEARNING AND TEACHING.
A SYSTEM-THEORETICAL APPROACH

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We were born without expertise,
And will die without experience.
Wisława Szymborska

Introduction

One of the greatest "inventions" of evolution was no doubt the feedback control mode. It enables learning and, indirectly, species' development. However, it is rather "expensive" in terms of intellectual work. So, although in learning processes feedback is indeed necessary, in the performance of already mastered skill its part should be reduced to a minimum or eliminated entirely. A comparison of the terms "performance" and "learning" is shown in Table 1.

Table 1. Comparison of the terms "Performance" and "Learning" (Magill, 2011: 249)

Performance	Learning
• Observable behavior	• Inferred from performance
• Temporary	• Relatively permanent
• May not be due to practice	• Due to practice
• May be influenced by performance variables	• Not influenced by performance variables

The process of learning includes the changeability of movements' management structures along with increasing experience. It may be defined as follows:

Learning – *"the psychological, intrapersonal process of transformation of respective mental representations of specific tasks, aimed at enhancing future solution of similar task"*.

N.R. Carlson distinguishes two kinds of learning:

Perceptual learning – *"learning to recognize a particular stimulus"*.

Motor learning – *"learning to make a new response"* (Carlson, 2007: 431).

The very basis of learning and teaching processes (as well as motor control) make the information processing and development of relatively stable and efficacious patterns of motor behavior the solutions for specific environmental tasks. They require the use of suitable codes and methods of information processing (in living beings termed "thinking"). However, unlike in technological devices, in living beings information processing is of a multimodal nature.

Multimodality of information processing in living creatures. The modalities ladder

Unlike physical processes, biological ones are hardly liable to mathematical mirroring and description (Buytendijk, 1956; Brillouin, 2004; Kawato, 2008; Heller, 2011). To bring this region of scientific knowledge into order, the systemic approach seems to be suitable.

The most primeval roots of systemic thinking can be traced back to antiquity. In 17th century the ideas of R. Descartes (division into *res cogitans* and *res extensa*) may be regarded as the germ of a system idea, though according to Cartesian theory it was a sum rather, and not a system. In 1852 British biologist W. B. Carpenter presented a systemic arrangement of information processing in humans (Carpenter, 1852), and in 1884 British physician J. Hughlings Jackson developed a three-level neurophysiological model of information processing in humans (Hughlings Jackson, 1884). In 1947 Russian neurophysiologist N.A. Bernstein (who referred to Hughlings Jackson, but not to Carpenter) invented probably the most advanced model of movements production in humans. It consisted of five levels: A (rubrospinal), B (thalamo-pallidal), C (pyramidal-striatal), D (cortical) and E (cortical) (Bernstein, 1947). In the 1960s American neuroscientist P. D. MacLean (who referred to Hughlings Jackson, but not to Bernstein) presented three-level model termed "triune brain" (MacLean, 1985; 1990).

Neurophysiology is indeed important, but in motor control the most significant factor is the way of motor behavior provides a pattern for production. Thus, on the basis of Bernstein's theory it seems possible to develop what might be termed the "modalities ladder" (ML). A simplified presentation of this is shown in Table 2.

Table 2. The modalities ladder

Bernstein's level	Stimulus	Type of skill	Type of control	Type of internal pattern
E	Engram – symbol	–	Politics	Vision
D	Engram – word	Performance	Strategy	Program
C	Remote (mainly visual)	Habit	Tactics	Scenario
B	Contact	Automatism	Technique	Stereotype
A	Intrinsic	Reflex	Internal	Coupling

It is worth noticing that in Table 2 there is neither a "conditioned reflex", nor an "unconditioned reflex". Those historically established names are rather confusing, because they suggest that one has to do with two varieties of the same phenomenon. On the contrary, each of them is controlled by another neural structure, each has its specific attributes and they both play different roles in the general structure of human (and animals') movements.

Engram is a memory trace, i.e. an internal representation of either environmental phenomena or processes, or product of internal processing of such representations. In short, one may state that A-level is a "feeling-in-hand" level, B-level – movements' harmony level, C-level – "measure-by-eye" level, D-level – "common reason" level, and E-level – fantasy level.

Importantly, it is the lower level that is the less complex and less "powerful", but at the same time, less time-consuming in terms of information processing. So, one automatism may include several reflexes, one habit may "command" several automatisms and one performance – several habits. The opposite direction is not possible.

The phases of motor learning according to Fitts

In 1964 P. Fitts developed a three-stage model of motor learning (Schmidt, & Lee, 2011). He divided the whole process of motor operation learning into three distinct phases, which make a single, coherent and continuously developing system of the internal representation of motor operations. It consists of:

1. The cognitive phase,
2. The associative phase,
3. The autonomous phase.

Thus, the learning process depends on efficiency of feedback control, but it is aimed at elimination – as much as possible – of this control mode and substituting it with the feed forward control, most desired in movements' control processes.

Cognitive phase: Down the codes' ladder

In the cognitive phase the learning individual applies at first the most powerful information processing tool, i.e. E-level **fantasy** (Petryński, 2010a). Here the "independent variable" is a planned action, and the "dependent variable" is the the environmental conditions. At D-level (common reason) situation changes: the environmental conditions play the function of "independent value", and the action has to be adjusted to them. At C-level ("measure-by-eye") the visual scenario of a planned action is being produced, at B-level (movements' harmony) – the muscle synergies, and at A-level ("feeling-in-hand") – the particular muscle contractions (Fig. 1).

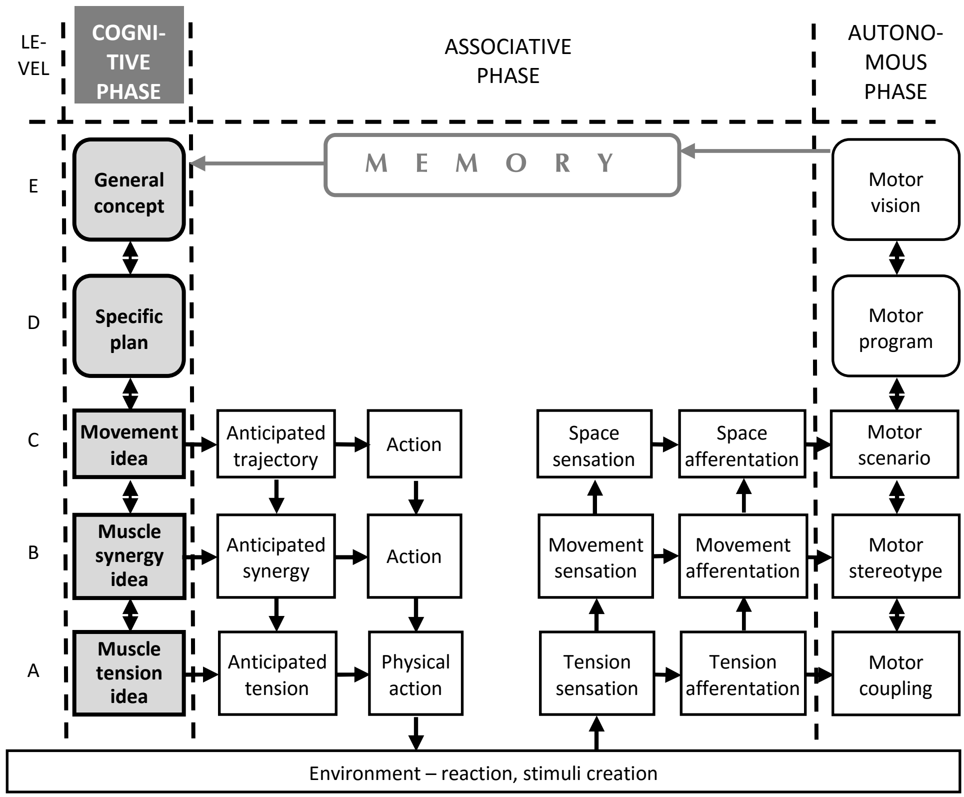

Fig. 1. Motor learning, **cognitive phase**: going down the modalities' ladder

While looking from physical perspective, the A, B, C, D and E levels are "responsible" for the dynamics, kinetics, kinematics, metric and topology of the movement, It needs to be emphasized that in cognitive phase we have to deal with **abstract conceptual representations of sensory phenomena**. So, abstraction is not assigned exclusively to D and E levels and is "structurally" deprived of physical contact with environment.

Associative phase: Bridging the gaps

After the rough ideas of particular actions at different levels of ML are already prepared, the system prepares itself to produce motor commands' structures corresponding to them. So, it is necessary to bridge the gap between imagination and the results of real actions, i.e. to check in practice the tentative working hypotheses developed in cognitive phase. This gap is clearly visible in Fig. 2.

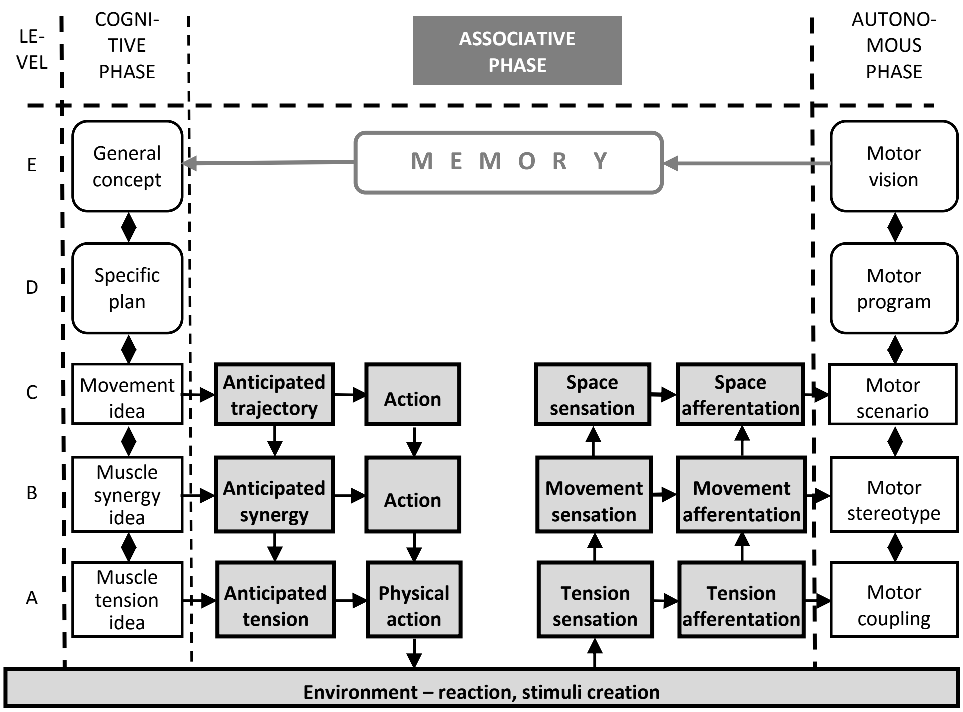

Fig. 2. Motor learning, **associative phase**. Bridging the gap, clearly visible "gap" between action and sensation

It is placed between columns "Actions" and "Sensations", and the only way to bridge this gap leads through the reaction of the environment.

The next step is the production of abstract afferentations on the base of physical sensations. The afferentations make the “building stuff” for purely abstract motor behavior patterns at particular levels of ML.

Autonomous phase: Up the modalities’ ladder

The creation of abstract motor behavior patterns is the essence of the third element of Fitts’ theory, i.e. the autonomous phase (Fig. 3).

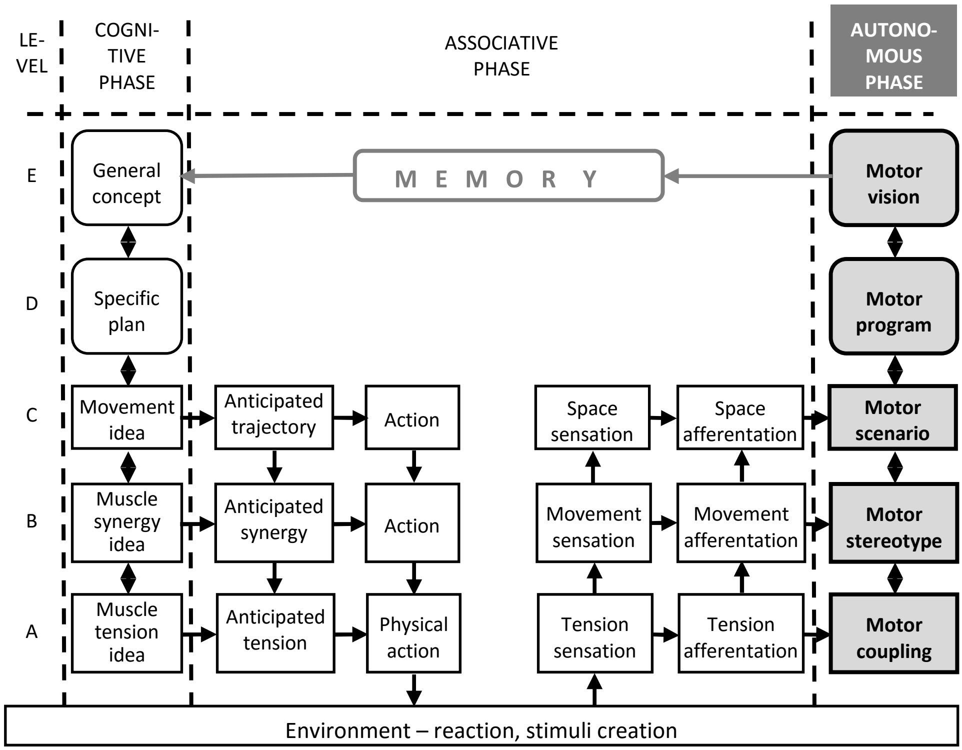

Fig. 3. Motor learning **autonomous phase**; going up the modalities’ ladder

Abstract afferentations may be transformed into **abstract** behavior patterns. They have two major advantages over ideas developed in the cognitive stage:

1. They are free from environmental noise that has to be eliminated before an action starts.

2. They are independent of environmental stimuli, so they may be initiated on the base of anticipation, before an essential stimulus appears.

In the latter point above the key word is "**anticipation**". This may be effectively applied when:

1. The environment is predictable enough.
2. The active person has properly recognized the task.
3. The active person has previously developed appropriate motor behavior patterns.

