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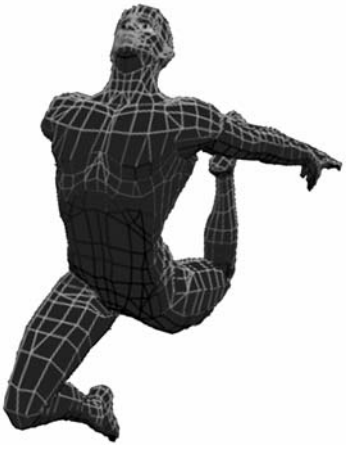

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Człowiek i Ruch (Human Movement)

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EDITORIAL

The present volume of *Human Movement* deserves particular attention as it contains a broad spectrum of papers from all significant fields of physical culture, including physical education and sport. The first group of articles includes various cross-sectional studies on social and educational aspects of human movement.

The paper "The situation of physical education in schools: a European perspective" presents a thorough analysis of physical education systems in European schools. The review of physical education in Europe is marked by 'mixed messages' with indicators of stabilization in some countries juxtaposed between positive, effective policy initiatives in other countries and reticence or little political will to act and continuing concerns in others. There are apparent deficiencies in provision, specifically in curriculum time allocation, subject status, financial, material (inadequacies in facility and equipment supply) and human resources, the quality of the physical education curriculum and its delivery as well as the extent of efficacy of beyond school networks. The crux of the situation is that there is a gap between promise and the reality. Another interesting paper "The role of physical activity in the lifestyle of the inhabitants of the Liberec region" aims to characterize physical activity and physical inactivity of the inhabitants in the Liberec region in their common life. These observations point to the necessity to increase knowledge about the negative impacts of inactive behavior and emphasize the advantages of performing regular physical activity along with the need to establish conditions that would contribute to physical activity performance. The following article "The state of health of women aged 20–59 at different levels of physical activity" is an assessment of the state of health of population using positive indices, which is crucial for health promotion. The study focuses on the levels of somatic growth and physical fitness of adult women living in small towns and on their dependence on physical activity. Systematic physical activity of two 50-min training units per week is an essential stimulation of women in productive age.

The following group of articles consists of experimental studies in sport concerning the effectiveness of training stimuli affecting mental, psychomotor and physical spheres of athlete's personality. The article "A combined sensorimotor skill and strength training program improves postural steadiness in rhythmic sports athletes" shows that the present-day sensorimotor skill and strength training programs point to short-term improved postural steadiness in rhythmic sports athletes. Exercises that specifically emphasize somato-sensory and back strength aspects of training for postural steadiness may be efficiently integrated into training routines. The next article discusses the results of a study of the impact of an annual training cycle of young rowers on the threshold power and changes in their blood antioxidative stress parameters. It was observed that the training cycle did not affect significantly the increase in the threshold power, but it lowered the level of post-exercise TBARS and increased the SOD activity at rest. Another study focuses on the influence of soccer training on the positioning of legs and feet resulting from excess straining of lower limbs, particularly the dominant leg, wearing soccer footwear and performing movements characteristic of soccer. The last paper on sports aspects of physical culture is the article "Stimulation demand in skiers versus skiing training results." The results of this study indicate that skiers – regardless of their sex – reveal a high level of stimulation needs of thrill and adventure seeking. The correlation between stimulation demand and success in skiing training was shown to be statistically significant.

The last two papers in the volume concern soccer efficiency models: "The efficiency model of soccer player's actions in cooperation with other team players at the FIFA World Cup", and current problems of doping in sport: "New prospects of doping."

We truly hope that the articles in the current issue of *Human Movement* will attract the interests of the entire physical culture community and will become inspiration to further research and scholarly debate.

As my term as Editor-in-Chief of *Human Movement* expires I would like to express my warmest thanks to all the Authors for their high-quality contributions to our journal reporting on the results of their invaluable research. My word of thanks also goes to the Members of the Editorial Board for their help and commitment in making *Human Movement* a truly interdisciplinary research journal. My special thanks go to all Reviewers for their thorough, often critical, but always straight-to-the-point reviews of submitted papers. The passionate commitment of Reviewers and Editors makes the prospects of formal inclusion of *Human Movement* into the world system of scientific information highly optimistic. I wish the successive Editor-in-Chief all the best.

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THE SITUATION OF PHYSICAL EDUCATION IN SCHOOLS: A EUROPEAN PERSPECTIVE

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ABSTRACT
Physical Education (PE) in Europe has evolved from influences and initiatives, which have variously shaped national systems either through assimilation or adaptation. As a geopolitical entity Europe is characterised by diversity, testimony to which are different and various forms of structures and practices but there are some elements of congruence in concepts and delivery. Survey and other research evidence indicates a perceived decline or marginalisation of PE in schools, particularly marked in the 1990s, which has attracted attention of the Council of Europe and the European Parliament. In presenting the situational trends and tendencies of PE in schools in the European region, this article draws from three European-wide surveys, a World-wide survey and an extensive literature review including global and regional qualitative studies and national reports. In some countries, there are instances of well implemented programmes and good practices. Equally, there is evidence to generate concern about the situation. The review of PE in Europe is marked by "mixed messages" with indicators of stabilization in some countries juxtaposed between positive, effective policy initiatives in other countries and reticence or little political will to act and continuing concerns in others. There are apparent deficiencies in provision, specifically in curriculum time allocation, subject status, financial, material (inadequacies in facility and equipment supply) and human resources, the quality of the physical education curriculum and its delivery as well as the extent of efficacy of beyond school networks. The crux of the situation is that there is a gap between promise and the reality. The article concludes with suggested strategies, underpinned by development of a "basic needs model", to assist in converting "promises" into "reality" and so secure a safer future for PE in schools.

Key words: physical education, status, policy, curriculum practices, strategies

Introduction

The story of Physical Education (PE) in Europe contains a rich tapestry of influences and developments, which have evolved from individual and/or "local" institutional initiatives with distinctive identities. These initiatives have variously shaped, or contributed to shaping, national systems either through assimilation or adaptation. Taking evolutionary developments into account, it is unsurprising that different and various forms of structures and practices are evident across Europe and that the region as a geopolitical entity is characterised by diversity but with some elements of congruence in PE and school sport concepts and delivery. Another dimension to the developing PE tapestry in Europe was the widespread perceived decline or marginalisation of physical education in schools, particularly marked in the 1990s and epitomised in the Loopstra and van der Gugten survey [1] conducted on behalf of the European Physical Education Association (EUPEA). This survey indicated that whilst in some countries within the region, especially in central and eastern Europe, there had been some encouraging developments, the subject appeared to be under greater threat than it had been at the beginning of the decade. Essentially, in most countries there was (1) insufficient curriculum time for PE, especially for primary age groups and the 17–18 year age group, which were well under the minimum; (2) the quality of PE in most countries was not, or was insufficiently, controlled particularly so in primary schools because of PE teacher education programmes with a majority of countries reporting inadequate PE training for primary school teachers; and (3) an undervaluing of the primary school phase for motor development and motor learning. The survey concluded that in a majority of countries there was insufficient quality control and that the political or educational decision-makers were not overly interested in the quality of PE delivered [1]. These and other issues and concerns (decreasing curriculum time allocation, inferior status, lower in value and importance than other subjects, PE lessons cancelled more often than so called "academic subjects"

and resource deficiencies such as funding limitations and impacts on, for example, swimming, which was being omitted from curricula in some countries, were borne out in on-going analyses of national and international documentation regularly reported by Hardman [2–7], in a world-wide PE survey [8] and in a Council of Europe commissioned survey [9] on the situation of PE in schools in Member States, the findings of which spawned a set of Ministerial *Recommendations* [10] on policy principles designed to remedy the school PE and sport situation in the region. Since the Council of Europe *Recommendations*, the developments in school PE policies and practices in Europe have been diverse with a plethora of positive initiatives juxtaposed with evidence to generate continuing disquiet about the situation. It was such disquiet at a time of widespread increasing levels of obesity and numbers of overweight children and young people, concomitant rises in sedentary lifestyle-related illnesses and high adolescent drop-out rates from sporting activity *inter alia* that prompted the European Parliament to engage (2006) in a study of the situation of PE in schools and its prospects in the then 25 and 2 acceding Member States. Specifically, the European Parliament's Committee on Structural and Cohesion Policies, Culture and Education section sought data on subject status, curriculum aims, delivery and content, quality PE criteria, responsible authorities, PE curriculum time allocation, status of PE teachers and teacher qualifications, material resources (facility provision and finance), inclusion issues related to disability, ethnic/religious groups and girls, case studies' information on links with/between health and school sport, pathways to participation in the wider community, the training of PE teachers (PETE) including initial and in-service training (INSET)/continuing professional development (CPD) and policy recommendations[1].

In presenting the situation of PE in schools in the European region, this article draws from the Council of Europe's 2002 commissioned survey [9], a semi-structured questionnaire instrument administered (2005) through the Council of Europe Committee for the Development of Sport (CDDS) unit with responses from representative government level agencies; a semi-structured "update" questionnaire distributed to recognised PE "experts" (2006) and administered in the 27 European Union States to inform the European Parliament's 2006–2007 funded study project [11], an on-going analysis of European data[2] extracted from of a North Western Counties Physical Education Association and University of Worcester supported and UNESCO, WHO ICSSPE endorsed Follow-up World-wide Survey undertaken by Hardman and Marshall (2005–2007) and an extensive literature review including qualitative studies of PE in global [12] and European [13] contexts and Reports, e.g. the German Sport Confederation "Sprint" Study [14].

At the outset, it is necessary to acknowledge potentially problematic issues surrounding validity and reliability of data generated from questionnaires, especially in terms of nature and size of samples. Nevertheless, in themselves these data do provide an indication of trends and tendencies as well as reveal some highly specific situations. Caution in interpretation is to a large extent alleviated by forms of triangulation embracing the range of questionnaire samples' sets, interviews, the review of research-related literature, including qualitative national studies, case and project studies undertaken and submitted by experts in the respective fields. Such forms of triangulation serve to underpin the questionnaire-generated data and bring a higher degree of validity and reliability to the content of the article.

The general situation of physical education in schools

Within the general education system, all countries in the region have legal requirements (or it is generally practised) with either prescriptive or guideline expectations for PE for both boys and girls for at least some part of the compulsory schooling years. In a majority of countries, national governments have at least some responsibility for the PE curriculum. In some countries there are joint and multiple (national, regional, local and school) levels of responsibility. Responsibility in some countries lies at two levels and where decentralised forms of government are constituted, responsibility is essentially at regional level as in, for example, the Belgian Flemish and French "Language Communities", in the 16 Länder of the Federal Republic of Germany and in the autonomous regions of Spain. Across Europe and

[1] The European Parliament (EP) Project Report can be accessed via the EP website at: http://www.europarl.europa.eu/activities/expert/eStudies.do?languages=EN

[2] The data include collated semi-structured questionnaire responses from PE teachers, administrators, government level representatives and experts in the field.

particularly in EU countries, administrative and delivery responsibility is frequently devolved to local authorities or even individual schools. Legally, PE has the same status as other subjects in some 90% of countries but its actual status is perceived to be lower in 34% of countries. Thus, its status may be equal in law but may not actually be matched in practice, a not untypical illustration of which is seen in a Portuguese teacher's observation that "…It (PE) can be considered compulsory in the 1st cycle, but, many times it is not taught". Moreover, designation of a subject as "foundation" or "subsidiary" implies a lower hierarchical status position than "core" or "principal" "or main" and in any event, PE is allocated less time in the curriculum than other subjects such as language, mathematics and science. Data related to the issue of implementation are confusing: on the one hand in 85% of countries, the PE curriculum is claimed to be implemented in accordance with regulations but on the other hand, nearly one third of countries indicate that its subject status is inferior and that PE classes are cancelled more often than other subject classes. There is a lower perception of PE teacher status than other subject teachers in over 20% of countries.

Physical education curriculum time allocation

Across Europe, there was a gradual erosion of school PE time allocation throughout the 20th century. **Denmark** experienced reductions from 7 to 4 lessons in 1937, 4 to 3 in 1958 and 3 to 2 in 1970, now it is 1–3 lessons (usually 2, but 3 in grades 4–6) [15]. In **Sweden** the daily provision in 1900 has shrunk to 1–2 lessons in Basic Schools [16] and Sollerhed [17] reported a reduction from 3 to 1 hour per week in the 1990s and cancellation of school sport days; however, in 1999, annual PE and Health "clock hours increased from 460 to 500 clock hours, i.e. 2×50 min" each week. In **France** the number of lessons was reduced from 5 to 3 in 1978 [18]; and in **Greece** reductions of PE time allocation occurred in the 1990s [19]. In former "socialist bloc" countries in central and eastern Europe, the erosion in time allocation has been more confined to post-1990 political reforms. In Hungary for example the former 4–5–6 PE hours per week-staged model in the 1980s has been replaced by a 2/3–1.5/2–1 hours per week-staged model. Over the decade after the (re)-unification of the two Germanys in 1990, Helmke and Umbach [20] indicated reductions as high as 25% in PE timetable allocation in all class stages (except class 4) in the Federal Republic of Germany.