In such a situation the feed forward mode is sufficiently efficacious and there is no need to carry out the time consuming feedback processing. So, in movement control the feedback may be regarded as a rescue action, some sort of prosthesis, necessary to save otherwise lost motor operation (Petryński, 2010b). This is why in Figs 1, 2 and 3 the block "Memory" is marked with grey lines, because the learning process is aimed at elimination of its role when the internal behavior patterns achieve their optimal efficiency.

External support for the motor learning process: Teaching

In Figs 1, 2 and 3 the **psychological process of learning** is shown, i.e. the confrontation of primary imagination with real environment's reaction and transformation of sensations into afferentations that in turn make the "building stuff" of abstract, internal motor behavior patterns.

Though learning is decisive in the process of improving the human motor competencies, in the course of evolution – from herd, through tribal to social modes of cooperation – the process of teaching that supports individual's learning has been developed. It enables extending the perfecting of particular skills to the intergenerational temporal scale. Accordingly, it may be defined as follows:

Teaching *– "the sociological (interpersonal) process of effective supporting the intrapersonal learning process in an individual."*

In short, teaching consists in substituting the environmental response to individual's action, i.e. feedback, with cues delivered by a teacher. Such feedback is aimed at:

1. Breaking the process of creation of a wrong motor behavior pattern.
2. Inducing the learner to create a right pattern.

The general pattern of the teaching process, while seen from the ML perspective, is shown in Fig. 4.

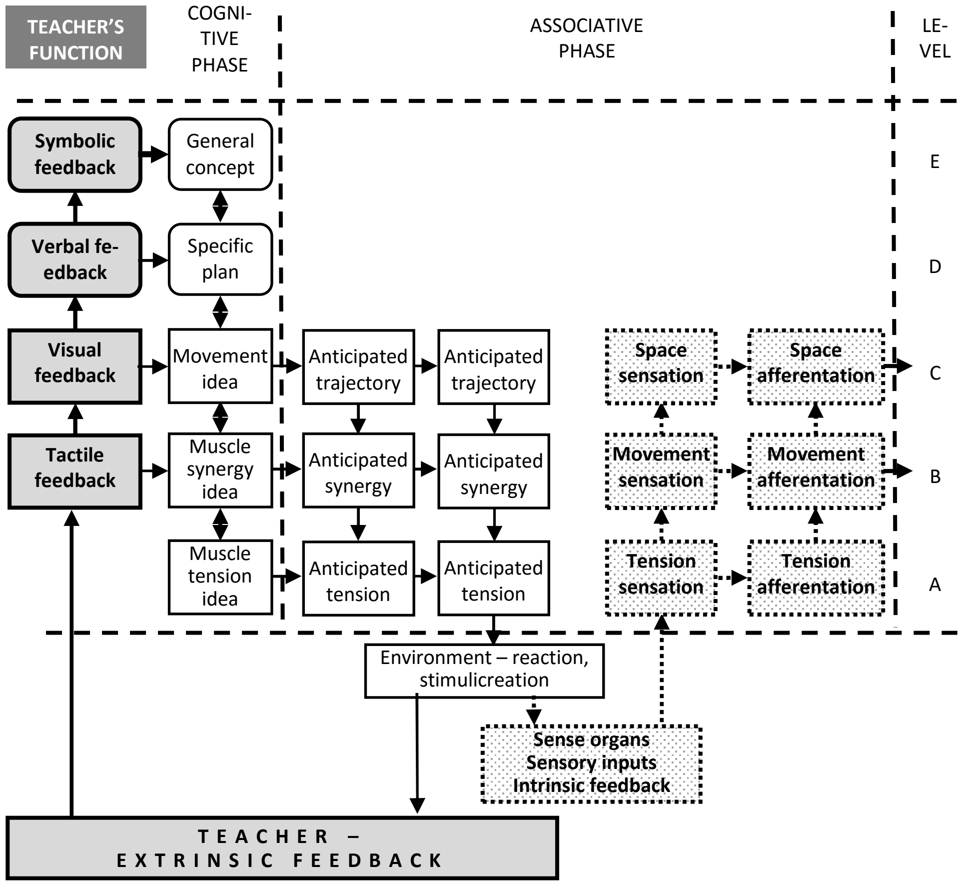

Fig. 4. Teaching as seen from the modalities' ladder perspective

While noticing an incorrect or inefficient performing of an action being learnt, a teacher (instructor, coach) should break the process of "bridging the gaps" in the association phase and substitute the environmental reactions with the proper cues, described in Fig. 4 as "Teacher – extrinsic feedback". In short, the teacher has to suppress the environmental feedback and substitute it with one's own instructions.

The teacher has no access to the A-level intrinsic sensations, i.e. creation of "feeling-in-hand". For example, it is not possible to explain how strong one has to grip an egg to prevent it both from dropping and from crushing its shell. Such "feeling-in-hand" – and respective coupling – has to be shaped independently by learner.

Only at B-level (movements' harmony) may the teacher actively influence the way of performing the learner's action. This is termed guidance (Schmidt, & Lee, 2011: 386–388; Park, Kim, & Obinata, 2011), or more pre-

cisely – tactile guidance. This technique is sometimes applied in rehabilitation
of a person with an injured nervous system. In sport or physical education it application is theoretically possible, but it induces a learner to sheer **reproduction** of specific movements (stereotypes). As a result, its "learning power" is rather poor.

At C-level ("measure-by-eye") teacher may apply a visual feedback, i.e. demonstration. It gives a ready image of a given action and so it induces the learner to **imitation** of teacher's action.

At D-level (common reason) the teacher delivers verbal description of an action to be done by learner. It gives ready program and the learner should realize it, i.e. to produce or reproduce independently necessary scenarios, stereotypes and couplings. Such a verbal description is commonly known as "knowledge of performance", in short KP. The learner is induced to **realize** the rather strictly described motor program.

At E-level (fantasy) the teacher delivers only an assessment – "good" or "bad" – and the learner has to independently **create** a proper program and respective system of scenarios, stereotypes and couplings. This kind of teacher's cue is termed "knowledge of results", in short KR (Knapp, 1963: 323; Belej, 2001: 56; Schmidt, & Wrisberg, 2008: 286; Schmidt, & Lee, 2011: 395).

Summing up, in spatial and temporal terms E-level is "responsible" for general topology of movements that make together an efficient motor performance; D-level – for metrics; C-level – for kinematics; B-level – for kinetics; and A-level – for dynamics.

It is worth noticing that there are only two "input gates" from environment to the human system of information processing – at B- and C-levels – and only one "output gate" at A-level. Accordingly, a teacher may analyze the only observable manifestation of internal mental processes in a trainee or learner – i.e. the movement – and only infer, what is wrong and needs corrections in a disciple's mind to make the teaching process effective.

As already mentioned, the lower level, the more straightforward information processing, is, at the same time, the faster. So, in very quick actions, such as hitting or throwing – so called "ballistic movements" – only feedforward control mode is possible. In such motor operations a teacher is able, especially with verbal instruction, to indicate the already made errors.

Furthermore, in moderately quick motor operations the visual control may be applied, but verbal information processing would be to slow. Thus, when in a given situation, the visual information processing is not effective enough and the verbal transformation has to be applied, an individual stops his/her actions and says: 'Just a moment, please, let me ponder over it!'.

However, in didactical practice the most popular method is verbal presentation, i.e. the lecture. When it is given in the lecture room, sometimes with special audio-visual didactic aids, the speed of "transmitter" complies with the speed of "receivers". Moreover, as it is fully detached from real run of events, the formed may be easily adjusted to the latter. In such a situation the potentialities of verbal information processing may be exploited in full. It is completely detached from purely sensory experiences, so it may reach far beyond the sensory limitations.

In motor control other popular way of teaching is the demonstration. It exploits the potentialities of remote modality of information processing. It is much quicker than the verbal one, but at the same time much less "powerful". Visual, auditory, or olfactory modality is tightly connected with sensory experiences, thus its spatial and temporal frames are limited by the potentialities of human's senses.

The specific method of teaching, especially in sport and physical education, is the instruction. It is a verbal cue given during the just being performed operation. So, here one has to join two incompatible ways of information processing: rather slowly "transformable" verbal directives and rather quickly running motor operation. This is not always possible, but to make it effective in a case when it may be effectively applied, the instruction has to be:

1. Extremely short, understandable and concise.
2. It has to concern the essential elements of what is going here and now.
3. It should evoke in the memory of the disciple a simple image rather, and not – say – a chapter from a 1000 pages book.

Let us remember, once more, that the movement is the only possible manifestation of what is going on in human's mind. Thus, a teacher has to be able to "read" the motor behavior of trainees effectively enough to give them useful assistance. Moreover, it has to be done as quickly as it would be processed with sensory modality. Therefore, instruction is probably the most difficult way of motor operations teaching.

It is also worth noticing that each motor action – reflex, automatism, habit and/or performance – is always directed to a future that is inevitably burdened with some uncertainty. So, each motor action may be planned only with some probability of the final success. It seems that this probability makes the further progress and evolution of whole species' possible.

The modalities' ladder and the learning cycle by D.A. Kolb

The presented paper includes a tacit premise that the sensory inputs – neural impulses induced by extrinsic stimuli, tactile (B-level) or remote (C-level) – only recall respective information chunks from memory. In other words, information comes not from outside, but – according to J. S. Bruner's cognitivist approach– is being created, processed, and stored inside the system (Bruner, 1973). The complete transformation and processing of information chunks happens inside the specific mind of an individual. Such transformation is strongly influenced by one's own experiences and knowledge. So, even the same stimuli evoke different information in different individuals. Such mental diversity may be regarded as a basis for intellectual development of humans as a species. However, on the other hand, this makes the job of a teacher, instructor or coach extremely difficult. So, by now it is more art than trade. To put it simple and succinctly, a teacher does not transmit information, but only recalls it from the memory of disciples.

Furthmore, J. S. Bruner's cognitivist approach is no doubt a philosophical one. As the outstanding mathematician, D. Hilbert has stated "*Philosophy is a game with objectives and no rules. Mathematics is a game with rules and no objectives.*" So, philosophy and mathematics from the intellectual "Pillars of Hercules", with science somewhere between them. Accordingly, in extremely innovative science there are neither completely clearly defined objectives, nor absolutely sharp rules; it seems that this probabilistic fuzziness provides a basis for progress and evolution. As a result, it is necessary to arbitrarily choose a starting point for further analyses. Thus, taking such a starting point e.g. the Bernstein's or Bruner's ideas seems to be fully justified.

Morover, Bruner's cognitivist perspective is not only a purely philosophical basis underlying one of many scientific world images. It has also very practical applications and forms one of the fundamentals of neurolinguistic programming that consists, to great extent, not of shaping of desirable behavior patterns by teacher, but in" potentialities mining" from one's own psychological resources by a disciple (Andreas, & Faulkner, 1994).

The presented model of motor learning and teaching is not contradictory to the commonly known learning cycle invented by D. A. Kolb (Fig. 5) (Chiong, 2011), though the latter does not take into account the full spectrum of modalities involved in the process of learning (and teaching, too).

On the contrary, the ML model may support that by Kolb. In Fig. 5 the categorization of "concrete experience" as an element of the block "*How we* ***think*** (our emphasis – authors) *about things*" seems inconsequential. "Feelings" are of sensory, and not mental, nature. However, while looking at Fig. 2, one may realise that in the association phase a sensory feeling produces abstract, mental afferentation. They are both strictly assigned to each other. As a result, the mental afferentations may be categorized as the elements of intellectual, and not purely sensory processes.

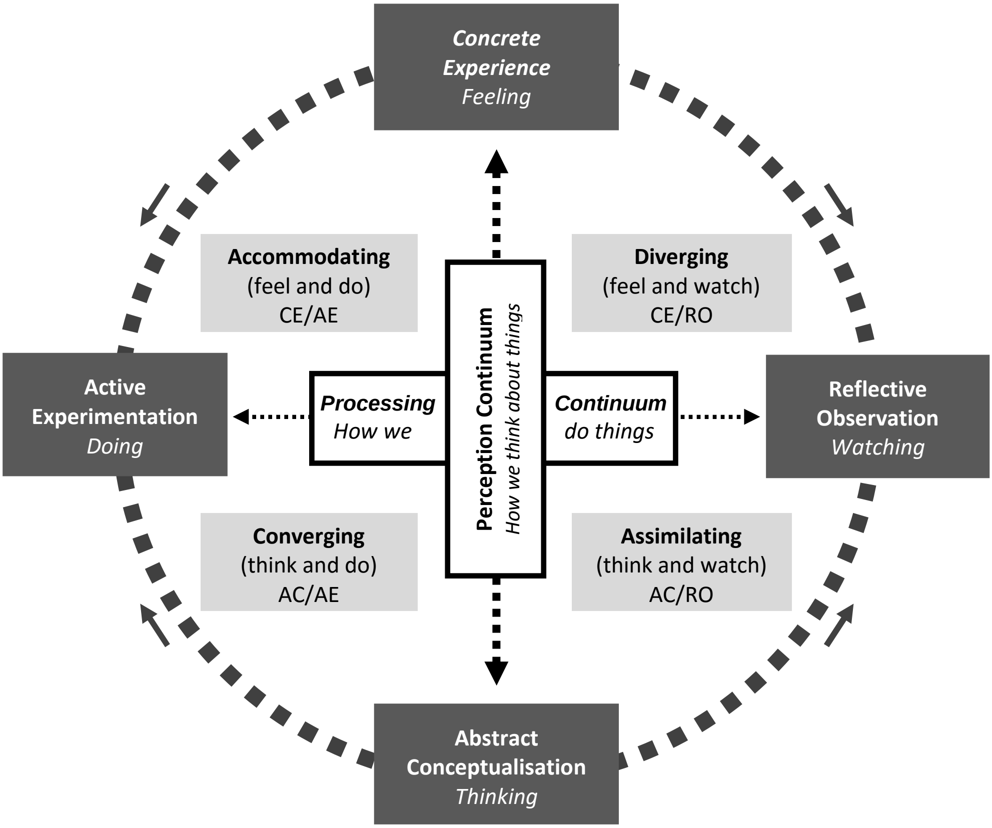

Fig. 5. The learning cycle by D. A. Kolb (Chiong, 2011), slightly modified

It is worth noting that Kolb discusses the learning styles, something that is not analyzed in the ML model. Thus, both theories may effectively support each other even in this respect. Unfortunately, the possible analysis, however promising, would probably go far beyond the limits of this single paper.

Conclusion

It is worth noting that the most important events underlying the motor behavior of living creatures, and especially humans, are liable neither to direct experimental verification, nor to simple mathematical description. In physics the situation is quite simple: the reactions are unambiguously assigned to specific stimuli (at least in statistical terms) and there is nothing between them. On the other hand, in motor control between a stimulus and response (no longer a sheer reaction!), there is information that has to be identified and processed.

As already mentioned, the only visible manifestation of all the internal processes is motion. So, it seems instructive to quote the following words of R. Dawkins: *Careful inference can be more reliable than "actual observation", however strongly our intuition protests at admitting it* (Dawkins, 2009: 15). As a consequence, the experimental methodology of scientific research, very effective in e.g. physics or chemistry, cannot be equally fruitful in biology (in a broad sense). Thus, in motor control the role of "careful inference", guided by a specific philosophy, has to be much more significant than in other branches of science. In other words, without "theoretical motor control" – even cultivated by scientists commonly labeled "daydreamers" – any significant development (and, all the more, progress) seems to be hardly possible at all.

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THE STRUCTURE OF PHYSICAL FITNESS AMONG YOUNG FENCERS (TRENDS OF CHANGES IN 2006–2013)

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Introduction

The increasingly high performance among athletes today causes coaches to have to meet more and more complex and more comprehensive requirements. Meeting these challenges calls for looking for solutions aimed at reasonable and effective preparation of athletes. Striving for achievement at a championship level has led to shifting the emphasis in coaching onto the period of youth and childhood (Raczek, 1991).

It is essential for top performance in any sport that an athlete has a particular level of comprehensive physical fitness. Consequently, this is reflected by the division of training processes into individual stages of comprehensive, sport-oriented and sport-specific training. The goal of the stage of sport-oriented preparation is to develop motor potential and equip a person in rich resources of motor skills oriented at sport-specific training in the future (Sozański, 1999). Constant verification of training effects helps coaches choose individual contents and load in programs for each athlete.

The training of children and young people is one of the most important stages and subsystems in coaching and determines future achievements of adult athletes (Ważny, 1981). The level of physical fitness determines effectiveness of coaching and development of technical skills, influences the effectiveness of tactical actions and has an impact on current psychical disposition of a person (Fraser-Thomas, Cote, Deakin, 2005; Sozański et al., 1985).

Physical fitness profile is dynamically developed over the entire period of growth. Therefore, it is largely determined by dynamic functions rather than static components of motor skills. From this standpoint, training in the period of intensive individual growth should be oriented at comprehensive improvement of the functions and transforming them into sport-specific physical fitness as the dynamics of natural body transformations slows down (Karpowicz, Strzelczyk, 2012; Kosendiak, 2012; Raczek, 1984; 1991; Sozański, 1986; 1999; Sozański, Adamczak, Siewierski, 2012).

Although undoubtedly true, the above postulates have often been neglected in sport practice. Furthermore, although coaches realize the importance of sport in stimulation of young athlete's development, they often go too far in intensification of load in particular directions in order to achieve the temporary effects. Thus, the process of sport training requires constant monitoring while the achievements might be one of the criteria for measuring progress (Ważny, 1981).

In light of the above, the aim of the present study was to identify the tendencies for changes in the structure and levels of motor effects among young fencers in 2006–2013 in the context of comprehensive development of functional, fitness-related and technical bases with respect to the requirements of specific training adapted as typical of oriented stages in coaching (Strzelczyk, Karpowicz, 2012).

Material and method

The study evaluated sport-talented young people from the Greater Poland Voivodeship who were members of the System of Youth Sports within the framework of the Voivodeship Junior Teams. The research material was collected from a survey that encompassed an 8-year time period (2006–2013). 254 young fencers participated in the survey. However, analyses included only the people with all the necessary test results. The number of cases analysed was 200 boys aged 15–16 years.

The survey was carried out as part of cooperation between Eugeniusz Piasecki University School of Physical Education in Poznań and the Greater Poland Sport Association. The measurements were made every year and the dates chosen were due to the temporal structure of training for young people in fencing.

The young fencers, who were a group of select players with best performance in the Greater Poland Voivodeship under the junior younger category, were exposed to both training load and competition load which is typical of this stage of training. The weekly training volume in the clubs ranged from 8 to 10 hours on average, with the number of battles played in the season ranged from 75 to 130 (depending on the sports level of the player).

The players included in the study took part in the training for the Voivodeship Junior Teams, focused on improvement in technical and tactical skills, were preparing for the finals of the National Youth Olympic Games.

The measurements focused on the level and structure of motor effects in the athletes studied. For this purpose, we used the International Physical Fitness Test (IPFT) (Rosandich1999) battery which included eight simple tests which were complementary enough to allow for a comprehensive evaluation of physical fitness. With its over 40-year history, IPFT has been widely used by numerous coaches and researchers who have used this non-complex method to evaluate the effective aspect of human motor activity (Szopa, Mleczko, Żak, 2000). IPFT battery is also recommended by the Ministry of Sport and Tourism in Poland as a tool for evaluation of physical fitness of young talented athletes.

Measurements of motor skills and flexibility were carried out according to the recommendations for the International Physical Fitness Test battery (Pilicz, Charzewski, 2004; Rosandich, 1999). Speed was evaluated by means of a 50-meter sprint test, also termed a short run (it evaluates locomotor speed); endurance of the girls studied was evaluated over a distance of 1000 metres (running endurance); flexibility: a 4 × 10 meter shuttle run with moving the block. Strength was tested with a standing long jump test (explosive power of lower limbs) and 30-second sit-ups (strength endurance of trunk muscles). Handgrip strength was tested by means of handgrip dynamometer, whereas upper limb strength and shoulder girdle strength were evaluated using a pull-up test on a bar. Trunk flexibility is an anatomical trait of a person, with standing trunk flexion test used to reveal the scope of vertebral column and hip joint movement.

All the procedures used in this study were approved by the Bioethics Committee at the Karol Marcinkowski Medical University in Poznań (Resolution no. 519/07).

Table 1. Standards for classification of physical fitness in IPFT (Drabik, 1997)

Physical fitness level	**Point range (regardless of age or sex)**
High	481 and above
Average	320–480
Low	319 and below

The results obtained in individual parts of the International Physical Fitness Test were converted into the scale of 0 to 100 points (calculated according to the T scale) depending on the chronological age of the subjects, which represents the main criterion in selection for training groups in children and youth sport at individual stages of coaching.

We also measured basic somatic parameters such as body height and weight and calculated BMI (Body Mass Index).

We used basic statistical methods for the analysis of the results. The following pieces of software were employed: Statistica 10 PL and Microsoft Office 2010. The statistics calculated included arithmetic mean, standard deviation, minimum and maximum. The results were normalized with respect to the mean and standard deviations. The significance of differences between mean results in individual years was evaluated using Tukey's honest significant difference (HSD) test (Stanisz, 2006).

Results

Basic statistical methods were used to analyse the results. We calculated arithmetic mean, standard deviation, minimum and maximum for each of the 8 examination dates. Statistics are presented in Table 2.

Table 2. Statistical characteristics of the results obtained for male fencers in consecutive years

Year		Body height	Body mass	BMI	50m run	Longjump	1000 m run	Hand gripstrength	Pull-ups	4x10 m run	Sit-ups	Standing forwardbend	IPFT score
		cm	kg	kg/m^2	pts.	pts.	pts.	pts.	pts.	pts.	pts.	pts.	pts.
2006	**N**	25											
2006	**Average**	174.3	63.2	20.7	59.4	57.2	52.8	62.1	43.7	61.0	59.7	54.8	450.6
2006	**Minimum**	159.6	39.5	14.9	44.0	42.0	37.0	35.0	10.0	48.0	49.0	34.0	358.0
2006	**Maximum**	186.5	79.0	26.5	76.0	84.0	62.0	99.0	65.0	70.0	71.0	68.0	542.0
2006	**Standard deviation**	7.2	10.4	2.7	9.8	11.4	7.1	20.9	11.0	5.7	6.1	9.3	53.4
2007	**N**	25											
2007	**Average**	169.5	55.3	19.1	56.1	54.1	51.1	50.2	42.0	60.5	54.4	53.6	421.9
2007	**Minimum**	155.0	39.0	15.0	36.0	35.0	39.0	28.0	10.0	41.0	36.0	33.0	294.0
2007	**Maximum**	190.0	79.6	22.7	78.0	74.0	64.0	73.0	75.0	73.0	68.0	73.0	516.0
2007	**Standard deviation**	8.9	10.1	2.0	8.2	10.0	7.1	12.6	18.9	7.8	8.4	10.1	59.4
2008	**N**	25											
2008	**Average**	171.6	59.3	20.1	56.3	53.9	55.0	47.5	45.2	60.1	58.3	56.0	432.3
2008	**Minimum**	152.3	42.4	16.0	29.0	34.0	40.0	33.0	10.0	47.0	45.0	38.0	324.0
2008	**Maximum**	184.2	80.0	27.1	64.0	69.0	63.0	63.0	65.0	68.0	76.0	78.0	501.0
2008	**Standard deviation**	8.0	7.8	2.5	7.4	8.3	6.5	8.0	14.6	5.3	8.6	10.0	40.1
2009	**N**	25											
2009	**Average**	174.3	63.4	20.8	58.0	51.9	54.0	47.7	35.2	60.3	60.3	56.3	423.5
2009	**Minimum**	159.8	49.1	17.9	40.0	31.0	37.0	31.0	10.0	48.0	49.0	29.0	299.0
2009	**Maximum**	185.4	81.2	25.2	68.0	65.0	65.0	65.0	56.0	68.0	73.0	77.0	510.0
2009	**Standard deviation**	7.4	9.0	1.9	6.7	8.9	7.0	8.9	17.4	6.4	6.7	11.0	53.4

2010	**N**	25											
	Average	174.0	63.0	20.8	57.2	50.3	53.1	49.8	38.7	58.8	56.4	52.0	416.3
	Minimum	165.0	51.0	15.9	31.0	30.0	26.0	35.0	10.0	39.0	20.0	30.0	284.0
	Maximum	189.0	81.0	26.2	74.0	99.0	67.0	77.0	56.0	73.0	75.0	74.0	561.0
	Standard deviation	5.3	7.5	2.3	7.5	12.5	8.4	10.0	15.0	6.9	11.5	9.5	53.9
2011	**N**	25											
	Average	176.0	62.0	20.0	56.0	57.9	55.2	50.8	46.4	65.8	56.0	54.6	442.7
	Minimum	157.0	43.8	16.3	33.0	42.0	43.0	38.0	10.0	55.0	43.0	34.0	380.0
	Maximum	191.0	76.3	25.8	64.0	68.0	66.0	69.0	59.0	72.0	73.0	72.0	502.0
	Standard deviation	7.0	8.0	2.1	7.2	6.9	5.7	8.4	10.6	4.2	8.2	10.4	35.5
2012	**N**	25											
	Average	175.9	63.5	20.5	56.7	54.9	49.0	49.2	42.6	62.8	58.1	53.0	426.2
	Minimum	161.0	48.2	16.7	43.0	40.0	37.0	38.0	10.0	54.0	47.0	34.0	336.0
	Maximum	184.0	96.3	30.4	72.0	73.0	63.0	63.0	62.0	69.0	68.0	72.0	489.0
	Standard deviation	5.8	9.7	2.6	6.7	8.6	7.4	7.3	15.5	4.3	4.8	9.6	41.0
2013	**N**	25											
	Average	174.2	58.9	19.3	52.0	55.9	47.2	48.3	38.2	61.6	54.2	55.2	412.6
	Minimum	160.0	43.6	15.8	36.0	40.0	26.0	34.0	0.0	47.0	38.0	38.0	320.0
	Maximum	187.0	71.3	23.3	63.0	67.0	57.0	69.0	65.0	70.0	64.0	73.0	477.0
	Standard deviation	7.0	8.6	2.0	7.5	7.6	9.1	9.0	22.2	5.6	6.7	10.1	44.2

Analysis of differences between mean results obtained in 2006 and 2013

The first step was to analyse the significance of differences between mean results. This was achieved using the Tukey's honest significant difference (HSD) test. The results of the calculations are presented in Table 3.

Table 3. Significance of differences between mean results obtained by subjects in consecutive years (Tukey's honest significant difference test)

	Body height	Body mass	BMI	50m run	Longjump	1000 m run	Hand grip-strength	Pull-ups	4x10 m run	Sit-ups	Standing forward-bend	IPFT score
	cm	kg	kg/m2	pts.	pts.	pts.	pts.	pts.	pts.	pts.	pts.	pts.
Average 2006	174.3	63.2	20.7	59.4	57.2	52.8	***62.1***	43.7	61.0	59.7	54.8	450.6
Average 2007	169.5	55.3	19.1	56.1	54.1	51.1	***50.2***	42.0	60.5	54.4	53.6	421.9
Difference	-4.8	-7.9	-1.6	-3.3	-3.1	-1.7	***-11.9***	-1.7	-0.5	-5.4	-1.4	28.7
Significance	0.368	0.083	0.319	0.845	0.969	0.995	***0.012***	0.999	0.999	0.393	0.999	0.535
Average 2007	169.5	55.3	19.1	56.1	54.1	51.1	50.2	42.0	60.5	54.4	53.6	421.9
Average 2008	171.6	59.3	20.1	56.3	53.9	55.0	47.5	45.2	60.1	58.3	56.0	432.3
Difference	2.1	4.0	1.0	0.2	-0.2	3.9	-2.7	3.2	-.04	3.9	2.4	10.4
Significance	0.965	0.765	0.756	1.000	1.000	0.547	0.988	0.996	0.999	0.644	0.989	0.995