During the last decade, many European countries have undertaken educational reforms. Whilst it is encouraging to see that PE has remained compulsory or is generally practised in all countries and that time allocation has increased in just 16% of countries and remained the same in 68% of countries, in 16% of countries it has actually been reduced. The latter is epitomised by an Irish PE teacher's comment that "PE is being squeezed out of the education system by more and more compulsory academic courses… which hold little benefit compared to PE".

The issue of time allocation is generally complicated (1) by localised control of curricular timetables, which vary considerably between schools and especially in those countries where responsibility for delivery of the curriculum has been divested to individual schools, and (2) practices of offering options or electives, which provide opportunities for additional engagement in PE and/or school sport activity. "Uptake" by pupils of such opportunities can vary within, and between, countries and not all pupils take advantage of any such extra provision. Whatever, the options/electives available may be included in curriculum time allocation indicated in some countries' survey responses and, therefore, may not accurately represent the actual prescribed or expected time allocation for all pupils. Thus, a cautionary note is necessary here because data for some countries do include additional optional or elective lesson hours and hence, provide some distortion of the actual situation in at least some schools in those countries where additional opportunities exist. "Triangulation" of curriculum policy documents, survey data and qualitative data derived from literature [see especially 12, 13] provide a scenario of policy prescription or guidelines not actually being implemented in practice for a variety of reasons. Geographically representative examples illustrate the point. In Austria there is a standard number of lessons but school autonomy prescribed by national Law 283/2003 produces variations and PE can, and in some schools does, give way to other subjects: the standard allocation of 3–4 lessons in secondary schools has been effectively reduced to 2 in lower secondary and 1 in upper secondary levels [21, 22]. In Bulgaria, some reductions are occurring as a result of increased time allocation to foreign language studies, furthermore, there are variations on the duration of lessons because they are determined by school staff, hence some schools offer less PE lesson minutes per week than others. In Cyprus, the 2×40 min lessons in primary schools

are "often abandoned when time is required for the main school subjects such as maths and language" [23]. In the Czech Republic, the third lesson in primary schools is frequently cancelled or has not been even included in the curriculum [24]. According to the curricula in most German Länder, time allocation for school PE is between two and three lessons per week (i.e. between 90 and 135 min per week). The results of the Sprint Study [14] show that there is a wide gap between policy and practice. In the secondary general schools (*Hauptschule*), differences exist between the demands of the curriculum and PE lessons that have been given with 2 hours per week instead of 3 hours, that is 33% of lessons are cancelled [25]. In Ireland despite a recommended 60 min per week, PE is not provided in all primary schools, quality of provision varies and research shows the average amount of time ranges from 12 to 60 min and 75% classes have less than 30 min; at post-primary level, 120 min are recommended (90 min is seen as a minimum but many schools offer less), however, there is a progressive reduction from 75 min (year 1) to 57 min (year 6) [26, p. 386]. In Lithuania, even though there is a legal basis, "it is difficult to put regulations into practice" [27, p. 445]; the School Boards decide PE hours (obligatory and supplementary); the 1995 Law on PE and Sports stipulated 3 lessons but only 26% achieve this in classes 1–4, moreover, 38.9% do not have a third lesson; fewer than 10% schools comply with the 1995 Act for 3 lessons [27, p. 445]. In the Netherlands, there is no specific prescription but there is an average of 90 minutes per week with considerable differences because head teachers determine actual time allocations; additionally facilities represent a considerable problem and present provision makes it difficult or impossible to realise prescribed attainment goals [28]. In Portugal, teacher's autonomy brings variations to the 3×30 min lessons allocated and only a minority of primary schools have the opportunity to benefit from PE classes [29, p. 556]. Since 2001 in Sweden, an increase in time allocation has occurred and two hours of additional options are popular but for more athletically talented children; schools may be designated as special profile schools (so-called "The School Choice") and sport can be "the profile…(one) outcome of the various tracks means prevalence of differences in allocated hours: in Basic Schools, the 1–2 lessons (80–100 min) can be increased; 25% have done this but 50% haven't and 24% have decreased" [16, p. 611]. Pervasive throughout the EU region is the low priority accorded to PE in Vocational Schools, where usually minimal provision is reported [8, 9, 12, 13, 30, 31].

Despite national policy concerning required, prescribed, recommended or aspirational guidelines, local levels of actual control of curriculum time allocation give rise to variations between schools and, therefore, difficulties in specifying definitive figures for a country or region. However, some general tendencies are identifiable. In primary/basic school years, weekly timetable allocation for PE across Europe is 109 min (range of 30–240 min) with clusters around 60 and 90 min and in secondary and high schools 101 min (range of 45–240 min) with a cluster around 90 min: there is a gradual "tailing off" in upper secondary (high) schools (post 16+ years) in several countries and optional courses become more evident. The figures represent a worrying trend of decreasing time allocation since 2000 when figures were higher with an average of 121 min in primary schools and 117 min in secondary schools [8] and this despite international advocacy supported by an overwhelming medical, scientific, economic, social and cultural case for adequately timetabled PE programmes and plans in some countries to introduce an entitlement of at least 120 min per week.

Physical education curriculum issues

An issue which is becoming significant in an increasing number of countries is that of the relevance to the outside-school world and quality of PE curricula. Within the context of educational reforms, associated philosophical and pedagogical changes, and in response to the obesity epidemic and concepts of active lifestyles in lifelong learning contexts, some curricular changes are now occurring in some parts of the region and some shifts in PE curricular aims and themes are evident with signs that the purpose and function are being redefined to accommodate broader lifelong educational outcomes including healthy well-being. Nevertheless, there remains an orientation towards sports-dominated competition- and performance-related activity programmes as seen in the proportion of time devoted to games, track and field athletics and gymnastics, which collectively account for over 70% of PE curriculum content in both primary and secondary schools (Tab. 1). Such orientation runs counter to societal trends outside of school and raises issues surrounding meaning and relevance to young people's lifestyles as well as quality issues of programmes provided and delivered. What is, however,

Table 1. PE curriculum activity areas

	Primary Schools		Secondary Schools	
Activity Area	Countries %	Curriculum %	Countries %	Curriculum %
Games	97	41	100	42
Gymnastics	97	17	100	13
Dance	80	78	74	5
Swimming	80	7	74	6
Outdoor adventure	71	4	69	7
Track & Field	94	14	100	17
Other	51	9	63	10

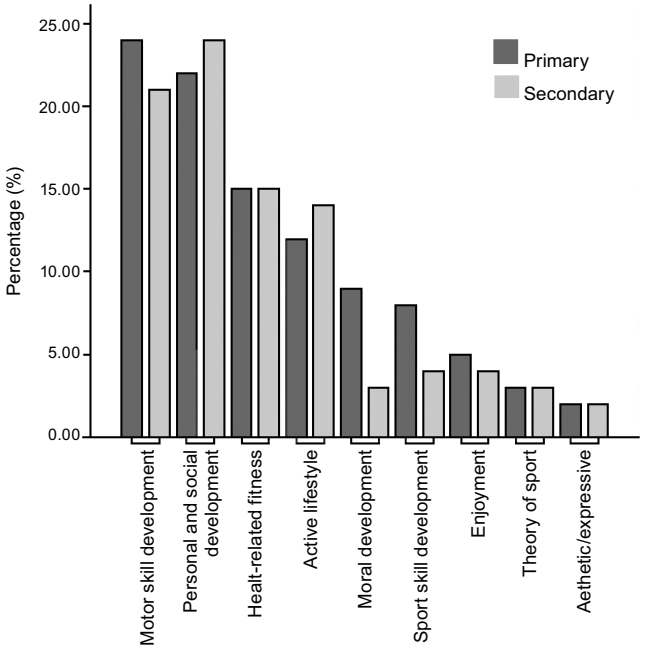

Figure 1. PE curriculum thematic aims

also evident, is increasing attention devoted to quality physical education (QPE) programmes.

From examination of thematic aims of PE curricula, it is possible to discern a number of patterns. These patterns are shown in Fig. 1, which reveals an orientation primarily to the development of motor skills (24% and 21% in primary and secondary schools respectively) and when added to the refinement of sport-specific skills represents a significant component of thematic aims.

The trend towards including broader lifelong educational outcomes is evident in the importance of PE in developing health-related fitness (15% of both primary and secondary schools' curricula) as well as promoting active lifestyles (12% and 14% of primary and secondary schools' PE curricula respectively). Substantial recognition is also apparent in PE's contribution to promoting a pupil's personal and social development (22% and 24% of primary and secondary schools' curricula respectively and moral (9% and 3% of primary and secondary schools' PE curricula respectively). However,

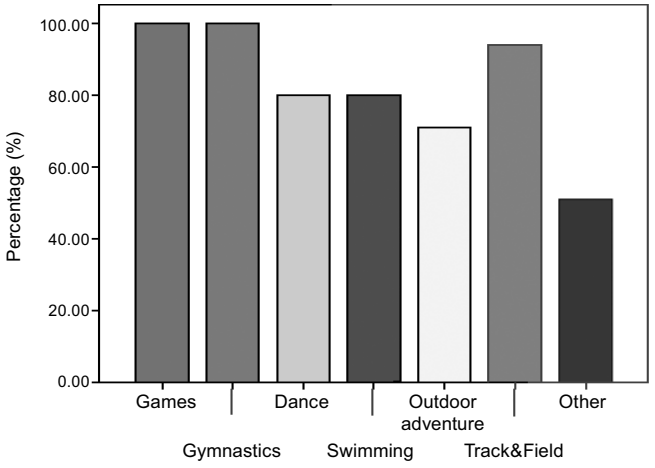

Figure 2. Primary curriculum activities taught across the EU countries

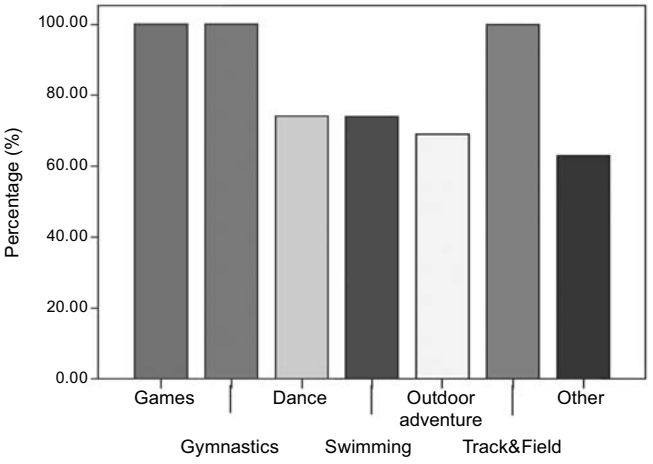

Figure 3. Secondary curriculum activities taught across EU countries

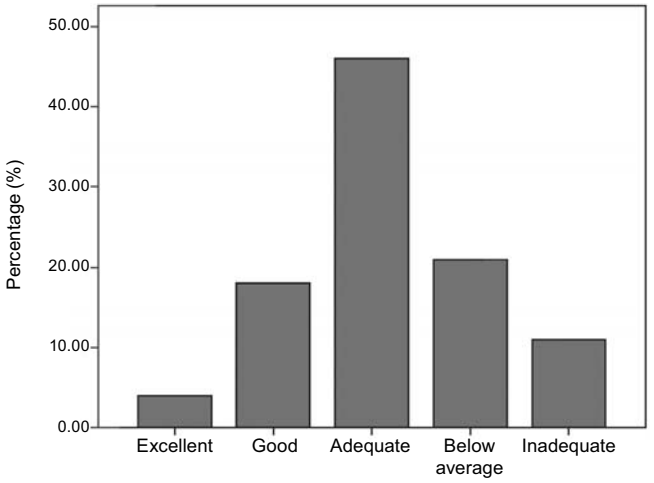

Figure 4. Assessment of the quality of facility provision

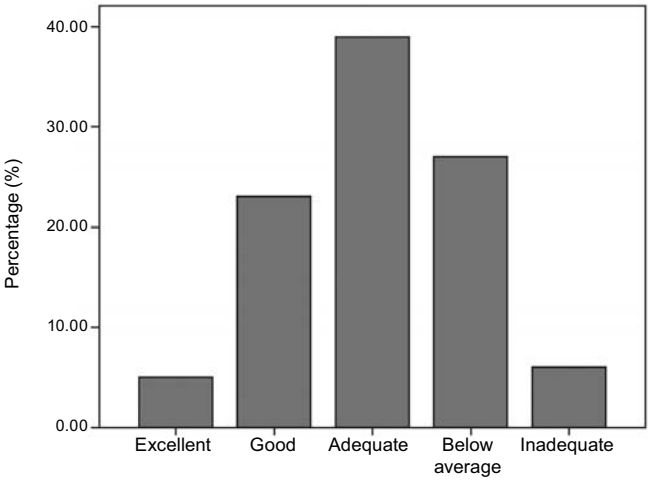

Figure 5. Assessment of the quality of equipment

curricular activity areas in EU countries (see Fig. 2, primary schools, and Fig. 3, secondary schools) reinforce the predisposition to the performance sport discourse mentioned earlier: primary and secondary schools have a predominantly Games (team and individual) orientation followed by Track and Field athletics and Gymnastics. Games and Gymnastics feature in all countries in both primary and secondary schools and they are closely followed by Track and Field athletics in 88% countries (primary schools) and 94% countries (secondary schools).

The proportion of time devoted to each activity area in EU countries is shown in Fig. 2 and 3. This is a situation which is not only seen in the content of curricula but also in structures related to extra-curricular activity and emphasis on school sport.

Illustrative examples underscore the sports discourse emphasis: in Bulgaria, programme documents indicate a broadly based curriculum but in practice PE content covers only basketball and volleyball in secondary schools; in Germany, from analysis of the content of PE lessons, the Sprint Study (2006) reveals a traditional sports discourse, which is also gendered with boys playing football and basketball, doing track and field and German *Turnen*, whilst girls are mainly confronted with *Turnen*, volleyball, basketball and track and field disciplines. This scenario of a discrepancy between what the school offers and what the pupils are looking for regarding sports-related activities is not untypical of the situation in other countries hence, there is little wonder that "drop out" of sport rates continues. For young population groups, the traditional content of PE and/or sports activity has little relevance to their lifestyle context. Collectively, such "joyless experiences" [32] acquired from unwilling engagement in competitive sport-related PE are a "turn-off" and only serve to increase the "drop-out" rate of participants from school-based and post-school sports-related activity. If PE is to play a valued useful role in the promotion of active lifestyles, it must move beyond interpretations of activity based upon performance criteria: its current frame of reference should be widened. The preservation of PE in its old state is not the way to proceed; it is time to move into the 21st century!

Monitoring of PE

Marked variations are evident in monitoring PE in schools. They vary from regular to irregular or random or not defined. Inspection of PE is a legal and generally practised requirement in around 70% of countries. Countries in which inspections are not undertaken include Denmark, Finland, Germany, Hungary, Lithuania and Malta. In Cyprus, Italy and Poland there are intimations of a difference between official and actual implementation realities. In Ireland, Luxembourg, Portugal and Slovakia, inspections are not a legal requirement. Monitoring is variously undertaken by national inspectors (50%), regional inspectors (25%), local inspectors (8%), school head teachers (8%), or combinations of two or more of these groups (9%). Frequency of monitoring varies from every 6 months to beyond every 5 years with a main cluster (31%) of annual monitoring. The scope of monitoring embraces a range of aspects

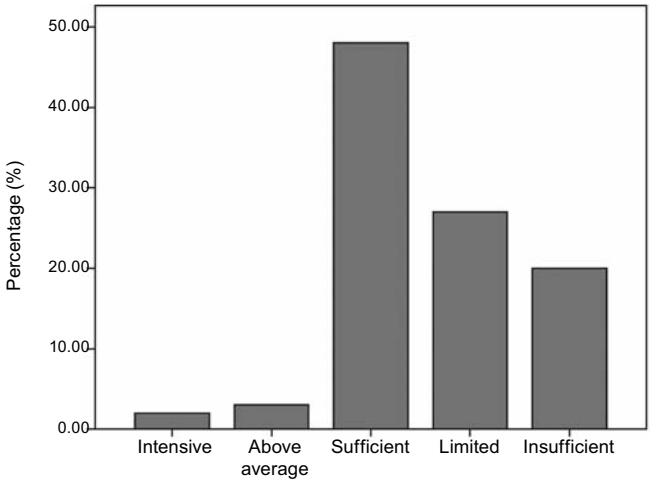

Figure 6. Assessment of the quantity of facility provision

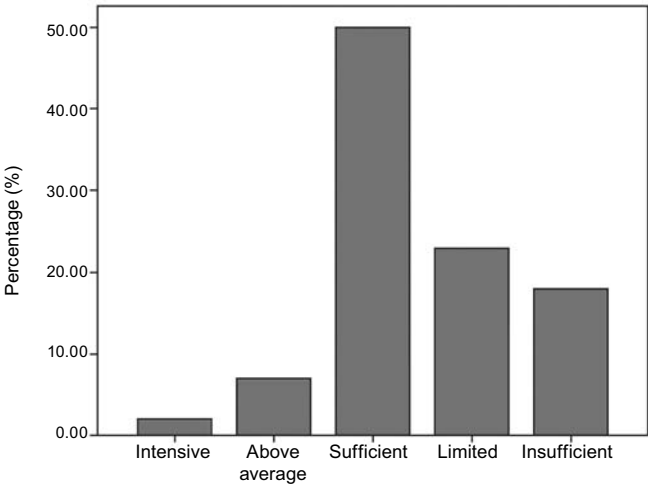

Figure 7. Assessment of the quantity of equipment provision

but predominantly the extent of curriculum implementation and quality of teaching, quality control and/or advisory guidance are given as the reasons for monitoring in over 90% of countries where this occurs.

Resources

Facilities and equipment

A pervasive feature of concern is related to quality and quantity of provision of facilities and equipment because levels of provision can detrimentally affect quality of physical education programmes. Around one-third of countries indicate below average/inadequate quality of facility (Fig. 4) and equipment provision (Fig. 5).

Additionally, nearly half of countries have limited/insufficient quantity of facilities (Fig. 6) and two-fifths of countries have limited/insufficient quantity of equipment (Fig. 7).

There is a marked geopolitical differentiation in quality and quantity of facilities and equipment in Europe. In the more economically prosperous northern and western European countries, quality and quantity of facilities and equipment are regarded as at least adequate and in some instances excellent; in central and eastern European countries inadequacies/insufficiencies in both quality and quantity of facilities and equipment are prevalent. Hence, there is an east-west European divide with central and eastern European countries generally far less well endowed with facilities and equipment, perhaps typically represented in a Serbia-Montenegro government official's observation that "…Quality of facilities is below average and quantity of equipment is limited". Transcending this east-west divide is the view that in 67% of countries, there are problems of low levels of maintenance of existing PE sites and whilst there are higher expectations of levels and standards of facilities and equipment in more economically developed countries, even here there are indicators of inadequacies and shortages in facilities and equipment as one PE teacher in otherwise generally well resourced England affirms: "…Quantity and quality of EQUIPMENT is very poor. … Damaged equipment is used frequently; quality and quantity of facilities is very poor; and facilities inadequate or poorly maintained".

PE teaching personnel

Across the region, the quality of teacher preparation for PE is variable and there are examples which suggest lack of commitment to teaching as well as pedagogical and didactical inadequacies in some countries. As previous research [see 9] has also shown, generally throughout Europe, PE teaching degree and diploma qualifications are acquired at universities, pedagogical institutes, national sports academies or specialist PE/Sport institutes. For primary school teaching, qualifications tend to be acquired at pedagogical institutes and or universities, whilst for secondary school teaching, qualifications are predominantly acquired at university level institutions, including specialist Academies and Faculties. In approximately half of the countries, PE/sport teacher graduates are qualified to teach a second

subject at least. A common scenario (94% of countries) is qualified "specialist" PE teachers at secondary level, (though some German Länder and Hungary indicate that, in practice, some generalists are also employed to deliver PE) and "generalist" teachers at primary/ elementary level (85%); some countries (67%) do have specialist physical educators in elementary (primary) schools, but the variation is wide and there are marked intra-regional differences. In some countries, the generalist teacher in primary schools is often inadequately or inappropriately prepared to teach PE, especially as minimal hours may be allocated for PE teaching initial training (in some higher education institutions in England, for example, this can be as low as 8–10 contact hours). The former point is well illustrated in Germany by the Sprint Study [14]: in order to teach PE in schools, the successful completion of a PETE programme and the associated qualified teacher status (according to the specific type of school) are prerequisites for all teachers; the reality in schools reveals a different picture because whilst 80% of all state qualified teachers who teach PE lessons have a PE subject degree qualification, every fifth teacher has no formal qualification in the subject; with regard to different school types, the problem is more salient in primary schools (*Grundschule*), where 49% of the teachers delivering the PE curriculum have no specific education in PE subject matter; in the different branches of the secondary school, the figures of formally unqualified teachers decrease considerably – *Hauptschule* (secondary general schools) 30%, *Realschule* (secondary modern schools) 11%, and *Gymnasium* (grammar schools) 2–3% [14].

In 63% of EU countries, there are opportunities for in-service training (INSET)/continuing professional development (CPD) but there are substantial variations in frequency of provision, which ranges from free choice through nothing specifically designated, every year, every two years, every three years to every five years. Duration of INSET/CPD also reveals differences in practice between countries: those with annual training range from 12 to 50 hours, from 3 to 25 days; biennial and triennial training courses of 4 weeks; and five years range from 15 days to 3 weeks or 100 hours over the five year period. Annual INSET/CPD is indicated in 50% of countries, every 2 years in 15% of countries and greater than two years in 35% of countries. No opportunities or strictly limited provision are evident in Bulgaria, **Cyprus**, **Czech Republic**, Finland, **France**, **Germany**, **Italy**, Latvia, Lithuania, Luxembourg, **Netherlands**, **Poland, Romania, Sweden**)[3]. In some countries, inadequate promotional infrastructure and finance can inhibit participation in INSET/CPD; a Swedish physical educator reports "…Often I have to find in-service training myself and I have also often to pay for it with my own money".

On a more positive note, there have been significant developments in CPD in the form of European Master's programmes in Physical Education and Adaptive Physical Activity and in national professional development programmes such as in England. CPD has a key role raising and/or enhancing educational practices and standards and yet, related data presented above show that in some European States CPD can be irregular and unstructured and in some cases may not even be available or accessible and this despite the need for professional development as a continuous process throughout a teacher's professional career. In primary/elementary schools in particular, where generalist practitioners are often responsible for PE teaching, this represents a potential problem. In such contexts, CPD is not only essential but it also needs to be delivered with appropriate expertise and with up-to-date content that is relevant to practice.

In the light of AEHESIS[4] PE Area recommendations pertaining to CPD, European-wide developmental changes linked with democratisation processes, political including intergovernmental agencies' (Council of Europe 2002/2003 and European Parliament 2006/2007) interventions, increasingly widespread recognition of CPD need and value for career development especially since the Bologna Declaration, and emergence of various pathway routes to qualification (linked with employability), an issue in terms of future directions within CPD is consideration of revisiting the European PE Master's Programme.

[3] **Emboldened** text denotes those countries where there is a discrepancy between survey responses.

[4] As part of the post-Bologna process in harmonising Higher Education provision, an ERASMUS Thematic Network project was initiated in October 2003 to "Align a European Higher Education Structure in Sport Science" (the AEHESIS Project). Amongst other initial objectives, the PE sector's overarching aim "having in mind the necessity of enhancing the process of recognition and European integration of qualifications" was to formulate a model curriculum for Physical Education Teacher Education (PETE), which could have applicability across higher education institutions in Europe involved with preparation of teachers and hence, represent a degree of harmonisation within the context of the intention and spirit of the Bologna Agreement.

Financial issues

With increasing demands by a range of social institutions and services for financial support, prioritisation of government financial resource investment occurs and PE with its initial high capital costs of facilities and recurrent maintenance, apparatus and equipment costs can be an expensive enterprise. In European countries, funding for school PE/sport provision emanates from several sources: national government; regional/provincial/local government only; joint national and regional/local government; joint national, regional/local government and other mainly private/commercial sectors.