Average 2008	171.6	59.3	20.1	56.3	53.9	55.0	47.5	45.2	60.1	58.3	56.0	432.3
Average 2009	174.3	63.4	20.8	58.0	51.9	54.0	47.7	35.2	60.3	60.3	56.3	423.5
Difference	2.7	4.1	0.7	1.7	-2.0	-1.0	0.2	-5.0	0.2	2.0	0.3	-8.8
Significance	0.910	0.701	0.982	0.996	0.997	0.999	1.000	0.402	1.000	0.992	1.000	0.998
Average 2009	174.3	63.4	20.8	58.0	51.9	54.0	47.7	35.2	60.3	60.3	56.3	423.5
Average 2010	174.0	63.0	20.8	57.2	50.3	53.1	49.8	38.7	58.8	56.4	52.0	416.3
Difference	-0.3	-0.4	0.0	-0.8	-1.6	-0.9	2.1	3.5	-1.5	-3.9	-4.3	-6.8
Significance	1.000	1.000	1.000	0.999	0.999	0.999	0.998	0.996	0.992	0.720	0.838	0.999
Average 2010	174.0	63.0	20.8	57.2	50.3	53.1	49.8	38.7	***58.8***	56.4	52.0	416.3
Average 2011	176.0	62.0	20.0	56.0	57.9	55.2	50.8	46.4	***65.8***	56.0	54.6	442.7
Difference	2.0	-1.0	-0.8	-1.2	7.6	2.1	1.0	7.8	***7.0***	-0.4	2.6	26.4
Significance	0.983	0.999	0.927	0.999	0.123	0.977	0.999	0.727	***0.002***	1.000	0.986	0.575
Average 2011	176.0	62.0	20.0	56.0	57.9	55.2	50.8	46.4	65.8	56.0	54.6	442.7
Average 2012	175.9	63.5	20.5	56.7	54.9	49.0	49.2	42.6	62.8	58.1	53.0	426.2
Difference	-0.1	1.5	0.5	0.7	-3.0	-6.2	-1.6	-3.8	-3.0	2.1	-1.6	-16.5
Significance	1.000	0.999	0.996	0.999	0.963	0.078	0.999	0.993	0.670	0.987	0.999	0.941
Average 2012	175.9	63.5	20.5	56.7	54.9	49.0	49.2	42.6	62.8	58.1	53.0	426.2
Average 2013	174.2	58.9	19.3	52.0	55.9	47.2	48.3	38.2	61.6	54.2	55.2	412.6
Difference	-1.7	-5.4	-1.2	0.3	1.0	-1.8	-0.9	-3.6	-1.2	-3.9	2.2	-13.6
Significance	0.995	0.690	0.7256	0.488	0.999	0.994	0.999	0.985	0.998	0.756	0.996	0.985

* denotes significant differences at $p \leq 0.05$

Analysis of the significance of differences between mean results obtained in consecutive years shows that statistically significant differences occurred between the years 2006 and 2007 (in handgrip strength) and between 2010 and 2011 and concerned the level of agility.

No statistically significant differences in somatic build variables were found between the teams studied in individual years of the study.

Analysis of differences in fitness tests revealed lower level of overall fitness, expressed by the total of points scored in IPFT by the young athletes tested in 2013. However, the difference was not statistically significant. It is remarkable that the girls obtained lower results in 6 of 8 tests compared to the members of the Voivodeship Junior Teams in 2006.

Analysis of trends of changes in mean results obtained in 2006–2013

Assuming that changes in the results that occur over the time period studied might exhibit a uniform pattern (which was reflected by the differences between individual years, see Table 2), the next stage of the study was to attempt to identify certain trends in the level of the parameters studied.

Using the least squares method, we matched a polynomial model of the first or second order to the pattern of changes that occurred. The results of the analyses are illustrated in the respective diagrams (Figs 1–12).

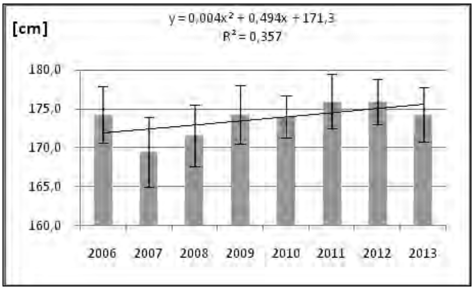

Fig. 1. Trends of changes in mean body height

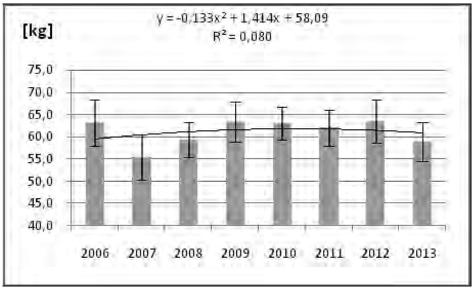

Fig. 2. Trends of changes in mean body mass

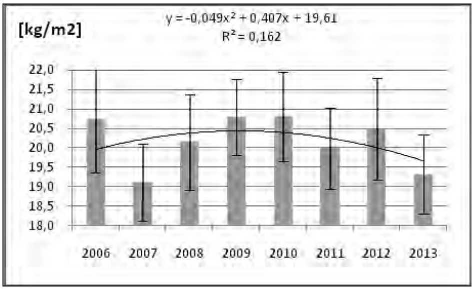

Fig. 3. Trends of changes in mean BMI

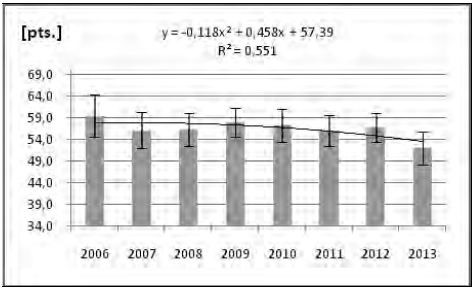

Fig. 4. Trends of changes in mean 50-meter sprint scores

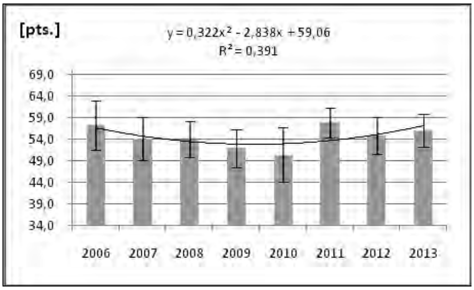

Fig. 5. Trends of changes in mean long jump scores

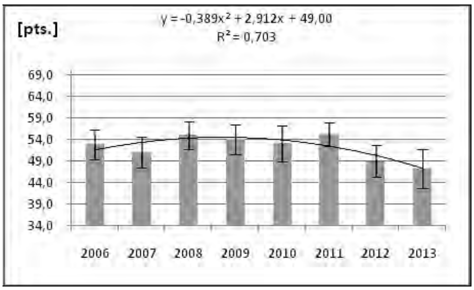

Fig. 6. Trends of changes in mean 1000-meter run scores

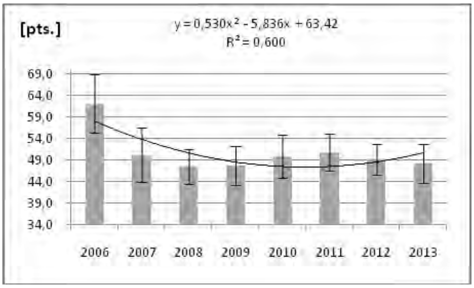

Fig. 7. Trends of changes in mean handgrip strength test scores

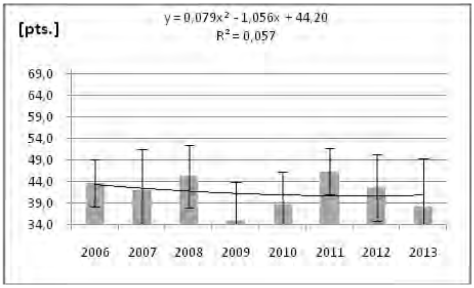

Fig. 8. Trends of changes in mean shoulder strength scores

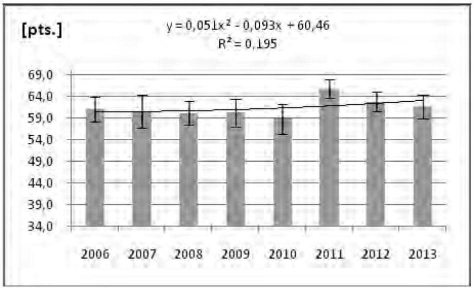

Fig. 9. Trends of changes in mean 4 x 10 shuttle run scores

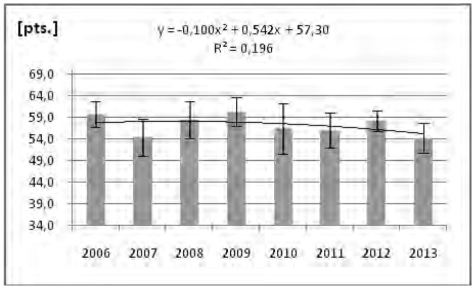

Fig. 10. Trends of changes in sit-up test scores

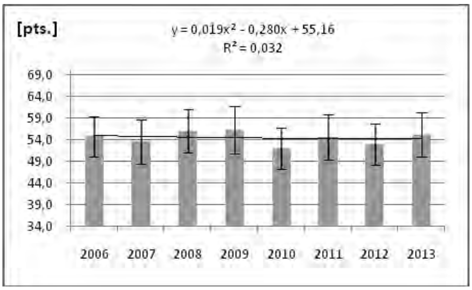

Fig. 11. Trends of changes in trunk flexion test scores

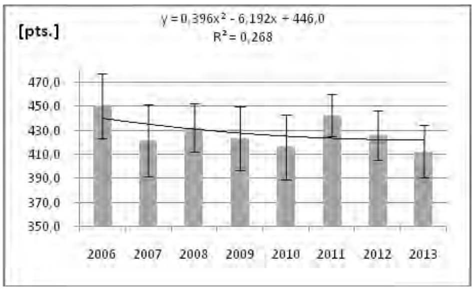

Fig. 12. Trends of changes in total results obtained in IPFT

Regarding morphological variables, a constant increase in body dimension in the male fencers studied was observed. The height of the body shows a continuous upward trend. (Fig. 1).

Changes in body mass, however, showed a different pattern, with a significant increase at the beginning of the period of the study and then the increase being not as sharp later on (Fig. 2).

Consequently, the above variations in body height and mass affected BMI, with its value providing information about weight-height ratio, was thus the indicator of a slimmer (lower values) or more obese (higher values) body build (Fig. 3).

In the running speed test, the highest mean value of the results was obtained in 2006. In subsequent years, the level of this property initially stabilized, but the trend line indicates a steady decline. Consequently, in the last 50m time trial run the test score reached the lowest level (Fig. 4).

A gradual decline was observed to 2010 in the results obtained from the long jump test. In subsequent years, there was an upward trend. However, the power level of the leg strength studied fencers in 2006 and 2013 are comparable (Fig. 5).

The average results obtained in the trial run for 1000 m tend to decrease the possibility of endurance in tested fencers. After the initial increase, subsequent years showed a decrease in endurance (Fig. 6).

The diagram that illustrates changes in the results obtained during handgrip dynamometer show an initial decline in the level of this parameter. In the following year this value rose and remained at the same level for two years, followed by a renewed decline in the final two years (Fig. 7).

The chart that illustrate changes in the results of shoulder strength reveals a decline over the entire period of the study. Although fencers surveyed in 2008 and 2011 obtained scores higher than their peers before, further research terms refer to a downward trend. Generally, the level of the characteristics of the fencers over subsequent years was very low (Fig. 8).

Changes in the results obtained in the shuttle run test were insignificant. An insignificant reduction in the level of flexibility was observed in the first half of the period of the study. The following test dates showed the results obtained by fencers similar to those obtained atthe beginning of the study (Fig. 9).

The results of the sit-up test showed a steady decline. Consequently, the young fencers examined in 2013 were characterized by a considerably lower level of abdominal muscle strength compared to their peers years ago (Fig. 10).

With regards to flexibility, a slight downward tendency in this parameter between the first and last date of study was recorded. In subsequent years, the average results of the trunk flexion fluctuated (Fig. 11).

The finalchart illustrates the total results for all the tests included in the International Physical Fitness Test battery. Despite certain variations in the level of overall fitness, the entire period of the study exhibits a declining tendency. It is worth noting that in the classification of physical fitness proposed by the Drabik (1997) the studied fencers showed average levels of fitness (Fig. 12).

Discussion

The stage of oriented training in sport is a specific period in human development, which coincides with the high sensitivity of the human body to external stimuli. It is impossible to develop young people's aptitudes through training based on the methods used in adult populations and consequently to neglect the postulate of comprehensiveness that promotes long-term sport-specific development, as it exceeds the adaptive capabilities of young athletes. From the biological standpoint, the training load used should reflect the developmental age. It should be stressed that if the training load is not based on the principle of individualization (with the main postulate being selection of the load appropriately to the athlete's capabilities), it ceases to have a positive effect. Furthermore, if continued over an extended period of time, an inadequate training load might cause developmental disturbances and become a traumatic factor that might cause overtraining and fatigue. Therefore, excessive training load with sport-specific exercises started at a young age is undesirable. Although using such stimuli allows young athletes to become quickly accustomed to them, the adaptive mechanisms present in the growing human body are substantially depleted. Consequently, some talented athletes depart from sport prematurely, due to numerous injuries (Hirtz, Starosta, 2002; Naglak, 1995; Sozański, 1986).

Regarding the physical fitness of athletes from the standpoint of long-term observation, the tendencies typical of general population should not be neglected.

The phenomenon of temporal variability of motor development caused by environmental factors has been thoroughly researched. Therefore, one of the directions of the research studies on physical fitness is the analysis of changes in motor development that occur between generations. Multiple studies have demonstrated a negative trend with increasing regression (Dobosz, 2007; Jarosz, 2006; Malina, Bouchard, Growth, 1991; Przewęda, Dobosz, 2007; Raczek, 2001; Tatarczuk, Asienkiewicz, 2001). The interpretation for these changes can be also found in the categories of development of a new fitness profile as a consequence of technological advances and, consequently, changes in lifestyles. The latter involves new systems adopted by young people, including the preferred model and dimension of motor activity.

The results of population studies can provide background for the observation of specific groups in different sports, such as fencing. On the basis of the literature (including studies by Czajkowski and Brola) Borysiuk (2005) has stated that the role of the overall efficiency decreases in subsequent stages of training. The its greatest importance falls on the initial step, which seems obvious. The author claims that results in fencing depend mostly on technical and tactical skills and mental preparation on the basis of the efficiency-oriented. Psychomotor skills and practical application are considered particularly important in fencing training exercises concerning honing ability as well as speed and improving mental processes.

Analysis of the results obtained from young fencers in consecutive years demonstrated that physical fitness evaluated by means of the International Physical Fitness Test battery on consecutive years is decreasing. These findings confirm the above mentioned regressive trend of intergenerational changes. This seems logical, especially because the group studied were selected from the population, that the changes should reflect the changes which are typical of the general population. However, one could expect that subjects belonging to the group of increased physical activity would gain higher than average results in the physical fitness test.