The complexities of funding in education with national budgets and devolvement variously to regional, local and even individual schools together with the added problems of disaggregating amounts invested in, or expended on, PE and school sport render it difficult to provide any definitive information on the financial resources. However, from information derived from survey-generated data and supported by the literature [12, 13], it is possible to report on some aspects of PE funding for school PE and sport[5]. Over half of European countries indicate reductions in financial support for PE in recent years. Reasons given for this situation include low status in relation to other subjects with minimal significance not worthy of support, diversion of financial resources to other subjects and areas of the school, expensive maintenance, low societal value in personal and national development and perceived lack of academic value of the subject, often linking this to the belief that the subject is just another "play time" or recreational experience. Such reductions have had, and continue to have, consequential impacts on school PE and sport.

As already intimated in an earlier section, inadequate funding for facilities, equipment and their maintenance and teaching materials is widespread in central, eastern and southern Europe (Bulgaria, Czech Republic, Estonia, Greece, Hungary, Malta, Poland, Romania, Slovakia and Slovenia): there is a shortfall of 600 gymnasia halls and facilities generally are not up to health standards' requirements in Hungary, where under-funding of extra-curricular activities is also evident. In the Czech Republic, it is alleged that proclaimed objectives cannot be fulfilled because of absence of funds, extra activities have ceased and the third lesson usually is not delivered because of lack of finance [33]. In Estonia "one of the main problems is that the equipment is very expensive. Also, most of the facilities require reconstruction". In Lithuania, (despite Article 38 of the Sports Law), PE "is not sufficiently financed" and is reflected in multi-class use of facilities (60–90 pupils) as well as in a shortfall for teachers' salaries (low PE teachers' salaries are reported in Poland and Romania). In Poland, many extra-curricular lessons are cancelled because of lack of money to finance teachers/coaches; finance for PE is a low regional/local authority priority and impacts negatively on facility provision (there is no PE audit) – in 1999, 80% gymnasia did not conform to regulations; "lack of financial resources has also led to retreat from the Physical Culture and Sport Statute goal of 225 min by 2000" [34]. In Slovakia there are "problems with lack of finances for maintenance of sports facilities and for reconstruction and acquisition of new sports materials. There are schools existing also without sufficient sports facilities… there is a decrease of financial areas to PE; leave of PE teachers into other, better paid areas; change of structure of pupils' interest".

Even in more economically developed western and northern EU countries, there is teacher-based anecdotal evidence to suggest deficiencies in provision due to inadequate or under-funding. Representative illustrations include:

- Austria
  - equipment shortfalls: "There is a very low budget, the financial support for PE is limited; there are big problems to buy new equipment"; "This school has a low budget – therefore, the financial support for PE is very limited; we annually collect money from students to keep our equipment up-to-date"
- Belgium (Flanders)
  - In Flanders "financial support for physical education is minimal"; "financial provision is less than for other subjects (e.g. computer classes)"
  - In Wallonia "financial support given to PE in comparison to other subjects is very poor" and "there is a lack of financial means allocated to sport in schools"
- Finland
  - "a decrease in educational resources (has) led to larger PE classes and one impact of financial constraints has been reduction of PE in lower schools from 3 to 2.5 lessons per week"

[5] Quotations in this section on *Financial Issues* have been drawn from PE practitioners and academic experts in the domain of PE in Europe. In the interests of confidentiality, names of sources have been withheld.

- Ireland
  - facilities and teachers: "…Facility provision and teachers employment are adversely affected by financial constraints. Many schools have been built with no indoor PE facilities"
- Italy
  - financial support: recurrent financial support is reported as less in PE in comparison with other subjects
- Luxembourg
  - financial support: "financial support to PE (is seen as) poor supply compared to other subjects"
- Spain
  - financial support: "financial support is inadequate; PE is a mistreated subject compared with others – it received below average money"

The considerable financial investment of maintaining, or gaining access to, swimming facilities exposes this important component of the PE curriculum to cancellation of lessons or even omission from curricula in many countries. Two examples will suffice to illustrate the point: in Denmark, swimming was a compulsory subject for all pupils, now "… Many communities tend unfortunately to save the money. Today only 2/3 of all pupils get adequate swimming lessons" (Swedish PE teacher); and in the Netherlands, swimming was removed from the curriculum because of "financial reasons" (Dutch PE teacher).

As the above overview demonstrates, financial considerations have had a number of impacts on school PE/sport in Europe: failure to refurbish/reconstruct/replace/maintain (out)dated and/or provide new facilities; shortages of equipment; inadequately trained teachers; employment of lower salaried unqualified teaching personnel; exit of physical educators to better paid jobs; reductions in numbers of PE lessons, timetable allocation and extra-curricular sports activities; omissions of curriculum activity areas and large class sizes. Part resolution of inadequacies in facilities and equipment and maintenance lies with wider community sharing of resources through multi-purpose and use provision with schools seen as one community entity in a wider community setting. Such provision implies shared cross-sector funding including operational and management costs.

The physical education environment

Within the PE environment, teacher networks exist at schools' level in most countries; municipal, region/county and national levels networks exist in around 70% of countries; less widespread are networks of PE/sport teachers, sports clubs and other outside school community providers. This is a situation which can be summarised by apparent inadequate links between school PE and the sports communities in some countries and regular co-operation in others. Voluntary links between school PE and sport and wider community physical activity are reported in only around 36% of countries and, in total, direct school-community links are indicated in only 51% of countries. There are suggestions that many children are not made aware of the multifarious pathways to out-of-school and beyond school physical activity opportunities. Nevertheless, varied and differentiated models linking school activity with out-of-school activity do exist throughout Europe, examples of which are: schools sport federations etc. in France; extra-curricular and out-of-school sport in the Czech Republic; integrated school-community and sport club action projects in Sweden; PE, School Sport, Club Links (PESSCL) in England, where the focus is on links between school PE and sport in the wider community; and the "one stop shop"; "Sport Service Punt" scheme involving vested interest partners from public, voluntary and education sectors in the Netherlands, which provides an exemplar of a coherently implemented multi-sector collaborative co-operation programme.

The school is the principal agent for initiation into organized general public sport and is in a prime position to eradicate excesses (drugs, aggression, violence, money etc.) evident in the sporting spectacle. This feature has particular resonance in the light of PE in schools no longer remaining a "stand alone" option in the resolution of the healthy well-being, active lifelong engagement in physical and sports-related activity concerns of this early part of the 21st century. Professionals and the large-scale European volunteer numbers alike are necessary to the process of facilitating inclusive participation. With more than 70 million members of sports associations, the voluntary-based "Sport for All" movement is one of Europe's largest social movements. It is served by millions of volunteers, who represent the main resource of the movement and as national studies [see 13] show, they form the "backbone" of sport associations and clubs with around 10% of the 70 million members serving as volunteer coaches, association leaders, assistants etc. In Germany, for example, where 27 million people are members of sports clubs some 2.7 million serve as volunteers in over 90.000 sports clubs.

Volunteerism in sport varies from country to country. Highest levels of volunteerism tend to be located in northern Europe and lowest levels in southern Europe [35].

Conclusions

Arguably, the data provide a distorted continental regional and individual national picture of PE in schools, particularly where questionnaire responses are based on policy principles and as such may mask the truth about actual practice. However, what the various surveys and literature review do reveal are congruent features in several areas of school PE policy and undoubtedly in some specific areas of practice. It is clear that in some countries there have been positive developments, which have contributed to an improved situation in the status of school PE, and there are instances of favourably implemented programmes and good practices. Equally there is evidence to generate sustained considerable disquiet about the situation. Thus, the review of the current situation of PE in Europe is marked by "mixed messages" with indicators of stabilization in some countries juxtaposed between positive, effective policy initiatives in other countries and reticence or little political will to act and continuing concerns in others. Many governments have committed themselves through legislation to making provision for PE but they have been (or are being) slow in translating this into action. The gap between policy and practice intimated by the Council of Europe Deputy Secretary General [36] in September 2002 in her comment "the crux of the issue is that there is too much of a gap between the promise and the reality" (p. 2) remains. The "gap" is seen in the rhetoric of official documentation on principles, policies and aims and actual implementation into practice, which exposes a range of deficiencies in PE in schools in Europe. There are considerable inadequacies in facility and equipment supply frequently associated with under-funding, especially in economically underdeveloped and developing countries and regions at a time of concern over falling fitness standards of young people, increased levels of obesity and related health issues and continuing youth dropout rates from physical/sporting activity engagement. There is evidence of general under-funding of PE/school sport as well as the low remuneration of PE/sport teachers in some countries. There is disquiet about teacher supply and quality: insufficiency and inadequacy of appropriately trained and qualified PE teachers are widely evident. Curriculum time allocation is a concern in some countries and the overall reduction in average time allocation for school PE curricula in both primary and secondary schools across Europe is a worrying trend.

The amount of curriculum time allocation represents an important issue for the delivery of quality PE. There is considerable scientific evidence to suggest that at least 60 min daily moderate to vigorous physical activity is necessary to sustain a healthy active lifestyle. EUPEA recommends daily PE in the early years of schooling (elementary grades, up to 11 or 12 years of age and 3 hours (180 min) per week in post-elementary (secondary/high schools) grades. In the United States, the National Association for Sport and Physical Education (NASPE) recommends a minimum of 150 min per week for physical education in elementary schools and 225 min per week for middle and high school students. *Recommendations* by the Council of Europe Committee of Ministers on 30 April 2003 included a significant reference to physical education time allocation: an agreement to "move towards a compulsory legal minimum of 180 min weekly, in three periods, with schools endeavouring to go beyond this minimum where this is possible" [10] and a call for one hour of daily physical activity in or out-of-school settings.

There are notable features concerning differential variations between central and eastern European EU Member states and the "older" 15 Member States. The "east-west divide" highlighted in references to facilities and equipment extends beyond this resource issue to embrace post-2000 PE curriculum time allocation reductions and provision for pupils with disabilities. Compared with the older, "western" Member States (over two thirds report stabilisation), the level of stabilisation of curriculum time allocation (2000–2006) is less in "newer" central and eastern EU Member States and since 2000, PE time allocation has been reduced more extensively in central and eastern EU States than in counterpart "western" EU States. Similarly in the domain of disability, survey data indicate that there are fewer opportunities (only 12% of countries) to "do" PE and for inclusion in "Mainstream" schools in central and eastern EU countries than in other parts of Europe. Moreover in central and eastern Europe inclusion in "normal" PE lessons is less than the overall EU average (32% as opposed to 45%). Also, facility provision for pupils with disabilities is a more acute problem in central and eastern Europe (60% of countries report defi-

ciencies, whereas only 25% report deficiencies in western Europe). Conversely, lack of staff expertise is perceived to be greater in western Europe than in eastern European countries.

Countries, via the relevant agency authorities, should identify existing areas of inadequacies and should strive to develop a basic needs model in which physical education activity has an essential presence and is integrated with educational policies supported by governmental and non-governmental agencies working co-operatively in partnership(s). Satisfaction of these basic needs requires high quality conceptually and contextually adjusted PE curricular programmes, provision of equipment and basic facilities, safe environments and appropriately qualified/experienced personnel, who have the necessary relevant knowledge, skills and general and specific competences according to the level and stage of involvement together with opportunities for enrichment through continuing professional development.

As a school's role extends to encouraging young people to continue participation in physical activity, through the provision of links and co-ordinated opportunities for all young people at all levels and by developing partnerships with the wider community to extend and improve the opportunities available for them to remain physically active, there is a need for wider **community-based partnerships**, for which PE should be seen as the cornerstone of systematic physical activity promotion in schools and recognised as the foundation base of the inclusive participation pyramid. Participation Pathway Partnerships is a key term for future directions in the best interests of PE and sporting, (particularly recreational) activity in and out of schools. If children are to be moved from "play stations" to "play-grounds" [37], bridges and pathways to community provision need to be constructed, especially to stimulate young people to participate in physical activity during their leisure time. The post-school gap is as much in the system as in participation, for many children are not made aware of, and how to negotiate, the multifarious pathways to opportunities. Physical educators are strategically well placed to reach the widest range of young people with positive experiences in, and messages about, participation in physical activity. They have key roles as facilitators and intermediaries between the school and wider local communities. They should identify and develop pathways for young people to continue participating in physical activity after and outside school and ensure that information is available to young people within school on the opportunities available in the local community. However, it is naïve to assume that the PE professional can take on and fulfil all of these responsibilities. Support, particularly of the human resource kind, is fundamental to the realisation of such ideals. It can be achieved through collaborative, co-operative partnership approaches involving other professionals and committed, dedicated and properly mentored individual and group volunteer enthusiasts.

With the increase in rates of inactivity and associated risk factors of overweight, obesity and personal health amongst children of school age and the limited time allocations to school PE and sport, the sport movement will represent a significant supplementary (and complementary) domain of efforts to stimulate engagement of this target group of young people in physical and sport-related activity across Europe. International non-governmental agencies such as the International Sport and Culture Association (ISCA) and the European Non-Governmental Sports Organisation (ENGSO) as well as national and local sports bodies can (and should be encouraged to) contribute to the process of motivation of young people to regularly participate in recreational sport and so adopt physically active lifestyles. Such voluntary sector organisations have important roles in assisting in the transition from school to community-based sport throughout the region [35]. A cause of some concern is that many volunteers lack formal training to work with young people and in a world of rising levels of child abuse as well as the propensity of some volunteers to inculcate perceived and actual negative attitudinal and behavioural norms and values, this is an issue to be addressed. Indeed, the ENGSO incorporated recommendations pertinent to volunteer involvement in its 1998 *Guidelines for Children and Youth Sport* [38]. Nevertheless, volunteers can bring knowledge, skills, commitment and dedication as a free time resource and there is a need to have a balanced view of their work by key actors and appropriate frameworks to work within, not least of which might be adherence to Codes as Ethics, such as those proposed by the European Physical Education Association in 2002. EUPEA's *Code of Ethics and Good Practice Guide* [39] has adopted the principles contained in the Council of Europe's Code of Sports Ethics. The Code offers a framework of guidelines and is intended for use in conjunction with similar guides on ethics produced by governments, education authorities and recognised national governing bodies of sport. It outlines some of the

key issues that need to be addressed in school PE and sport by teachers and helpers (volunteers), who need to operate within an accepted ethical framework of good practice, which guides the individual. Issues include: integrity and respect in relationships, various forms of child abuse and protection there from, bullying, anti-social behaviours, equality and inclusion, stress and burn-out, fair play and a balanced approach to winning, stress and burn-out, fun and enjoyment.

There is a narrow and unjustifiable conception of the role of PE merely to provide experiences, which serve to reinforce achievement-orientated competition performance sport, thus limiting participatory options rather than expanding horizons. Also of some concern are levels of curriculum implementation and monitoring and large class sizes. The falling fitness standards and high youth dropout rates from physical/sporting activity engagement are exacerbated in some countries by insufficient and/or inadequate school-community co-ordination and problems of communication. Physical education delivery will benefit from re-orientation towards placing more responsibility on students for their learning with the managerial responsibility of the teacher progressively transferred to pupils. The enhanced pupil involvement generated by this process will assist in facilitation of opportunities for individual meaningful and socially relevant experiences [40]. Reflective practitioners will translate into reflective students! Initial and in-service training/further professional development should properly address these pedagogical developments. This is particularly important in primary/elementary schools, preparation for which is often generalist rather than specialist.

Finally, it is imperative that **monitoring of developments in physical education** across the world be maintained. The Council of Europe, UNESCO and the WHO have called for monitoring systems to be put into place to regularly review the situation of physical education in each country. The Council of Europe [10] referred to the introduction of provision for a pan-European survey on physical education policies and practices every five years as a priority! The European Parliament's entry into the PE arena with its *Current Situation and Prospects for Physical Education in the European Union* Study is one example of the monitoring process in action and importantly provides an opportunity to assist in converting "Promises" into "Reality" and so helps in the process of surmounting threats to a sustained safe future for physical education in schools. Otherwise with the Council of Europe Deputy Secretary General's intimation of a gap between "promise" and "reality", there is a real danger that the well intentioned initiatives will remain more "promise" than "reality" in too many countries in Europe and indeed across the world.

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THE ROLE OF PHYSICAL ACTIVITY IN THE LIFESTYLE OF THE INHABITANTS OF THE LIBEREC REGION

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ABSTRACT

Purpose. The aim of the study is to characterize physical activity and physical inactivity of the inhabitants of the Liberec region in their common life. **Basic procedures.** The research sample consisted of 818 males and 831 females aged 15–69, which were either systematically or randomly drawn from throughout the region. Physical activity and its correlates were assessed using the IPAQ questionnaire. **Main findings.** According to self-reported data, 10% of the inhabitants are insufficiently physically active, 30% are sufficiently physically active, and 60% are highly physically active. The median of performed physical activity in the inhabitants in Liberec region expressed in MET · min^{-1} · week^{-1} was 3822 MET · min^{-1} · week^{-1} (IQR = 4371). On average, men spent sitting 393 min and women 415 min in total during a working day. Out of the total sample of respondents, 58% of the inhabitants in the Liberec region were of normal weight, 9% were underweight, 23% were overweight and 10% obese. **Conclusions.** These facts point to the necessity of increasing knowledge about the negative impacts of inactive behavior and emphasizing the advantages of performing regular physical activity along with the need to establish such conditions that would contribute to physical activity performance.

Key words: IPAQ, BMI, inactivity, intensity, correlates

Introduction

The decline in physical activity is one the characteristics that are monitored worldwide, and not only in relation to obesity and overweight [1–4]. It is essential to distinguish between physical activity and energy expenditure as these are not identical terms. Physical activity is defined as behavior that results in energy expenditure and is often described using FITT characteristics (frequency, intensity, time, type). The energy expenditure or its energy equivalent in MET is through the level of metabolism or PA intensity associated with the particular physical activity and thus is the indicator of the level of the physical activity [5].

The positive effect of regularly performed physical activity is well reflected in literature. Regular physical activity of optimal intensity and duration positively influences the efficiency of cardiovascular system, diabetes mellitus, hypertension, osteoporosis, overweight, mental health, etc. [6–8]. Recommendations for and effective intervention in physical activity regimes should be based on a standardized tool for assessing physical activity, which would allow such assessment to be made according to different intensities and different contexts [9]. The standardized International Physical Activity Questionnaire (IPAQ) can be applied as such a tool, since it also allows international comparisons and identification of the correlates of physical activity.

The aim of the study is to characterize physical activity and physical inactivity of the inhabitants of the Liberec region in their common lives. Further, through providing the findings to regional policy-makers to facilitate the improvement of the conditions necessary for active lifestyle of the inhabitants.

Material and methods

The survey was carried out as a part of the nationwide research of physical activity which itself was a part of an international research called International Physical Activity Questionnaire Prevalence Study. Physical activity was assessed using the IPAQ, namely its internationally standardized short administrative version

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[10, 11]. The questionnaire assesses physical activity performed during the past seven days. It makes it possible to compare physical activity of vigorous and moderate intensity, walking and sitting in relation to other personal, demographic and environmental data. The data were collected in 2002–2004. In total, four surveys were carried out during this period; in two fall terms and two spring terms. The questionnaires were distributed systematically and randomly. Overall, 1649 questionnaires were collected from the respondents aged 15–69 in the Liberec region (818 men and 831 women). The Liberec province is a mountainous area offering lots of opportunities for physical activity. Any changes to the collected data were done in compliance with the internationally implemented guidelines for data processing issued by the "IPAQ Research Committee" (for more information, visit www.ipaq.ki.se). When assessing the intensity of physical activity in METs, vigorous activity was set to equal the energy expenditure of 6 METs, moderate activity of 4 METs, and walking of 3.3 METs.

The overall average physical activity expressed in terms of $MET \cdot min^{-1} \cdot week^{-1}$ was calculated from average minute data for a given physical activity (vigorous PA, moderate PA, walking) multiplied by the appropriate energy equivalent in METs for the given physical activity intensity. The sum of the values of vigorous PA, moderate PA, and walking in terms of $MET \cdot min^{-1} \cdot week^{-1}$ expresses the total physical activity.

The participants were divided into age groups of 15–29, 30–49 and 50–69 for further analyses. The basic characteristics of the sample according to age are given in Tab. 1. Based on the Body Mass Index (BMI), the participants were classified into the following categories in compliance with the classification by Placheta et al. [12]. BMI is defined as the individual's body weight divided by the square of their height. The formulas universally used in medicine produce a unit of measure kg/m^2. Underweight men have the BMI of $< 20\ kg \cdot m^{-2}$ and underweight women have BMI $< 19\ kg \cdot m^{-2}$. BMI in the range of 20–24.9 $kg \cdot m^{-2}$ for men and 19–23.9 $kg \cdot m^{-2}$ for women denotes normal weight. BMI values in the range of 25–29.9 $kg \cdot m^{-2}$ for men and 24–28.9 $kg \cdot m^{-2}$ for women denote overweight.

BMI values over 30 $kg \cdot m^{-2}$ in men and over 29 $kg \cdot m^{-2}$ in women inclusive denote severe or morbid obesity. In order to assess the level of activity, we follow the classification by Abu-Omar et al. [9], who consider the respondents to be sufficiently physically active if they reach the minimal level of 600 $MET \cdot min^{-1} \cdot week^{-1}$ and as highly physically active if they reach the minimal level of 1500 $MET \cdot min^{-1} \cdot week^{-1}$ (for more information, visit www.ipaq.ki.se). The persons who have not reached the level of 600 $MET \cdot min^{-1} \cdot week^{-1}$ are insufficiently physically active.

In order to assess the significant differences, use was made of the non-parametric Kruskal-Wallis test along with the effect size coefficient η^2, the values of which are: $\eta^2 = 0.01$ for low, $\eta^2 = 0.06$ for medium and $\eta^2 = 0.14$ for high effect [13].

Results

The results show that men overall performed vigorous physical activity 2.46 days in a week, moderate physical activity 2.87 days in a week and walking 5.30 in a week. Women performed vigorous physical activity 1.72 days in a week, moderate physical activity 2.4 days in a week and walking 5.65 in a week. Other results concerning the performance of physical activity and sitting differentiated according to age categories are presented in Tab. 2.

In total, regardless of the age, men show higher level of physical activity than women ($H_{1, 1649} = 16.03$, $p = 0.0001$,

Table 1. Characteristics of the sample (weight, height, BMI, age)

Age	Sex	Weight (kg) M (SD)	Height (cm) M (SD)	BMI ($kg \cdot m^{-2}$) M (SD)	Average age in the category M (SD)
Aged 15–29	Males (n = 363)	74.62 (10.75)	179.99 (8.15)	23.00 (2.77)	21.66 (5.88)
	Females (n = 330)	58.81 (7.61)	137.84 (6.59)	20.87 (2.39)	21.61 (4.06)
Aged 30–49	Males (n = 296)	83.33 (11.10)	180.12 (7.37)	25.69 (3.22)	41.42 (5.88)
	Females (n = 337)	65.53 (10.94)	166.94 (5.83)	23.51 (3.74)	41.19 (5.44)
Aged 50–69	Males (n = 159)	84.52 (12.51)	176.99 (6.88)	26.92 (3.55)	55.58 (4.95)
	Females (n = 164)	71.05 (11.32)	164.91 (6.17)	26.15 (4.09)	55.85 (5.27)

M – mean, SD – standard deviation, n – the size of the sample

Table 2. Average data on physical activity performance and sitting depending on age

Physical activity		Aged 15–29				Aged 30–49				Aged 50–69			
		Males (n = 363)		Females (n = 330)		Males (n = 296)		Females (n = 337)		Males (n = 159)		Females (n = 164)	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Vigorous PA	day·week^{-1}	2.74	2.19	2.07	1.87	2.34	2.07	1.60	1.94	2.04	2.05	1.25	1.83
	min·week^{-1}	311	362	198	257	299	373	168	275	279	387	127	231
Moderate PA	day·week^{-1}	2.89	2.16	2.43	2.05	2.85	2.19	2.44	2.23	2.82	2.50	2.33	2.17
	min·week^{-1}	296	348	218	282	337	381	427	348	345	442	247	328
Walking	day·week^{-1}	5.50	2.04	5.82	1.87	5.10	2.35	5.53	1.88	5.22	2.21	5.56	1.89
	min·week^{-1}	593	505	969	529	605	514	683	563	624	544	702	542
Sitting	min·workday^{-1}	408	181	429	177	377	188	401	179	389	194	418	175

PA – physical activity, M – mean, SD – standard deviation, n – the size of the sample

Table 3. Assessment of the differences in the total weekly physical activity depending on sex and age (MET·min^{-1}·week^{-1})

Age category	Sex	n	Mdn	IQR	H	p	η^2
Aged 15–29	men	363	4158	4452	3.22	0.073	0.005
	women	330	3879	3918			
Aged 30–49	men	296	4152	4704	**10.99**	**0.001**	**0.017**
	women	337	3383	4011			
Aged 50–69	men	159	3726	6270	2.77	0.096	0.008
	women	164	3306	4626			
Aged 15–69	men	818	4020	4833	**16.03**	**0.0001**	**0.010**
	women	831	3537	4143			

n – the size of the (sub)sample, Mdn – median, IQR – inter-quartile range, H – testing criterion of Kruskal-Wallis test, p – the level of statistical significance, η^2 – coefficient of effect size

$\eta^2 = 0.01$). Based on a more detailed analysis, we can conclude that there is significantly higher level of physical activity in men only in the age category of 30–49; in other age categories this premise has not been confirmed (see Tab. 3).