The causes of these phenomena might lie in changes in weight-height proportions that lead to an increase body stoutness, which was most noticeable in the studies conducted in 2009 and 2010. With regard to population studies, this reflects the trend of increasing body mass in children and young people observed in recent years, in which overweightness and obesity can be observed (Dobosz, 2007; Jarosz, 2006; Karpowicz, Karpowicz, 2013).

The findings of the present study may partially support the view proposed by Przewęda (1999), concerning the structure of physical fitness of the young Polish population. Przewęda argued that if the trends of changes continue, speed- and flexibility-oriented types will be favoured over those strength-based. With regard to the young male fencers studied, this theory has reference mainly to agility. In the shuttle-run test participants received the highest scores of all the tests and the results were clustered at around 60.0 points. In two anaerobic trials, the 50 m run and the standing long jump, results formed a range of about 59.0–54.0 points, and thus were at a relatively low level, although higher than the results of other trials. Such results confirm Borysiuk (2005), who indicates a predisposition to the anaerobic efforts of fencers among the five characteristics that affect performance in fencing.

Physical capacity in young people represents an essential problem as one of the components of physical fitness. Changes in the course of development, which have been observed over recent years, show a progressively negative trend (Przewęda, Dobosz, 2007).

Some premises might suggest a confirmation in this unfavourable trend in the groups of young athletes studied. Over the period of eight years an insignificant decrease in stamina was observed despite the reduced levels recorded in the penultimate date of examinations. Obviously this is a disadvantage from the standpoint of the demands of fencing as a sport of combined endurance and speed nature. Many authors point to the high values of VO^2 max in top fencers at approximately 50.0 mL • kg • sec-1 in women and about 55.0–60.0 mL • kg • sec-1 in men (Bottoms, 2011; Koutedakis et al., 1993; Nystrom et al., 1990). Borysiuk (2005) confirms the high ceiling of oxygen levels in the top young Polish athletes from the Silesia region. The author concludes that the fencers presented a similar level of capacity as athletes in other endurance discipline, however this is the result of specialized fencing training, control fights and tournaments. In this case capacity is not an object of separate training but only the "side effect" of specialist training, which may provide poor performance in endurance running. The authors cited above point to the need to include in fencing training both aerobic and anaerobic loads.

Although dissimilar in its nature, another important issue is the level of flexibility recorded in the groups studied. In many sports, including fencing, the development and maintainence of the level of this skill is often neglected and coaches seem to forget that it has a substantial effect on the effectiveness of movements and also helps to prevent injuries.

Most of time of the training process in various sports is spent on the improvement of technique and tactics. Development of motor skills is often achieved as a by-product of specific training, but general physical fitness represents a solid foundation for development of technique and tactics, thus making it necessary to train motor skills (abilities) separately (Wachowski, Strzelczyk, 1991).

Conclusions

1. The overall physical fitness of young male fencers who participated in the study, evaluated using the International Physical Fitness Test, was found to decline year by year. On the one hand, this might have been caused by the tendencies for regression in motor modifications across generations that have been observed among populations.

2. The essential decline we observed in strength (connected with overcoming the athlete's own body resistance) is likely to be due to the above changes in body build. Therefore, it seems that it cannot be used as evidence to confirm the current views of the decreasing percentage of strength-based types in the structure of physical fitness of young people.

3. A substantial decrease in endurance in the period studied can be viewed as a negative trend from the standpoint of fencing requirements

(pointing to some neglect training) and also in the broader context of reversing the negative tendencies among younger generations to present reduced physical fitness.

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IMPORTANCE OF MOTOR ABILITIES IN FENCING

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Introduction

Fencing is a combat sport in which two competitors fight against each other indirectly using a weapon (Roi, & Bianchedi, 2008). Its main purpose is to hit (in fencing referred to as to touch) the opponent with simultaneous avoidance of the opponent's touches. Competitions are mainly held inside a sport hall. Both male and female competitors use one of three types of weapon: épée, foil and sabre. The first two weapons are exclusively the piercing ones by means of which opponents only thrust (the end of the weapon touches a valid target of the opponent). On the other hand, a sabre is a bladed-piercing weapon and touches are performed by means of cutting as well as thrusting (although cutting provides a distinct advantage). Competition in fencing takes place individually and in teams. In the individual tournament, competitions are divided into two parts: group qualification and direct qualification. In the group qualifications opponents fight up to five touches, or four touches in the category of juniors and younger juniors, which determines the time of a fight. Maximally, a fight may take two or three minutes after which the duel is considered to be finished. Direct qualification fights are performed up to 15 touches or 12 touches depending on the age category. Cup competitions last 3 x 3 minutes with one-minute break between rounds or shorter 3 x 2 minutes in younger age categories.

Fencing fights take place on a limited strip of metalized material called a fencing board, or piste (Fig. 1). According to FIE regulations, its size is as follows: width – 1.5–2 m, length – 14 m.

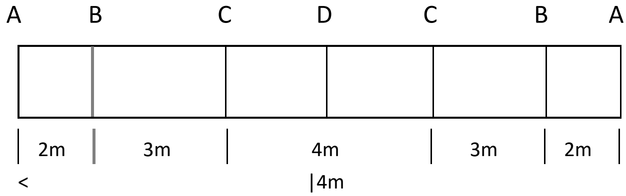

Fig. 1. Fencing board

Fencing combats are judged by means of electric apparatus which registers touches or cutting on the basis of closing the electric circuit. In foil combats it signalises touches on a valid target (colourful light) and an invalid target (white light). Its introduction revolutionised fencing and made it easier for the judges to determine the fight. In sabre combats the electric apparatus was introduced in 1936 in foil combats in 1956, and in sabre combats in 1988. These modernisations resulted in rapid changes of fencing technique (Roi, & Bianchedi, 2008). In a later part of the study we shall focus on the description of issues connected with one of these competitions, the foil.

The weapon used in the foil discipline consists of a blade (pommel, iron), a crossguard (quillons) and a handle. The blade is conventionally divided into three parts: near-crossguard, central and final. It is ended with a knob whose pressing during thrusting closes the electric circuit and registers touching by means of a referee's apparatus. A foil handle occurs in two variants, i.e. a French one (simple shape) and Belgian (anatomic, pistol shape). The French handle is particularly often used in the process of teaching fencing techniques at the preliminary stage; in tournament combats the contestants mostly use a handle with the anatomic shape. The maximum length of a foil is 110 cm and its mass should not exceed 500 g. In lower age categories shorter blades are used such as 0, 1, 2 thanks to which foils are lighter and they can be more easily used by children when practising fencing.

The particular categories (sabre, épée, foil) in fencing differ due to the valid target of touching. In the foil combat, both in the case of men and women, constitutes a valid target. Specifically, this consists of, at the front, 6 cm from the base of the neck, then on the sides passing the heads of humeral bones along the lines of sleeve seams, then downwards to a horizontal line on the back passing the tips of the hip bones, then back to the front and from there in straight lines converging in the groin flexures. In the foil combat, touches beyond valid areas are considered to be invalid, and landing touches in this area result in cancellation of the next valid touch (Czajkowski, 1984). The valid target area in the foil is limited by a metalized jacket which a player is obliged to wear throughout the fight. The bib of the mask (up to the mask mesh line) also constitutes a valid target area. During the foil fight it is forbidden to cover the valid target area by any part of the body which does not constitute a valid part of the target area. In practice, we can often observe an offence in the form of covering the target area by a shoulder or unarmed hand. For this kind of the offence the referees are obliged to punish a contestant using a penalty card. Two penalty cards which are received in one fight result in receiving a penalty touch.

The particular weapons differ from each other in the rules concerning awarding points in the situation when both fencers land valid touches at the same time.

In sabre and foil so called convention are obligatory, i.e. contractual rules of conducting the fight and awarding points. This means that the offensive fighter's attack has a priority in relation to the counterattack. The offensive loses its priority at the expense of the cover and the return attack which follows it immediately. A cover means removing the tip of the opponent's blade from the line of one's own target area.

Significance of features and psycho-physical abilities in fencing

Independent of the weapon they use, fencers are characterised by very high mobility. During one fight players cover a distance from 250 to 1000 m with fencing steps and the duration of the whole tournament may reach up to 11 hours (Iglesias, & Reig, 1998). During a tournament players remain on standby and attempt to keep their bodies in 'warm-up' condition. In fencing most of the energy is delivered in the creatine phosphate system (90%) and the remaining part in the glycolytic system (Dal Monte, 1983). Fencing fights are often stopped by referees. For example, in a foil fight one action lasts approximately five seconds (Roi, & Pittaiuga, 1997). According to Choutka (1987) fencing belongs to a group of combat sports in which the opponent is defeated by technical, tactical and physical means. According to the same author, in fencing there are a great number of motor skills, highly complex motor structures and a substantial variety of actions. During fights energy expense is low or medium and the cardio-respiratory system is subjected to various loads – from small to maximum. In a fencing fight aerobic effort is at a medium level, whereas anaerobic effort is at a high level. A fencing fight also requires high volitional activity, mastery of aggression, quick decisiveness, anticipation and dominance (Choutek, 1987). During the fight, independently of the weapon used, players move continually along the board, perform a lot of various forms of specialised leg work (advances, glides and throws) and quickly respond to changing tactical situations. Fencing is a type of sport with variable intensity of effort. In the fights there are phases with very high and medium intensity as well as phases of rest (Sobczak, & Smulskij, 2009). In each fight there are preparatory actions which are less intensive as well as much more intensive elements connected with performing various actions of an attack.

The heart rate (HR) of fighting female fencers in the category of younger juniors oscillates between 160 and 190 per minute (own research). The time of the fencing duel amounts to three minutes of pure fighting or 3 x 3 minutes, but after each fight the duel is stopped. A feeling of tiredness is to a large extent intensified by fencing clothing and a relatively heavy mask.

In modern fencing, we can observe a continuous increase of the significance of fitness preparation for fights. Endurance abilities are indispensable for a player to be able to take part in tournaments lasting many hours and in order to participate in year-round training programmes with full commitment. Force, and in particular breakaway force, is invaluable both in leg work and in achieving high dynamics of actions such as advances, pushes and throws. Speed is also a key ability which is necessary to move dynamically on the fencing board and to perform simple and complex movements in the shortest period of time. Some of these abilities are determined genetically (Gronek, & Holdys, 2013), others are developed via environmental influences.

According to Czajkowski (2004), right-handed and left-handed players, of tall or of medium height, careful, venturesome as well as representatives of various fencing schools can become fencing champions (Czajkowski, 2004). However, according to the opinions of both coaches and researchers, some features are conducive to achieving successes in fencing. Left-handed players are in the minority and they are accustomed to confronting right-handed players, therefore they have a strategic advantage. As a consequence, we can observe a relatively high number of finalists and medallists of championships in fencing who wield a weapon with their left hands (Voracek, Reimer, & Ertl, 2006).

Many researchers point to the role of coordinating and psychomotor abilities or psychical features which is decisive in sports such as fencing (Starosta, 2003; Ljach, 2003; Borysiuk, 2002; Czajkowski, 1991; 1994; 2007; Raczek, & Ljach, 1995; Raczek, Młynarski, & Ljach, 2003; Ryguła, 1998; Tomczak, 2010).

Fencing belongs to a group of sports with open habits and although motor abilities do not constitute a component part of the motor habit, it is obvious that it is impossible to work out any motor habit without a certain level of motor abilities (Czajkowski, 1991). Motor abilities constitute a foundation for further shaping of the technique and tactics in many types of sports (Wachowski, & Strzelczyk, 1991). According to Czajkowski (1991), motor habits in sport activities always occur along with motor abilities formed in their cohesive and functional entirety. Fencing has always been a sport which has demanded very fast perception and accurate as well as quick movement responses. Fencing is also a sport with a great number of open habits (external) of the cognition-movement type. A good fencer should be characterised by excellent motor coordination which is manifested first of all in movement memory and movement management. Movement adaptation, including rapid movement resourcefulness, also constitutes an important feature (Czajkowski, 2004).

Research on significance of motor abilities in fencing

Research has examined various aspects of fencer's abilities and the conditions of competition combat as influencers of fencer's progress and rank. Steward et al. (1977) found significant correlation of VE max (maximum ventilatory uptake), $\dot{V}O_2$ max (maximum oxygen uptake), 2 km run, and body weight with fencing success over the whole season. Although endurance is one of the factors determining success in fencing over the duration of the whole season, in the training process long distance running ought to be avoided as runs counter to the characteristic of a fencing fight composed of short bouts and quick changes of tempo. In a more recent study (Tsolakis et al., 2010) on structural correlates of fencing performance it was found that lunge time was best predicted by drop jump and tight cross-sectional area and squat jump on the shuttle test. The both parameters were also determined by Lean Body Mass. In another research, examining parameters of fencing lunge (Sannicandro et al., 2010), statistical differences were observed between male and female fencers in peak concentric force and ground reaction force indicating a need for adjustment of muscle conditioning to reduce this functional asymmetry. However, since simple movements are a part of global movements in fencing, they should not be assessed in isolation. Other research results show that performance is higher in the expert group of fencers when the task is performed in the sequential touché + lunge condition (Yiou, & Do, 2000).

In some studies concerning the functioning of the nervous system reaction time (RT), movement time (MT); total response time (RMT); and accuracy were studied (measured by EMG) under a dual response paradigm requiring a full lunge (Williams, & Walmsley, 2000). Although elite fencers had lower MT, their faster RT resulted in significantly shorter total response times. Elite fencers showed more muscle synergies and consistent patterns of muscle coordination. Similar findings were confirmed in another study (Borysiuk, 2006) which found elite fencers quicker in RT, MT and in RMT, when compared to novice ones.

In a study to establish the level of motor parameters of Polish cadet elite fencers aged 14–16 (Rokita et al., forthcoming) three tests were used: 2 hand test (from Vienna Test System) for precision accuracy and time managing, five-time shuttle run to gates test for special orientation, and 2 m run test for reaction times. Anthropometrical parameters were also analysed. On the basis of the analysis of anthropometric measurement results and the level of abilities requiring fast activeness of the nervous system, i.e. reaction time, quick reaction or hand precision, it was concluded that there was no significant differentiation between girls and boys. On the other hand, differentiation as regards sex was found in the obtained results of the trial determining the level of spatial orientation. A statistically significant difference between the obtained results was also observed in the trial '2m run' in relation to the age of the subjects. Differences in controlling and regulating coordination movements are probably connected with disorders in body proportions and muscle mass which occur in this period (puberty) (Ljakh, 2003; Gierczuk, 2012; Hirtz, & Starosta, 1991; Domaradzki, & Ignasiak, 2009). However, muscle mass development makes it possible to release more power, which may influence the speed of movement and therefore, in the research it was ascertained that there was a certain relation between the body mass of subjects and the time of movement over a short distance of 2 m. Disorders in the proportions of body mass and muscle mass, which occur during the period of puberty, probably result in changes in coordination and they also may have an influence on reaction times in the case of young fencers.