According to the self-reported data, 10% of the inhabitants are insufficiently physically active, 30% are sufficiently physically active and 60% are highly physically active. In the age category of 15–29, we have identified only 8% of respondents who were insufficiently active, 27% are sufficiently active and 65% are highly physically active. In the age category of 30–49, 11% of respondents were insufficiently active, 32% are sufficiently active and 57% are highly physically active. In the oldest age group of 50–69, we identified 15% of respondents who were insufficiently active, 32% are sufficiently active and 53% are highly physically active.

The development of physical activity depending on sex and the intensity of load is described in Fig. 1. Women perform less vigorous physical activity than men ($H_{1,1649} = 68.5$, $p < 0.0001$, $\eta^2 = 0.04$), but the differences are of low logical significance. Statistically significant

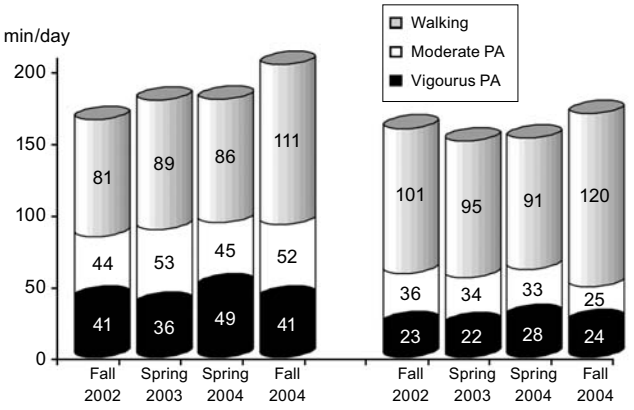

Figure 1. Physical activity (PA) in men and women aged 15–69 (min·day^{-1})

differences, but not logical differences, are also found in moderate physical activity $H_{1,1649} = 2.87$, $p < 0.0001$, $\eta^2 = 0.001$). In walking, there are found higher values in women than in men ($H_{1,1649} = 11.09$, $p < 0.001$, $\eta^2 = 0.006$) but the difference is not considered logically significant again. The median of physical activity of the inhabitants

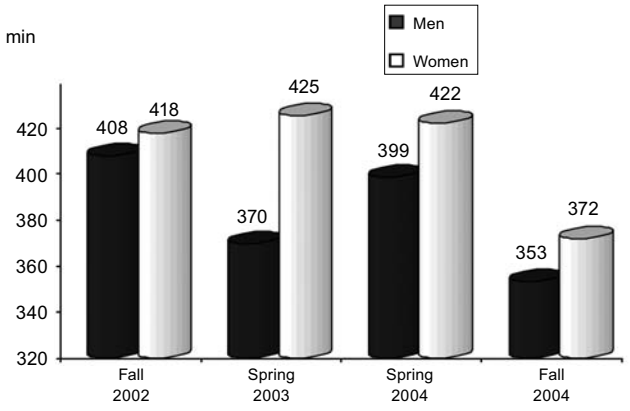

Figure 2. The time spent sitting in men and women (aged 15–69) – an average value for one working day

in the Liberec region expressed in MET-min·week^{-1} was 3822 MET·min^{-1}·week^{-1} (IQR = 4371).

The assessment of the differences between men and women based on the total time spent performing physical activity proves that men are more active than women ($H_{1,1649}$ = 6.75, p = 0.009, η^2 = 0.004) but according to the coefficient η^2 these differences are not significant.

The evaluation of the time spent sitting during five working days shows that women spend significantly more time sitting than men ($H_{1,1649}$ = 7.50, p = 0.006, η^2 = 0.005), yet logical significance has not confirmed these differences (Fig. 2). In total, men spend on average 393 minutes and women 415 minutes sitting during one working day.

Table 4. The evaluation of physical activity of different intensity for various weight groups (based on BMI) – women aged 15–69 (MET·min^{-1}·week^{-1})

Activity	Weight (based on BMI)	n	Mdn	IQR	H	p	η^2
Vigorous PA	underweight	73	1080	2160	**17.20**	**0.001**	**0.021**
	normal	488	540	1440			
	overweight	191	120	1080			
	obesity	79	0	1080			
Moderate PA	underweight	73	480	960	0.45	0.930	0.001
	normal	488	480	1080			
	overweight	191	480	1440			
	obesity	79	480	1920			
Walking	underweight	73	1386	2970	1.55	0.670	0.002
	normal	488	1584	2772			
	overweight	191	1980	3465			
	obesity	79	1584	3465			

PA – physical activity, n – the size of the (sub)sample, Mdn – median, IQR – inter-quartile range, H – testing criterion of Kruskal-Wallis test, p – the level of statistical significance, η^2 – coefficient of effect size

Table 5. The evaluation of physical activity of different intensity for various weight groups (based on BMI) – men aged 15–69 (MET·min^{-1}·week^{-1})

Activity	Weight (based on BMI)	n	Mdn	IQR	H	p	η^2
Vigorous PA	underweight	48	720	2295	**15.35**	**0.002**	**0.019**
	normal	431	1440	2700			
	overweight	270	1080	2520			
	obesity	69	360	2160			
Moderate PA	underweight	48	720	1080	3.51	0.320	0.004
	normal	431	720	1680			
	overweight	270	720	1680			
	obesity	69	840	1200			
Walking	underweight	48	1386	2376	0.11	0.990	0.000
	normal	431	1386	2178			
	overweight	270	1386	2524			
	obesity	69	1485	2871			

PA – physical activity, n – the size of the (sub)sample, Mdn – median, IQR – inter-quartile range, H – testing criterion of Kruskal-Wallis test, p – the level of statistical significance, η^2 – coefficient of effect size

The greatest differences between underweight women, women with normal weight, overweight women and obese women have been identified in vigorous physical activity ($H_{3, 831} = 17.2$, $p = 0.001$, $\eta^2 = 0.021$). We can say that women with a low BMI perform more vigorous physical activity. Times spent performing moderate physical activity and walking are similar in all BMI groups (Tab. 4). Analogous results are also found in men (Tab. 5). Significant differences between the BMI groups are identified only in vigorous physical activity ($H = 15.35$, $p = 0.02$, $\eta^2 = 0.019$). Significant differences we not reported between the individual BMI categories in men for moderate physical activity and walking.

Upon assessing the correlates of physical activity such as the size of residence (number of inhabitants) and lifestyle (single, in family, in family with children), the most frequently appearing significant differences were reported in the age category of 15–29 years. For example, participants living in residences of smaller sizes are reported to show significantly higher level of physical activity ($H_{3,1165} = 19.83$, $p < 0.001$, $\eta^2 = 0.12$) (Tab. 6).

Despite a general expectation that smokers perform less physical activity than non-smokers, this premise has been proved only in the age category of 15–29 ($H_{1, 691} = 5.509$, $p = 0.019$, $\eta^2 = 0.008$). However, according to the coefficient η^2, the differences are not logically significant. In the other age categories, physical activity of smokers and non-smokers is similar. Out of the total sample, 75% were non-smokers, 24% were smokers and 1% did not answer.

Table 6. Assessing physical activity in relation to the size of residence (number of inhabitants) and age category (MET · min^{-1} · week^{-1})

Age category	Size of residence	*n*	Mdn	IQR	H	*p*	η^2
Aged 15–29	> 100 000	141	3516	3348	**17.30**	**0.001**	**0.025**
	30 000–100 000	208	3362	4079			
	1 000–29 999	228	4554	4011			
	< 1 000	111	5199	4725			
Aged 30–49	> 100 000	90	3746	4212	6.19	0.103	0.010
	30 000–100 000	187	3024	4068			
	1 000–29 999	241	3972	4452			
	< 1 000	110	4128	4743			
Aged 50–69	> 100 000	59	3399	4398	2.48	0.479	0.008
	30 000–100 000	87	3465	4269			
	1 000–29 999	130	3251	5091			
	< 1 000	43	4986	5754			
Aged 15–69	> 100 000	290	3621	4056	**19.83**	**0.000**	**0.012**
	30 000–100 000	482	3318	4066			
	1 000–29 999	599	4035	4572			
	< 1 000	264	4553	4548			

n – the size of the (sub)sample, Mdn – median, IQR – inter-quartile range, H – testing criterion of Kruskal-Wallis test, *p* – the level of statistical significance, η^2 – coefficient of effect size

Table 7. Assessing physical activity of smokers and non-smokers in relation to age category (MET · min^{-1} · week^{-1})

Age category	Smoking	*n*	Mdn	IQR	H	*p*	η^2
Aged 15–29	smokers	157	3300	4331	**5.509**	**0.019**	0.008
	non-smokers	534	4239	4059			
Aged 30–49	smokers	163	3546	4137	0.122	0.727	0.000
	non-smokers	461	3750	4489			
Aged 50–69	smokers	77	4128	5646	0.622	0.430	0.002
	non-smokers	241	3519	4539			
Aged 15–69	smokers	397	3486	4509	0.739	0.390	0.000
	non-smokers	1236	3966	4369			

n – the size of the (sub)sample, Mdn – median, IQR – inter-quartile range, H – testing criterion of Kruskal-Wallis test, *p* – the level of statistical significance, η^2 – coefficient of effect size

Similarly, we cannot confirm that physical activity is influenced by the way a respondent lives (single, in a family, in a family with children). Significant differences are affirmed only in the age category of 15–29 ($H_{2, 683} = 6.608$, $p = 0.037$, $\eta^2 = 0.009$), where the single living respondents performed less physical activity than the other respondents but the differences were not logically significant. In the other age categories and in the total sample the correlate of lifestyle does not influence physical activity.

Discussion

Our study has not proved the premise that men are more physically active than women in all age categories. Men perform more physical activity in total and in relation to age categories in the category of 30–49. Previous studies reported differences also in the age category of 15–29, but this study has not confirmed it. The study by Trost et al. [3] and other studies that applied monitoring of physical activity using the accelerometer CSA have usually reaffirmed the differences in physical activity in boys and girls. At the same time, the authors point out the fact that the magnitude of significance of the differences between physical activity in boys and girls is smaller than that documented in studies using questionnaire methods. Based on the analysis of physical activity, we can observe that women perform less vigorous physical activity than men, but on the contrary they walk more.

Regarding the individual self-reported results, the level of physical activity of the inhabitants in the Liberec region appears satisfactory. Only 7% of the inhabitants are insufficiently active, 11% are sufficiently active and 82% are highly active. In comparison to this, for example, the study by Muntner et al. [14] of Chinese population reported that only 66.3% of the subjects were physically active.

Defining the levels of sufficient and high physical activity is in compliance with the general recommendations for physical activity. The recommendations issued by the "IPAQ Executive Committee 2003" are based on the short version of the IPAQ questionnaire. Abu Omar et al. [9] regard subjects to be sufficiently active if they perform vigorous physical activity at least three times a week for the minimum of 20 min per day, or if they perform at least five times a week moderate physical activity or walking for the minimum of 30 min a day, or if they perform any combination of moderate or vigorous physical activity reaching the minimum of 600 MET·min^{-1}·week^{-1}. In addition to that the authors consider the subjects to be highly physically active if they perform vigorous physical activity at least three times a week and reach the minimum of 1500 MET·min^{-1}·week^{-1} or if by the combination of moderate and vigorous activity they reach the minimum of 1500 MET·min^{-1}·week^{-1}. The translation of physical activity into MET·min^{-1}·week^{-1} is based on the compendium by Ainsworth et al. [15]. With regard to the specifics of questionnaire surveys, we consider the established levels for sufficient activity (600 MET·min^{-1}·week^{-1}) and high activity (1500 MET·min^{-1}·week^{-1}) as being too low.

Wilcox et al. [16] report the subjects to be active when they carry out at least three times a week running, cycling, swimming or dancing for the minimum of 20 min at a time or if they perform at least five times a week walking, gardening, calanetics, etc., for the minimum of 30 min at a time.

The median of performed physical activity in the inhabitants of the Liberec region in MET·min^{-1}·week^{-1} was 3822 MET·min^{-1}·week^{-1}, which corresponds to 63.7 MET·hour^{-1}·week^{-1}. In comparison to other European countries, we reached even higher levels than it was reported for The Netherlands in the study by Rütten and Abu-Omar [17] using the IPAQ questionnaire where the identified value was 39.4 MET·hour^{-1}·week^{-1}, which was the highest out of total of 15 countries participating in the study, whereas the average median of all the states was 24 MET·hour^{-1}·week^{-1}.

One of the diseases commonly associated with the lack of physical activity and the imbalance between the energy incomes and expenditure is obesity. The most obvious measure identifying obesity and overweight is the BMI, which denotes overweight as the range of 25–29.9 kg·m^{-2} and obesity as 30 and more kg·m^{-2} [18]. Obesity in American population amounts to 20–30% [19]. Over the past 20 years obesity has increased from 14.5% to 22.5% in the adult American population [20].

In this study, 23% of the inhabitants were overweight and 10% were obese (Fig. 3). It is apparent that we are going along the same route as the advanced industrialized countries as far as these negative indicators are concerned.

Insufficient physical activity is a major cause of the rising prevalence of obesity in western countries [21]. Assessing the association between physical activity and the BMI, we have not found any differences in the lev-

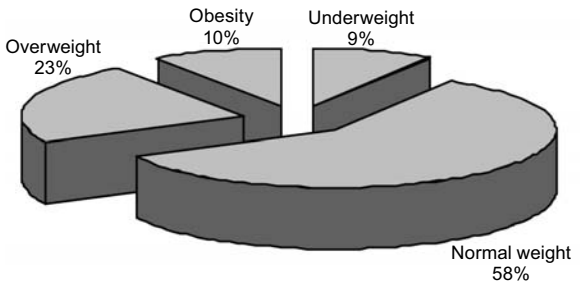

Figure 3. Percentage proportion of the inhabitants in Liberec region adjusted for BMI categories

els of moderate physical activity and walking between the groups of respondents who were underweight, with normal weight, overweight and obese. As opposed to that the findings indicate that overweight and obese respondents perform significantly less vigorous physical activity.

Based on the findings, we foster the assumption that since the groups of underweight subjects and subjects with normal weight perform more vigorous PA than the other groups, the maintenance of "healthy" body weight or body weight reduction could be achieved through vigorous physical activity.

Overweight has become a worsening health problem even in children as a study carried out in 2630 children in Great Britain showed. The findings from this study point out that overweight is observed in the range from 22% in 6 year old children to 31% in 15-year-olds and the range of obesity is from 10% in 6 year old children to 17% in 15 year old children [22]. The dispositional factors for obesity are of both genetic and environmental origin. The risk of becoming obese in a child whose both parents are obese is 80%, in a child who has one parent obese that risk is 40%, and if the parents are not obese the risk is 20% [23]. Heredity amounts to 25–40% in the inter-individual differences in adiposis [24].

When identifying the correlates of physical activity, we investigated the associations between the population density of the residence and physical activity. We have found differences only in the age group of 15–29. As for this age group, we can conclude that the smaller the residence was, the higher the levels of physical activity were observed. Different results, however, were found in a study of leisure time physical activity of women aged 40–49 [16], which showed that women living in villages performed more sedentary behavior and encountered more barriers to participation in physical activity as opposed to women in towns. Batch and Baur [21] assume that in some developing countries and in pure children a greater risk for becoming obese is associated with living in a village, whereas in countries going through economic transition obesity in children is attributed to a more wealthy lifestyle and living in urban areas.

Differences in physical activity between smokers and non-smokers have been identified only in the age category of 15–29, where non-smokers showed significantly more physical activity. In the total number of subjects in the Liberec region, 75% were non-smokers, 24% were smokers and 1% did not answer. In comparison to the results across the nation, the age category of 15–29 in Liberec region comprises 23% of smokers and 77% of non-smokers. On the other hand, Chmelík et al. [25] identified only low number of smokers (17.41%) in a questionnaire survey carried out on a representative sample of the Czech population (n = 3549). The authors found that youths regarding themselves as non-smokers have performed moderate and vigorous physical activities more frequently than youths regarding themselves as smokers.

Conclusions

1. Men are in total more physically active than women.

2. Women perform less vigorous activity than men but they are more active in walking.

3. The total time spent sitting on a working day is 6.5 hours in men and 7 hours in women. To improve the conditions in this area, we recommend to design physical activity regimes for working days and to intervene primarily in sedentary-type of jobs.

4. Based on self-reported data, 7% of the inhabitants of the Liberec region are insufficiently physically active, 11% are sufficiently active and 82% are highly active.

5. Significant differences in relation to BMI are identified only in vigorous physical activity in both men and women. Subjects having lower weight-height BMI coefficient are more physically active.

6. 58% of the inhabitants in the Liberec region are of normal weight, 9% are underweight, 23% are overweight and 10% are obese. It is necessary to intervene in this area and to increase the awareness of the negative effects of physically inactive lifestyle and the positives of regular physical activity. Furthermore, it is important to establish conditions encouraging physical activity.

7. In relation to the size of residence, we have found differences in the age category of 15–29 as well as in total, where the inhabitants of smaller-sized residences (< 30.000) showed more physical activity.

8. Out of the total number of subjects in the Liberec region, 75% regard themselves as non-smokers and 24% as smokers.

9. Non-smokers aged 15–29 perform more physical activity than smokers of the same age.

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THE STATE OF HEALTH OF WOMEN AGED 20–59 AT DIFFERENT LEVELS OF PHYSICAL ACTIVITY

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ABSTRACT

Purpose. The assessment of the state of health of population using positive indices is crucial for health promotion. The following study focuses on the levels of somatic growth and physical fitness of adult women living in small towns and on their dependence on physical activity. **Basic procedures.** The research sample consisted of two groups of women: one consisting of women taking part in health-related training and a control group. All in all, 421 subjects participated in the study aged 20–59 years, divided into age 'decade' cohorts. The procedures applied included measurements of the main somatic parameters and physical fitness tests. **Main findings.** More favorable somatic parameters and a higher level of physical fitness were noted in the training women than in women from the control group. **Conclusions.** Systematic physical activity of two 50-min training units per week is an essential stimulation of women in productive age.

Key words: physical fitness, somatic growth, health-related training

Introduction

The emerging global culture based on the dynamic development of technology, communications and the media has been exerting an unquestionable impact on human beings and their living environment. It might be hazardous, but it is also conducive to fostering important values, including health.

A lifestyle dominated by consumption and passivity, reliant on technological development, isolates man from his natural conditions and inhibits stimuli for proper psycho-physical development [1].

Present-day communication has an inhibitory influence on physical activity. The resultant hypokinesia can be a threat to man's health and social status. Modern civilization presents man with enormous challenges and upsets man's homeostasis and interactions with the social environment. It seems necessary that one's adaptability to physical effort should be increased [2]. At the same time, the concept of health is no longer confined to the domain of medicine. More and more areas of public life become included in the widely understood healthcare and prophylaxis. The assessment of the state of health of a population using the so-called positive indices, i.e. physical activity, physical fitness and somatic parameters, is crucial for health promotion and prevention of diseases, especially civilization diseases. A number of researchers recognize physical fitness as a measure of human health [3–9]. Increased physical activity not only develops one's physical sphere but also different psycho-social aspects of personality. It becomes a significant element of culture and healthy lifestyle of modern man, and – to some degree – compensates for the negative results of the 21st-century civilization [10, 11]. Research shows that systematic physical activity increases resistance to stress and enhances treatment of a number of illnesses and disorders [12–14].

The most anticipated effect of increased physical activity among adults is the maintenance of the most optimal level of circulatory and respiratory parameters, body composition and motor efficiency [4, 11, 15, 16]. A significant reduction in physical activity may lead to adverse changes in the proportion of basic body components, mostly to the growth of adipose tissue. It can be conducive to diseases of the circulatory system and

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metabolic disorders or even death [4, 12, 16–19]. In Poland, about 70% of men and women are at the risk of health loss due to overweight and obesity. This risk increases with the growth in body mass [19–21].

It thus seems necessary to carry out a thorough analysis of the state of health of adult Poles, with regard to community differences, which are still quite extensive in Poland [22]. The data gathered could serve as tools for diagnosis of the so-called positive measures of health and determine the future direction of programs shaping pro-health behavior patterns in society.

The present study focused on the analysis and assessment of selected aspects of the state of health of female inhabitants of the town of Nysa, engaged in different levels of physical activity.

Material and methods

The study was carried out in the town of Nysa (pop: 50 thousand) in the Opole Province, Poland, in 2003. The subjects included a group of 301 women who had participated in some organized forms of physical activity on a regular basis for at least 6 months, and a control group of 120 women, aged 29–59 years. The subjects who practiced aerobics amounted to about 75% of the training women. The group of training women was subdivided into age ('decade') cohorts according to their age. The control group consisted of 30 subjects in each age cohort.

The health training in the group examined was led by an instructor, 2 × 50 min a week. Each 50-min session consisted of three parts: opening (aerobic exercises), main part (exercises aimed at strengthening particular muscle groups) and closing (relaxation exercises and info about a healthy lifestyle).

The following somatic measurements were used in the study: body height and weight to calculate the BMI (body mass index); and the total measurement of skinfold thickness in three anatomical sites (brachial, subscapular, abdominal) [23].

The subjects' physical fitness was measured using the following tests [24]:

- plate tapping test measuring the speed of hand movement (s),
- handgrip test measuring the forearm muscle strength (kG),
- sit and reach test measuring the flexibility of the lower back and hamstring muscles (cm),
- standing broad jump measuring the explosive power of the legs (cm).

The study also used data gathered from a standard questionnaire filled in by the subjects.

The results obtained were processed statistically. The arithmetic mean ($\bar{x}$), standard deviation (SD) and index of variability (v) were used in the statistical analysis. The significance of the differences was measured with Student's t-test for independent variables.

All statistical calculations were made in the Laboratory of Biokinetics and Statistics of the Chair of Anthropokinetics in the University School of Physical Education, Wrocław, using the Statistica for Windows 6.0 software package.

Results

Body height and weight

In the cohort of 20-year-olds the training women were significantly higher than their non-training counterparts. In other age (decade) cohorts the body height revealed non-significant differences. The body height was lower with age, both in the group of training women and in the control group. The low indices of variability demonstrated a significant uniformity of body height in the other cohorts.

The body weight was observed to increase with age. The most slender body build was observed among the 20-year-olds. In other age cohorts, both in the training women and the control group, the body weight increased. The non-training women were significantly heavier than the training subjects, and in the cohort of 40-year-olds the difference amounted to 7 kg between both groups under study.

The statistical spread pointed to a significant variability in the subjects' body build, much higher among the non-training women (Tab. 1).

Body mass index (BMI) and fat tissue

The body mass index (BMI) is commonly used to assess body fat deposition, obesity and nutritional status. It is also used to estimate the body mass as a phenotypical characteristic determined by genetic makeup and environmental influences [22, 23, 26, 27].

The mean BMI increased with age in the groups of physically active and inactive women, however it was much higher in the latter (Fig. 1).

The BMI showed significant differences between the active and inactive women in favor of the former,

Table 1. Statistical analysis of selected somatic and motor parameters in women under study

Parameter	Age cohort	Training			Non-training		
		$\bar{x}$	SD	v	$\bar{x}$	SD	v
Age (years)	20–29	24.47	2.94	12.03	24.43	3.66	15.00
	30–39	33.63	2.91	8.64	34.40	3.06	8.89
	40–49	44.25	2.93	6.61	44.67	2.68	6.01
	50–59	53.95	2.78	5.15	53.77	3.05	5.67
Body height (cm)	20–29	167.50	6.04	3.61	165.25	7.61	4.61
	30–39	165.74	6.47	3.90	165.00	5.57	3.38
	40–49	163.52	6.45	3.94	163.65	6.65	4.06
	50–59	161.50	4.99	3.09	162.42	5.69	3.51
Body weight (kg)	20–29	58.50	8.87	15.15	60.31	9.71	16.10
	30–39	**63.02**	9.81	15.57	67.23	11.52	17.14
	40–49	**65.35**	9.00	13.77	72.91	10.92	14.98
	50–59	**67.91**	8.64	12.72	73.16	12.50	17.09
BMI	20–29	20.79	2.50	12.01	22.12	3.64	16.46
	30–39	**22.89**	2.89	12.61	24.69	4.11	16.63
	40–49	**24.43**	3.12	12.76	27.25	4.09	15.02
	50–59	**26.05**	3.22	12.36	27.69	4.17	15.07
Skinfold thickness (mm)	20–29	**52.62**	13.53	25.70	63.72	16.63	26.10
	30–39	**64.41**	15.46	20.01	74.17	17.26	23.27
	40–49	**69.74**	17.51	25.11	85.69	16.03	18.70
	50–59	**77.30**	13.82	17.88	88.70	16.12	18.18
Plate tapping (s)	20–29	**12.31**	1.07	8.70	15.33	2.13	13.90
	30–39	**13.49**	1.95	14.44	15.31	2.42	15.80
	40–49	**14.19**	1.73	12.20	16.56	3.19	19.29
	50–59	**15.68**	1.72	10.99	16.62	2.59	15.57
Sit and reach (cm)	20–29	**26.78**	5.52	20.60	21.10	6.57	31.11
	30–39	**26.90**	5.29	19.68	21.23	6.04	28.43
	40–49	**26.23**	5.30	20.21	19.32	5.70	29.49
	50–59	**24.50**	6.24	25.46	18.04	6.31	34.99
Handgrip strength (kG)	20–29	33.87	4.27	12.60	32.43	4.40	13.57
	30–39	**34.03**	4.58	13.47	31.83	3.20	10.04
	40–49	33.33	3.79	11.38	31.70	4.79	15.10
	50–59	30.61	3.25	10.61	29.23	3.95	13.50
Standing broad jump (cm)	20–29	**162.86**	17.89	10.99	140.37	19.62	13.98
	30–39	**150.58**	14.01	9.31	131.10	13.78	10.51
	40–49	**136.26**	15.67	11.50	116.13	19.11	16.46
	50–59	**120.49**	14.72	12.22	112.87	13.59	12.04