An analysis of the regression model (linear, step) showed that a particular place in a sport's ranking had the strongest connection with the level of spatial orientation (Beta = 0,50) and hand precision in '2Hand test' in Vienna Test System (Beta = 0,64) as well as with the calendar age (Beta = 0,56). The quality of prediction of these relations is evidenced by R – square (R^2). The higher the ratio, the higher the power of relations between variables – this fragment is used in the description of statistical methods (Table 1).

According to Starosta (2003), coordination is a 'super feature' which appears as the ability to integrate other motor activities and constitutes an external manifestation of the central nervous system actions. The performance of each movement is possible due to the following smooth cooperation of the movement apparatus and the central nervous system. The very notion of movement coordination includes a number of properties such as agility (ability to move the body precisely and quickly), dexterity (manual movements of arms), a sense of time and space, and a sense of movement (movement memory). The dispute concerning its categorisation as a motor predisposition (Szopa, Mleczko, & Żak, 1996) or as a motor ability (Raczek, 1986; Osiński, 2003) has been going on for many years. Therefore, in this context it is difficult to expect unequivocal conclusions in the near future.

Table 1. Results of linear regression analysis model with tested variables as predictors of cadet fencer place on the national ranking list

Results of linear regression analysis	Beta	p (value)	R^2
Age	0.5572	0.0275	0.2518
Spatial orientation average time	0.4983	0.0046	0.4947
Hand precision – number of mistakes	0.6407	0.0015	0.6346

Movement coordination is an exceptionally important element of training for fencers. The richer the choice of technique elements a given type of sport has, the greater its significance is. A high level of movement coordination development facilitates the process of achieving significant sport success, particularly in such technical sports as rhythmic gymnastics, acrobatics, figure skating, team games or combat sports. Its level also depends on the following factors: condition and level of the nervous system efficiency, motor aptitudes, previous experiences and movement skills (and sports skills) as well as the ability to form movement ideas and take advantage of movement memory.

The research conducted for this paper has proven the significance of coordination ability level and experiences in achieving a particular position in a sport's ranking. The knowledge and determination of spatial orientation movement level or the speed of movement, time of reaction and eye-hand movement coordination at various stages of sports training enable better determination of means and methods of motor preparation in the long-term training process, which contributes to a more effective and faster achievement of sporting success. In turn this determines the place in a given sport's ranking that a player reaches. For example, on the basis of their research, Torun, Ince, Durgun (2012) suggest enriching fencers' basic training programmes with speed training in order to improve the reaction times of the upper and lower limbs (as one of the components that are manifested in coordination motor abilities).

On the other hand, in boxing – a sport that requires a similar repertoire of tactical activities (attack-counterattack, defence-guard) undertaken in dynamically changing circumstances of a fight – an experimental training programme for young boxers (Ashker, 2012) yielded positive effects. One training group was enriched by introducing diverse training consisting of movement tasks, whereas the other group was trained in accordance with an old scheme consisting of repeating simple elements of motor activities. A statistically significant improvement of efficiency both in motor activities, as well as in complex technical skills and their use in fight conditions, were observed in the experimental group. However, according to other research (Laborde et al., 2012) on individual sports (on the example of table tennis), the need to take into consideration emotional intelligence in training, as well as the educational and cultural experience of individual players, was also emphasised. A high level of these parameters provides more frequent opportunities for athletes to learn to cope with the situation of sport competition stress in a more efficient way.

Research led by Nuri et al. (2013) with the use of speed anticipation and reaction time test based on visual and auditory complex choice reaction time indicated some statistical differences in auditory reaction time between sprinters and team sport players, and the letter ones were significantly better in anticipatory skills. No significant differences were found in visual choice reaction time tests. It was concluded that athletes have greater sensory-cognitive skills, both open and closed, related to their specific sport domain. Determination of spatial orientation or motion speed, reaction time or eye-to-hand coordination at different stages of sporting careers allows coaches to better select appropriate measures and resources used in motor preparation over long-term training processes. Consequently, this may help fencers develop faster and more effectively, which is then reflected in the position in national rankings.

Summary

It can be stated that in terms of motor characteristics fencing is considered a predominantly anaerobic sport requiring explosive high power movements and mastered coordination. It is reaction time and time of the whole fencing action (especially in response to the opponent's action), movement precision and special orientation that determine achievement of the highest performance level among fencers. Together with such psychological attributes as focus of attention, the enables a fencer to undertake the appropriate course of action against an opponent in the limited space of a fencing piste.

Fencing requires good physical preparation from players. In spite of the short distances that a player covers during the fight, the total time of its duration requires manifestations of endurance from players which is specific for a sport that is characterised by maintaining a state of stimulation of the player's central nervous system. As well as these energetic predispositions, it is also necessary for a player to perform movement activities accurately and efficiently. Therefore, physical abilities ought to work together with coordination abilities which are responsible for the regulation and control of movements.

A substantial diversity of actions during fencing fights and the very complex movement structures revealed in this sport require a high level of coordination abilities and the presence of indispensable mental features, as well as anthropometric parameters, in order to achieve success. A considerable increase in the level of physical and coordination abilities in fencers, along with a harmonious physique, contributes to an improvement in their physical efficiency. It should also be noted that these abilities are connected to each other and according to Starosta (2003: 110) "due to increasing a level of coordination abilities, it is possible to obtain the increase in fitness abilities". This dependency also has to be taken into consideration in the case of unfavourable changes which might hinder the achievement of sporting success.

The the example of fencing, the ability to react quickly plays a decisive role in achieving top results. According to Poliszczuk and Lampkowska (2007), experienced fencers recognise their opponents' actions due to such preliminary intentions as tension of a shoulder girdle or extension of a knee as preparations for action. However, they emphasise that the tougher the opponent, the tougher it is to recognise his or her intentions and consequently, it is harder to prepare defensive actions. During actions in dynamically changing conditions in combat sports, complex reactions clearly appear more often. However, when observing fencers' fights, it must be noticed that taking advantage of such a simple reaction becomes more and more significant. This assumption can be confirmed by the actions of fencers in the final stage of a duel, in which one single touch decides who wins a competition. Poliszczuk and Lampkowska (2007) emphasise that the performance of a complex action brings a high risk, whereas making a simple attack after a signalled opponent's fault might be very surprising and much more efficient.

During the fencing bouts, the handedness of players is of great importance. Left-handed participants have a strategic advantage over right-handed opponents, which is often manifested in the result. The current state of knowledge makes allows us to assume that functional dominance of one hand over the other determines a high level of movement precision and leads to achievement of a higher level of efficiency (Bogdanowicz, 1991).

Success in fencing also depends on the level of presented movement skills and how they are used in task situations as well as on the numerous emotional processes which occur in a player before and during a fight or tournament.

Taking all of the above into account, training programmes prepared for fencers ought to take into account the biological, especially genetic heritage (Gronek, & Holdys, 2013), motor, mental, social and intellectual development of persons as well as differentiations as regards sex and differences in sports experience. These programmes ought to be characterised by individualisation in the training process at each stage of the training programme.

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SPEED-RELATED DETERMINANTS OF SPECIALIST SKILLS IN YOUNG FEMALE FOIL FENCERS

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Introduction

Modern sport imposes increasingly demanding motor training requirements on all athletes, regardless of their practiced sports discipline. Competitive fencing is no exception. It is a sport where high motor demands are already laid down on very young contestants.

The usefulness of widely understood speed abilities has often been discussed in the context of athletes' pre-competition preparation. The present study attempts to define aspects of speed that are crucial for acquisition of specialist skills by young female foil fencers. The determination of speed factors affecting fencers' success or level of specialist skills is highly significant for sport selection and the training process.

According to Sozański (1999) speed is the ability to perform movements in specific conditions in the shortest time possible. Osiński (2003) defines motor speed as an ability to translocate one's body or its parts in the shortest time possible. He adds that a performed motor task must not cause fatigue reducing the speed of movement. The most fundamental speed components include single movement speed, movement rate (tempo), complex movement speed, and the ability to attain and maintain the maximal speed (Ljach, 2003). In order to assess fencers' speed abilities in the present study three tests were applied measuring:

– simple reaction time;
– cyclic hand movement speed;
– running speed.

A fencing bout, regardless of the type of fencing weapon (foil, epee, saber) requires an immensely high degree of mobility. During a match the fencers move along a 14 m long piste extremely dynamically and employ a great number of various rapid lunges and fleches. The execution of these techniques in the shortest possible time requires perfect speed preparation. It can be asserted that speed is a crucial ability in fencing at any level of training. Furthermore, the ability to deliver quick complex reactions is a also major determinant of success in fencing (Johne et al., 2013).

Aim of study

The study aimed to identify speed-related factors that may affect the development of specialist skills in female foil fencers in the youth age category.

Subjects

The study sample consisted of twenty (n = 20) top Polish female foil fencers in the youth category (under 14 years of age). The sample was purposefully chosen on the basis of the ranking list of the Polish Fencing Association. With regard to their calendar age the subjects were divided into two age groups: 13-year-olds (15 fencers) and 12-year-olds (5 fencers).The subjects' fencing training experience ranged from 3 to 7 years. Two fencers in the sample were left-handed.

Methods

The study consisted of two main parts:

1. Identification of the level of specialist skills (technical, technical-tactical, tactical);
2. Performance of speed ability tests.

The level of specialist skills (technical, technical-tactical, tactical) of the examined foil fencers was determined on the basis of a questionnaire survey carried out among certified fencing coaches and experienced fencers, constituting a group of "competent judges." The "judges" assessed the level of each of 21 fencing skills on a ten-point scale: from 1 – "very poor" to 10 – "perfect." The fencers' skills were assessed during the Polish Youth Fencing Championships. On the basis of judges' assessments a global ranking list of fencing skills as well as ranking lists of specialist skill types (technical, technical-tactical, tactical) were compiled to determine the levels of particular fencing skills in the further part of the study.

In the present study fencing skills were divided into three types:

1. Technical skills;
2. Technical-tactical skills;
3. Tactical skills.

Technical fencing skills are strictly related to performing fencing motor habits. They can be further divided into three subgroups:

– footwork: basic fencing position, steps forward, steps backward, lunges, patinandos (advance-lunges) and fleches;
– bladework: parries, beats and binds;
– basic thrusts: direct thrusts, direct thrusts with a disengagement, counter-disengagement and cut-over.

Technical-tactical fencing skills are primarily related to the appropriate application of selected techniques on the basis of learnt sensorimotor responses (Borysiuk, 2005). Four subgroups of technical-tactical fencing skills can be distinguished:

– controlling the foible, i.e. accuracy of fencing actions;
– assessing the opponent's threat;
– adjusting the rhythm and speed of movements to changing bout conditions;
– responding to changes during a fencing bout and choosing the appropriate timing.

Tactical fencing skills involve well-planned and programmed application of fencing techniques preceded with preparatory actions (Borysiuk, 2005). Four subgroups of tactical fencing skills were identified in the present study:

– preparing one's own actions;
– reconnoitering the opponent's actions;
– concealing one's own intentions;
– selecting appropriate fencing actions.

Three tests were carried out to assess the level of fencers' speed motor skills. The tests fulfilled the requirements of objectivity, accuracy and validity (Osiński, 2003) and were conducted in indoor fencing halls, which ensured their repeatability. The tests were preceded with detailed verbal instructions, demonstrations and a three-minute warm-up, and were performed in the following sequence:

a) Simple reaction time to visual stimuli

The time taken to carry out the test was measured with a stopwatch and data on the subject's reaction to visual stimuli were processed using special equipment. A fencer was to respond in the shortest time possible to ten light impulses emitted at various intervals, by pressing a switch on a hand-held device with her thumb. The measurements were made with the accuracy of 0.001 seconds. After excluding three highest and three lowest results, the arithmetic means of the four remaining readings were analyzed (Wachowski, & Strzelczyk, 1999).

b) Hand cyclic movement speed

Plate tapping test. A subject stood in front of a table with two yellow discs placed with their centers 80 cm apart. A rectangle was placed equidistant between both discs. The subject placed her non-preferred hand on the rectangle and moved the preferred hand back and forth between the discs over the hand in the middle as quickly as possible. This action was repeated for 25 full cycles (50 taps) (EUROFIT 1989).

c) 20 m run

The test measured the fencers' running time over a distance of 20 m. A fencer commenced the run from an upright position, and the time necessary to cover the distance was measured with a Casiostopwatch to the nearest 0.01 s. Each fencer performed two runs and the better result was recorded.

Speed and the level of specialist skills of young female foil fencers

The fencers' mean time of simple reaction to visual stimuli was 252.2 ms (SD = 22.88), and individual results ranged from 203 to 288 ms. The mean result of the plate tapping test was 11.9 s, with individual results ranging from 9.47 to 13.80 s (SD = 1.1 s). The mean results of the 20 m run test was 4.1 s (SD = 0.3 s), with individual scores ranging from 3.55 to 4.15 s (Table 1, below).

Table 1. Results of motor skills tests – speed

	N	Min	Max	Mean	Standard deviation
Simple reaction time to visual stimuli (ms)	20	203	288	252.2	22.88
Hand cyclic movement speed (s)	20	9.4	13.8	11.9	1.14
20 m run (s)	20	3.5	4.7	4.1	0.32

Figures 1, 2 and 3 show the mean results of the simple reaction test, plate tapping test and 20m run test. The Y-axis illustrates the ranking of foil fencers on the basis of assessment of their specialist skills by the competent judges.

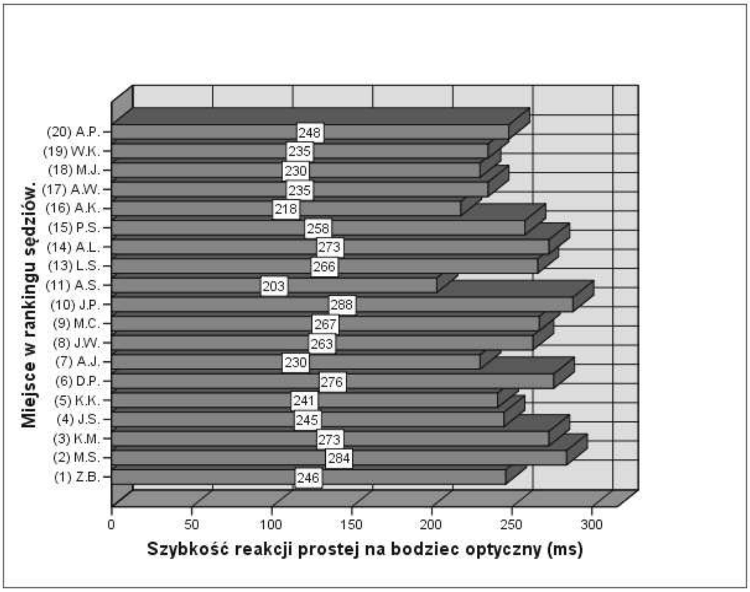

Fig. 1. Competent judges' total assessment ranking of fencers' level of specialist skills and foil fencers' mean results of the simple reaction test to visual stimuli

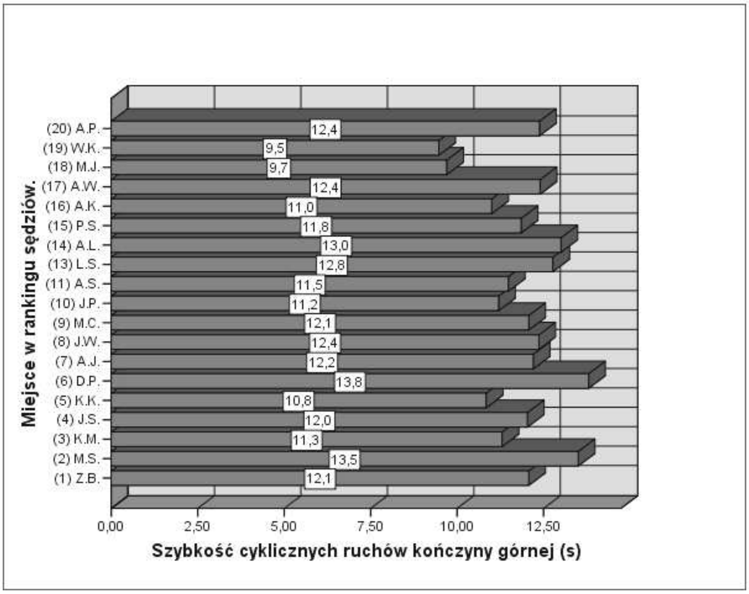

Fig. 2. Competent judges' total assessment ranking of fencers' level of specialist skills and foil fencers' mean results of the plate tapping test

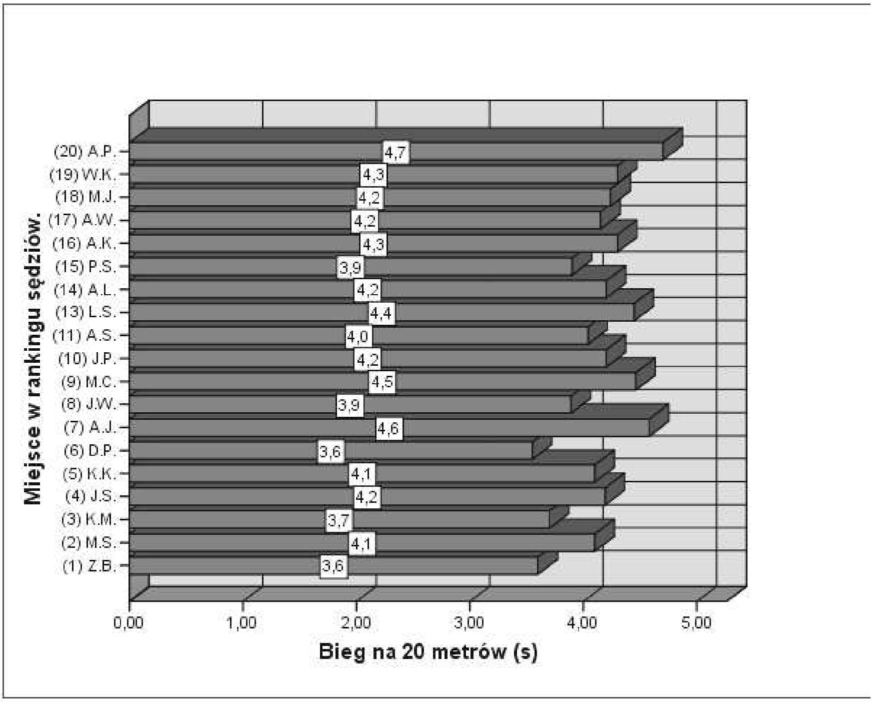

Fig. 3. Competent judges' total assessment ranking of fencers' level of specialist skills and fencers' mean results of the 20 m run test

Table 2. Pearson's coefficient of correlation (Pearson's r) between foil fencers' simple reaction tests results and level of specialist skills – beats

		Simple reaction time to visual stimuli (ms)
Beats	**Pearson's r**	.503(*)
	Significance (two-sided)	.024
	N	20

* statistically significant at 0.05 (two-sided)

The fencers' simple reaction time was only correlated with a high level of execution of beats, i.e. one component of blade work skills. It can be assumed that an improvement in the time of simple reaction to visual stimuli can lead to an improvement of the level of this particular technique; however, no correlations were found between simple reaction time and other technical fencing skills.

Table 3. Pearson's coefficient of correlation (Pearson's r) between foil fencers' plate tapping test results and level of specialist technical skills – basic thrusts

		Plate tapping test [s]
Beats	**Pearson's r**	.541(*)
	Significance (two-sided)	.014
	N	20
Direct	**Pearson's r**	.459(*)
	Significance (two-sided)	.042
	N	20
Technical skills – basic thrusts	**Pearson's r**	.456(*)
	Significance (two-sided)	.043
	N	20

* statistically significant at 0.05 (two-sided)

Table 4. Pearson's coefficient of correlation (Pearson's r) between foil fencers' 20 m run test results and level of specialist technical skills – footwork

		20 m run [s]
Basic fencing position	**Pearson's r**	-.486(*)
	Significance (two-sided)	.030
	N	20
Steps forward	**Pearson's r**	-.545(*)
	Significance (two-sided)	.013
	N	20
Steps backward	**Pearson's r**	-.453(*)
	Significance (two-sided)	.045
	N	20
Lunge	**Pearson's r**	-.496
	Significance (two-sided)	.026
	N	20
Patinando (advance-lunge)	**Pearson's r**	-.553(*)
	Significance (two-sided)	.011
	N	20
Technical skills − footwork	**Pearson's r**	-.542(*)
	Significance (two-sided)	.014
	N	20

* statistically significant at 0.05 (two-sided)

The speed of cyclic hand movement measured by the plate tapping test correlated with a high level of bladework components such as beats and direct thrusts (Table 3, above). Furthermore, the results of the plate tapping tests also correlated significantly with the total assessment of fencers' technical skills – basic thrusts. The strongest correlation was noted with beats (Pearson's r = 0.54); in the other cases the strength of correlation was moderate.

The analysis showed, however, that the aforementioned speed factors (simple reaction time, cyclic hand movement speed) had no significant influence on the levels of majority of specialist skills in youth female foil fencers.

The fencers' running speed was assessed by the 20 m run test. The analysis indicated the level of correlation between dependent variables, i.e. 20 m run test results, and independent variables, i.e. fencers' specialist skills (Table 4, below).

Table 5. Pearson's coefficient of correlation (Pearson's r) between foil fencers' 20 m run test results and level of specialist technical skills – bladework

		20 m run [s]
Parries	**Pearson's r**	-.480(*)
	Significance (two-sided)	.032
	N	20
Beats	**Pearson's r**	-.392(*)
	Significance (two-sided)	.087
	N	20
Technical fencing skills – bladework	**Pearson's r**	-.485(*)
	Significance (two-sided)	.030
	N	20

* statistically significant at 0.05 (two-sided)

The fencers' running speed measured by the 20m run test most strongly correlated with their high level of footwork skills in total and with lunge and advance-lunge skills in particular.

The fencers' good results in the 20 m run test were also significantly correlated with the level of their bladework skills. This correlation was not, however, as strong as with footwork skills, and was not statistically significant with the execution of binds.

In the case of technical skills – basic thrusts, a significant correlation was noted between the 20 m run test results and the level of technical fencing skills such as direct thrusts and disengagements. The obtained data show that the better 20 m run test results (shorter times) of the fencers corresponded with a higher level of performance of basic thrusts as assessed by the "competent judges" (Table 6, above).

Table 6. Pearson's coefficient of correlation (Pearson's r) between foil fencers' 20 m run test results and level of specialist technical skills – basic thrusts

		20 m run [s]
Direct thrusts	**Pearson's r**	-.577(**)
	Significance (two-sided)	.008
	N	20
Disengagements	**Pearson's r**	-.577(**)
	Significance (two-sided)	.008
	N	20
Technical skills – basic thrusts	**Pearson's r**	-.589(**)
	Significance (two-sided)	.006
	N	20

** statistically significant at 0.01 (two-sided)

The mean results of the fencers' 20 m run test were also correlated with the levels of accuracy of fencing actions and adjusting the rhythm and speed of movements to changing situations in a bout. The observed correlation was also statistically significant between the fencers' test results and total assessment of their technical-tactical skills (Table 7, below).

Table 7. Pearson's coefficient of correlation (Pearson's r) between foil fencers' 20 m run test results and level of specialist technical-tactical skills

		20 m run [s]
Controlling the foible, i.e. accuracy of fencing actions	**Pearson's r**	-.470(*)
	Significance (two-sided)	.037
	N	20
Adjusting the rhythm and speed of movements	**Pearson's r**	-.551(*)
	Significance (two-sided)	.012
	N	20
Technical-tactical skills	**Pearson's r**	-.445(*)
	Significance (two-sided)	.049
	N	20

* statistically significant at 0.05 (two-sided)

The statistical analysis showed that the foil fencers' run test results were most strongly correlated with the high level of such tactical skills as choosing appropriate fencing actions during a bout (Table 8, above).

Table 8. Pearson's coefficient (Pearson's r) of correlation between foil fencers' 20 m run test results and level of specialist tactical skills

		20 m run [s]
Selecting appropriate fencing actions	**Pearson's r**	-.640(**)
	Significance (two-sided)	.002
	N	20
Tactical skills	**Pearson's r**	-.546(*)
	Significance (two-sided)	.013
	N	20

* statistically significant at 0.05 (two-sided); ** statistically significant at 0.01 (two-sided)

Conclusion

The study results clearly show that the speed-related factor with the most significant impact on the level of specialist skills in female foil fencers in the youth category is running speed.

Discussion

Sport training of children and adolescents is one of the most important stages of athlete training and has a great impact on the future sports achievements of adult athletes (Karpowicz et al., 2012). This opinion is commonly shared by authors of various stage-based models of the training process (Czajkowski, 1988; Sozański, 1999; Smith, 2003; Platonov, 2004; Balyi, 2009). In the first stage of training only simple task aims rather than longterm outcome objectives should be formulated (Czajkowski, 1987). In fencing this translates into the acquisition of basic fencing skills. Entering a fencing competition at that level is not the aim, but a means, leading to the realization of outcome objectives at further training stages (Kosendiak, 2012). Due to its high technical complexity, fencing training requires precision in learning all specific movements that may influence the future sport results of fencers. The main study areas for sport researchers include the appropriate organization, professionalization and technical aspects of the training process (Sozański, 1999), and therefore seeking determinants of the sport result or specialist skills level in young fencers. The differentiation between the level of specialist skills and sport result is crucial in the context of sport goals set for young fencers at an early stage of their training. It should be remembered that the training process must correspond to developmental changes in young fencers and involve the adjustment of task aims and training loads and methods to fencers' age (Malina, & Bouchard, 1991). The group of subjects in the present study consisted of female foil fencers in the youth category, i.e. below the age of 14. The choice of this group was deliberate since, according to Stone et al. (2007), at this age fencers should advance to the stage of specialist training. Malina (1990) points out that the age of 11–14 years is crucial in terms of development of young athletes. The sport result is the last element of a properly conducted, long-term training process, which should be divided into stages, depending on the selection of tasks aims and training loads. An interesting concept of division of training into stages is the model of Long-Term Athlete Development designed in Canada (Balyi, 2009).The number of stages in the LTAD depends on whether a trained sport discipline requires an early specialist training. Each LTAD stage features different assumptions and aims.

Out of all speed-related factors the most significant in the present study of female foil fencers was the running speed (20 m run test). Running speed is a basic skill in fencing determining the fencer's movement on the piste, maintenance of an appropriate distance to the opponent, and performance of simple and feinted attacks.

The correlations between speed skills and specialist skills can be of great use to fencing trainers. In fencing training a high level of speed abilities affects the acquisition of specific skills. This is connected with the nature of fencing as a sport in which open motor habits play the key role. A great indication of mastery of a motor habit is the ability to use it in real competitive conditions. The need to use effectively reaction time and movement time as components of speed usually arises in "unexpected" situations. The execution of a motor habit without any speed limit significantly decreases the probability of a successful hit (cut or thrust). Thus speed is an important correlate of specialist fencing skills.

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CHARACTERISTIC OF FUNCTIONAL ASYMMETRY IN FENCERS MEASURED WITH OPTOJUMP NEXT SYSTEM

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Introduction

Although a human body is not symmetrical, both of its sides demonstrate similar functions and physique. In the literature, the human body asymmetry is consider in several different aspects (Malinowski, 1999): sensory, psychical, dynamic, morphological and functional. Morphological asymmetry is associated with external somatic features including length, width and circumference of body segments (Stokłosa, 1995). Functional asymmetry, or lateralization, is identified as domination of one of the brain hemisphere and consequently reflects the functional superiority and predominance to one of the body sides (Osiński, 2003). It also takes part in assigning different roles to each side of the body (Dominguez-Ballesteros, & Arrizabalaga, 2014).

Functional asymmetry plays essential role in sports based on unilateral movement pattern, such as court tennis, badminton or fencing. Due to movement structure present in fencing, it was classified as asymmetrical sport which use both, lower and upper limb, located on the same side of the body (Starosta, 1990). Anthropometric characteristics of fencers reveal that sustained unilateral training, and therefore increased unilateral activation of the muscles related to unbalanced load, can cause morphological asymmetries within the extremities (Roi, & Bianchedi, 2008). Morover, and Tsolakis (2006) reported low, but significant, common variance between training experience and arms asymmetry, suggesting possible impact of training on magnitude of observed asymmetries. The greatest disproportions of body segments in teenage fencers have been found in arms, forearms and thigh circumferences (Żurek, 2014). The difference between dominant and non-dominant forearm cross-sectional area of professional fencers oscillated from

10–12% (-12% men foil, -11% women foil, -12% men epee, -10% women epee). Similar asymmetries has been found in arms (-9% men foil, -8% women foil, -8% men epee, -10% women epee), thighs (-11% men foil, -13% women foil, -9% men epee, -8% women epee) and calves (+2% men epee) (Roi, Toran, Maserati, 1999). Lower limb asymmetry was observed later (14–17 years old) than arms asymmetry (10–13 years old). What is more, fencing training affects athletes' skeletal system by cortical and trabecular bone thickening. The relationship between fencers' lateralization and bones density was also observed (Żurek, 2014). Comparing to amateurs, fencers demonstrated significant differences in shoulders, heels and head placement, and additionally in shortened distance between the angulus costae and anterior superior iliac spine on the opposite side of the body (Sinoracki, 2014).

It has been shown that long-term fencing training may influence the strength and power of the involved muscle groups due to repeated, rapid, and highly coordinated muscle contractions, especially by the extensor and flexor muscles of the legs (Yiou, & Do, 2001). Professional fencers show greater strength of hip (+10%) and knee (+26%) abductors in front leg than the rear leg. Nevertheless, the rear leg is strongly correlated with production of speed during an attack in sagittal plane (Guilhem et al., 2014). Also, the strength of the grip in the armed arm turn out to be 10% greater than in the hand which do not participate in sword control. Force of body segments examined with EMG and isokinetic dynamometer indicate the presence of functional asymmetry based on an anthropometric parameters.

According to examined parameters of asymmetry, the researchers mostly use isokinetic dynamometer to measure muscle strength (Rahnama, Lees, & Bambaecichi, 2005; Schiltz et al., 2009) and force palate – ground reaction forces (Menzel et al., 2013; Sadauskaitė-Zarembienė, & Žumbakytė-Šermukšnienė, 2013). The kinematic parameters of asymmetry are measured with fast cameras (Ciacci, Michele, Fantozzi et al, 2013; Sugiyama et al., 2014). In the unilateral sports, the symmetrical tests are not sufficiently specific (Roi, & Bianchedi, 2008) therefore various studies measured efficiency of single leg jumps with Myotest device (Stanton, Reaburn, & Delvecchio, 2015), Swift Performance (Lockie et al., 2013) or as functional performance tests (Brumitt, Heiderscheit, Manske et al., 2013; Lockie et al., 2013). We found two studies using Optojump Next in evaluation of asymmetry of lower limb explosive strength among basketball players (Schiltz et al., 2009) and examination of lower limb asymmetry after reconstruction of the anterior cruciate ligament (Ventura et al., 2013).

The aim of the study was to evaluate functional asymmetry of lower limbs in fencers during series of single leg jumps using optical measurement system Optojump Next.

Methods

Material

29 healthy male subjects took part in the study including 15 professional fencers aged 22.7 ± 1.8 years. Their average body mass and height were 77.1 ± 9.7 kg and 180.8 ± 5.7 cm respectively. Training experience of each athlete was over 6 years. Control group consisted of 14 students from Academy of Physical Education in Katowice aged 20.4 ± 0.6 years. Their average body mass and height were 77.6 ± 11.3 kg and 182.8 ± 0.6 cm respectively. Subjects in this group was not professional sportsmen. All subjects were right legged.

OptojumpNext

Optojump is an optical measurement system consisting of a transmitting and receiving bar. Each of these contains 96 leds (1.0416 cm resolution). The leds on the transmitting bar communicate continuously with those on the receiving bar. The system detects any interruptions in communication between the bars and calculates their duration. This makes possible to measure flight and contact times during the performance of a series of jumps with an accuracy of 1/1000 of a second. Starting from these fundamental basic data, the dedicated software let to obtain a series of parameters connected to the athlete's performance with maximum accuracy and in a real time (http://www.optojump.com/What-is-Optojump.aspx). Optojump uses flight time to calculate rise of the center of mass of the subject (Schiltz et al., 2009):

$$\mathrm{H} = \frac{g \cdot T_v^2}{8}$$

Device is highly accurate and reliable for measuring vertical jump height (H) and can be used as an alternative for force platform (Glatthorn et al., 2011). Based on flight time ($\mathrm{T_f}$) and ground contact time ($\mathrm{T_c}$) software calculates jump power (P):

$$P = \frac{\mathrm{g}^2 \cdot \sum \mathrm{T_f} \cdot (\sum \mathrm{T_f} + \sum \mathrm{T_c})}{4 \cdot n^{\circ} jumps \cdot \sum \mathrm{T_c}}$$

One of many benefits of Optojump Next system is possibility of moving in the measurement area without any restrictions what allows the subject for natural movement execution (Castagna et al., 2013).

Statistics

Data were analyzed using descriptive statistics. Further analysis and test selection was based on the results of data distribution evaluated with Shapiro-Wilk's test and equality of variances calculated with Levene's test. Differences between measured variables were assessed with t-Student test for independent groups. Differences between compared variables were considered significant for p values that were smaller or equal to 0.05.

Procedure

Subjects lateralization was assessed with three tests: kicking a ball, stepping on the stair and regaining stability according to the procedure described by Hoffman (1998). After 10 minutes of standardized warm-up consisting of running, dynamical stretching of lower extremities and jumps, each subject was introduced to proper execution of Drift protocol and allowed to perform several testing trials. These trials was not included in further analysis. Firstly, subjects were instructed to stand in the measurement area sideways to camera recording the test. Subjects stood freely with legs at hip width. After the acoustical signal athlete were instructed to lift one foot to the opposite knee height and perform five jumps as high and fast as possible without tucking legs to chest during the trial. The same procedure where repeated on the other leg.

Results

In the group of fencers single leg jump height (Fig. 1) was significantly higher for right leg. In the control group the same variable was significantly higher during single leg jumps on the left leg. In both groups similar values were observed. However, the proportions of these values were reversed to each other: higher values for right leg in fencers group corresponded to lower values in control group. A similar relationship was observed for power (Fig. 2). Fencers achieved significantly higher jump power on the right leg, while the control group performed better on the left leg.

Despite expected relationships in ground contact time for both groups, differences between registered values for both legs did not reach the level of statistical significance (Fig. 3). Flight time was significantly longer for left leg in both groups (Fig. 4), but fencers were characterized by a longer flight time than the control group.

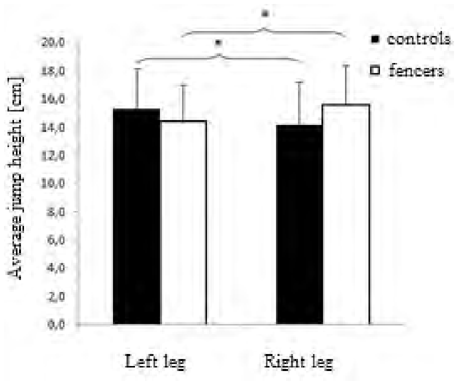

Fig. 1. The average jump height on left and right leg in fencers and control group

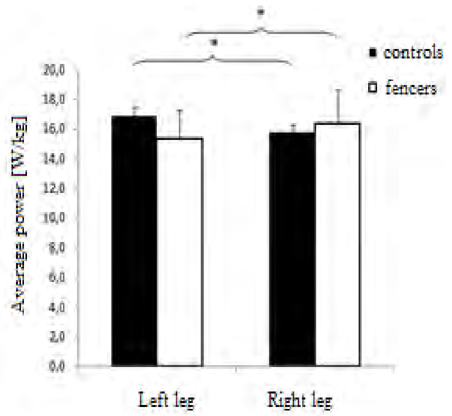

Fig. 2. The average jump power for left and right leg in fencers and control group

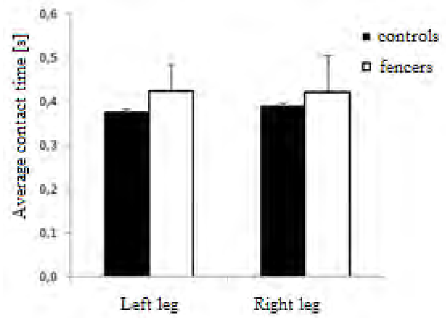

Fig. 3. The average contact time for left and right leg in fencers and control group

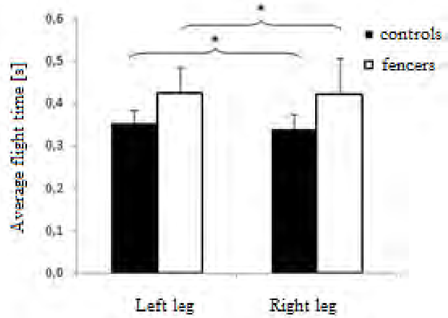

Fig. 4. The average flight time for left and right leg in fencers and control group

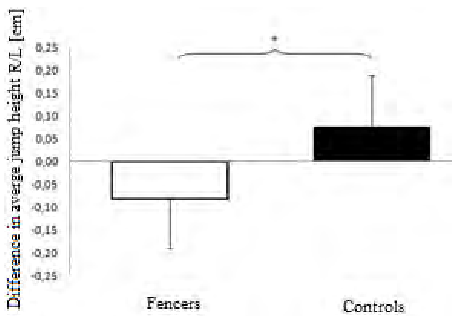

Fig. 5. The difference in the average jump height on left and right leg in fencers and control group

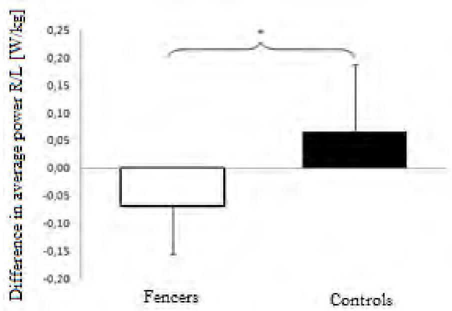

Fig. 6. The difference in average jump power of right and left leg in fencers and control group

Jump height (Fig. 5), power (Fig. 6) and flight time (Fig. 7) in fencers and control group was significantly different. However, just like in overall jump height, greater results for one leg in fencers group corresponded to lower results in control group. The difference in absolute values for jump height, power and average flight time was not statistically significant.

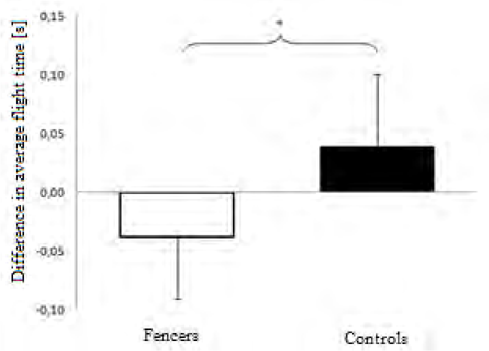

Fig. 7. The difference in the average flight time of right and left leg in fencers and control group

Discussion

Long-term fencing training caused significant lower limb asymmetry in examined group of fencers. The results are consistent with previous studies dealing with asymmetry in fencing (Roi, & Bianchedi, 2008; Tsolakis et al., 2006; Yiou, & Do, 2001; Żurek, 2014). As we assumed, there was a relationship between jump height and power output during series of jumps in both, fencers and controls. Jump height is derivative of power therefore lower limb power output influence its magnitude. The greater power being generated, the higher jumping performance. Greater values of jump height and power output on the dominant leg in the group of fencer were caused by specific features of fencers' legs muscles. During a lunge, one of the basic type of footwork in fencing, rear leg muscles are mainly activated in the concentric phase of attack. In contrast, hip and knee extensors of the front leg are strongly stimulated during the breaking (eccentric) phase (Borysiuk, & Pakosz, 2011) and are intended to reduce the velocity of body mass (Guilhem, Giroux, Couturier et al., 2014). Two different tasks assigned to front and rear leg causes unbalanced growth of leg muscles and may be observed in their circumferences. One of the factors influencing muscle force is its cross-sectional area. The power output, which is a product of force and velocity is increasing proportionally to muscle cross-sectional area (Żołądź, 2003). Opposing to fencers, controls showed significantly higher values of jump height and power output on non-dominant leg. In the literature, we found similar trend in professional handball and basketball players, where the strength of knee extensors and flexors were significantly higher while performing a task on non-dominant limb (Sadauskaitė-Zarembienė, & Žumbakytė-Šermukšnienė, 2013). Domination of the limb may be associated with its strength but choice of preferred limb may also depend on task characteristics. For example, dominant leg can be used for more precise kick while non-dominant leg will ensure the stability and balance (Guilherme, Garganta, Graça et al., 2015). It is worth to notice, that the controls consisted of physical education students who was not professionally involved in any sport. Nevertheless, physical education students represent superior physical fitness compared to average population. Selection of the control group could significantly affect the results.

In spite of statistically significant differences in power output between right and left leg, the relationship with contact time has not been found. Increase in contact time allows to achieve maximum force and is beneficial for jump height. Nonetheless, decrease in contact time is profitable to increase the jumping speed and frequency (Flanagan, & Comyns, 2008). Initially we assumed that jump height and flight time should be consistent. However the results show their diversity.

Several studies (Brumitt et al., 2013; Hägglund, Waldén, & Ekstrand, 2013; Schiltz et al., 2009) reveal, that the more than 10% muscle strength asymmetry within the limbs increase the risk of injury. Hewit (2015) points, that 15% difference between the limbs in single leg jumps parameters may also lead to injury. To eliminate or reduce functional asymmetry caused by long-term fencing practice, compensation training should be applied. Sannicandro (2014) showed beneficial influence of balance training in reducing functional asymmetry among tennis players. Exercises performed on unstable surface improve intramuscular coordination. In addition, extra load enforces an athlete to appropriately distribute body mass between the legs.

Conclusions

Results confirm that practicing fencing causes typical functional asymmetries of lower limbs. Optojump Next appears to be appropriate measurement device in identifying functional asymmetry of lower limb.

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