Statistical significance at $p < 0.05$ in bold

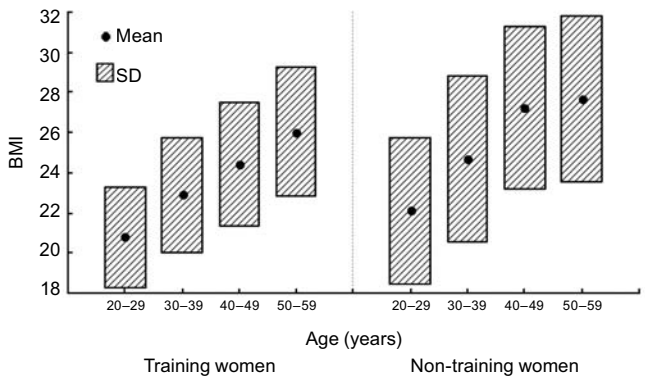

Figure 1. Mean BMI of women under study

with the exception of the youngest cohort where the difference was statistically non-significant.

The lower values of the index of variability among the training women point to a greater uniformity of the index values with reference to the control cohorts.

The World Health Organization (WHO) [28] describes the BMI ranges in the following weight statistical categories: underweight (to 18.49), normal (18.5–24.9), overweight (25–29.9) and obesity (30 and more).

The sample under study was predominantly in the normal range, with the exception of the oldest cohort in which 50% of subjects were overweight. The percent-

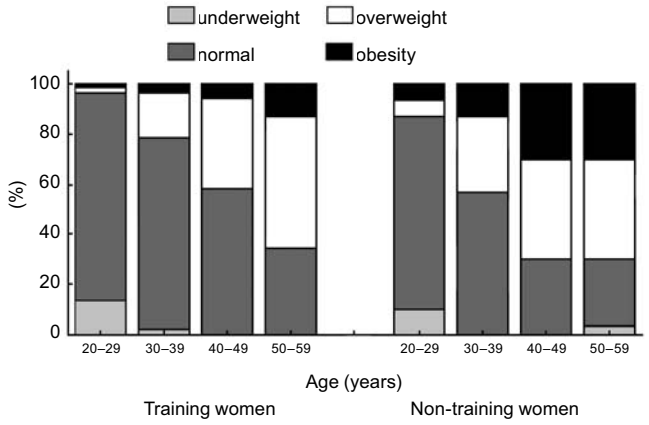

Figure 2. Percentage BMI values according to WHO ranges

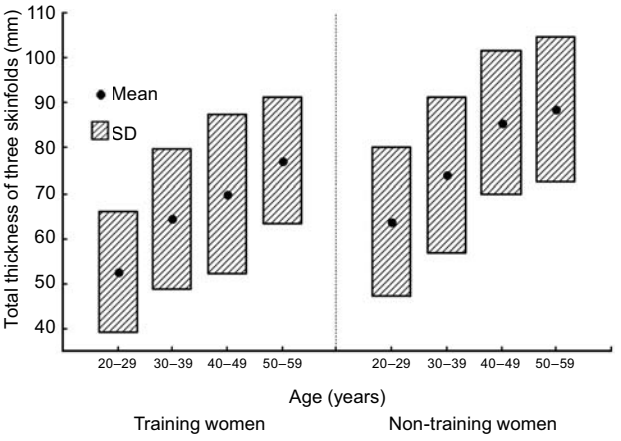

Figure 3. Mean total thickness of three skinfolds

age of the index value in the normal range (18.5–24.99) decreases with age, while the percentage of overweight and obese women increases (Fig. 2).

The analysis showed that young women up to 30 years of age had similar BMI values. The majority of physically active women were slender, whereas the majority of non-training women were overweight or obese. Among the 30-year-old physically inactive women, the number of overweight and obese subjects exceeded 40%; while it was twice as low in the group of training women. Among the 40-year-olds and 50-year-olds in the control group only 30% were in the normal range. In the other cohorts of the control group 30% were obese and 40% were overweight. In the cohorts of 40-year-old and 50-year-old physically active women the number of obese persons amounted to 5 and 12%, and of overweight persons to 34% and 50% respectively. Nearly 60% of the 40-year-old training women were in the normal BMI range. In the cohort of 50-year-olds the percentage in the normal BMI range was below 40%.

The skinfold thickness significantly increases with age in both groups under study. However, in the parallel cohorts in the group of physically active women the amount of fat tissue was significantly lower than in the group of non-training women. The measures of statistical spread pointed to a great variability within the groups under study (Fig. 3).

All in all, it can be concluded that the subjects undergoing health training achieve better BMI and skinfold thickness values than the subjects from the control group. In the case of the former more women were in the normal BMI range, and a decisively smaller number in the overweight and obese ranges.

Speed of hand movement

As expected the speed of hand movement, as measured with the plate tapping test, increases with subjects' age, and the longer performance of the test performance indicates a decreasing hand speed (Fig. 4).

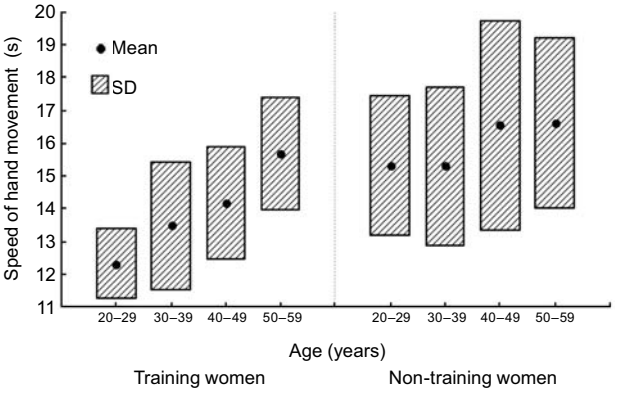

Figure 4. Mean speed of hand movement

The analysis of differences between the cohorts of training and non-training women revealed that the former achieved a significantly shorter performance time of the plate tapping test than their non-training counterparts.

The values of the index of variability in the group of training women were lower than in subjects from the control group and they show that physically active women are more uniform in hand movement speed than their counterparts from the control group.

Flexibility of the lower back and hamstring muscles

Flexibility is an element of physical fitness, which particularly determines an individual's wholesomeness and independence. The sit and reach test performed with the subject's sitting on the floor with legs out straight ahead was chosen for the study as a determinant of flexibility of the lower back and hamstring muscles.

The flexibility remained at a similar level among the training women between 20 and 49 years of age; the test results were lower among the 50-year-old subjects. In the non-training women the flexibility level was significantly lower than in their training counterparts (Fig. 5).

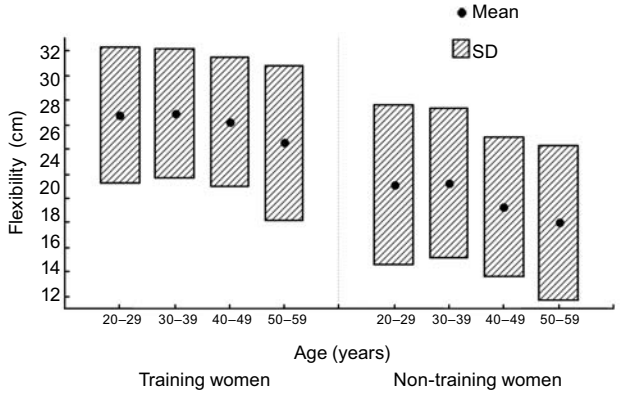

Figure 5. Mean flexibility of the lower back and hamstring muscles

The mean results of the sit and reach test revealed statistically significant differences between all cohorts of training women and their counterparts from the control group. The values of index of variability indicates greater uniformity of results among the training subjects than subjects from the control group.

Forearm muscle strength

In the group of training women the forearm muscle strength decreased starting with the fifth decade of life. In the younger age cohorts the test results were at a similar level (Fig. 6).

The declining muscle strength with age was also observed in the control group. A significant decrease in muscle strength was recorded in women over 50 years of age. Non-training women featured lower muscle strength than their physically active counterparts in each age cohort.

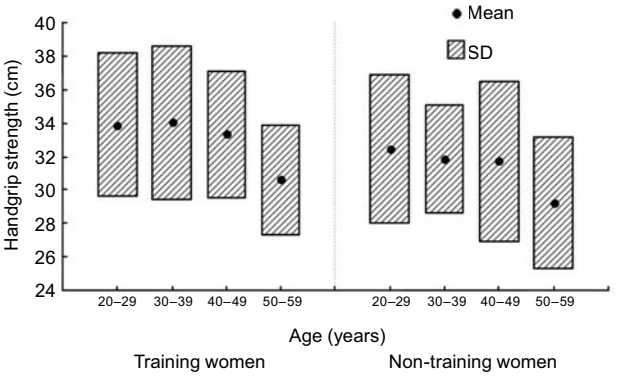

Figure 6. Mean forearm muscle strength

Explosive power of the legs

In terms of explosive power of the legs the standing broad jump test results were lower with age in both groups of subjects under study, which is clearly linked to the involutional processes in the human body. A comparison of the mean results of the standing broad test in both groups under study yielded statistically significant differences between all age cohorts. The physically active women achieved a significantly higher level of the explosive power of the legs than women in the control group (Fig. 7).

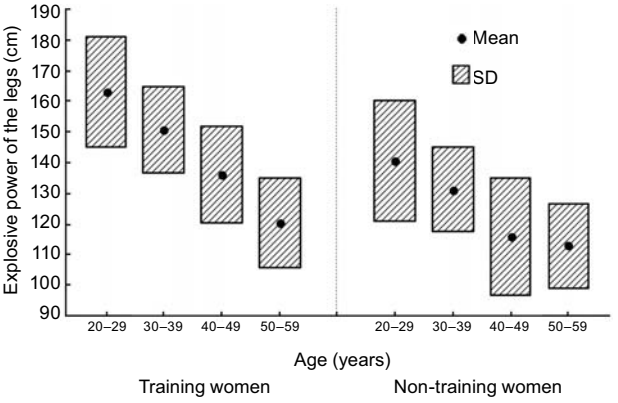

Figure 7. Mean explosive power of the legs

Discussion

Systematic and regular physical activity is an inseparable element of a healthy lifestyle, which definitively positively affects one's state of health and life quality. Numerous studies carried out in different countries have shown that a low level of education and income is related to a low level of physical activity [19, 29]. A higher level of education is conducive to the develop-

ment of a greater awareness of one's own health and pro-health behavior patterns.

The results of our questionnaire revealed that 52 to 69% of women who actively took part in the health training had a secondary education, and 37 to 5% had a higher education, depending on the age cohort. 6% (20-year-olds) to 25% (50-year-olds) of the physically active women had a primary education.

In the control group the percentage of women with secondary education (57 to 40% in the oldest age cohort) and primary education (17 to 50% in the oldest cohort) was higher – the highest among the 40-year-olds (47–50%).

Women taking part in health training revealed different reasons for their participation in physical activity. For 20-year-old and 30-year-old women the most important reason was to look attractive. Other reasons were health-related. Among the 40-year-olds and 50-year-olds, health reasons took priority. Some other motives included keeping fit, stress management and establishing new relationships.

The observed tendency of changing body height is associated with a secular trend, i.e. increasing the body height in consecutive generations for about 1–1.5 cm per decade. Besides the changing body height with age is affected by involutional processes in the organ of locomotion manifested by greater spinal curvatures, flattening of intervertebral discs or lowered arching of the foot [14, 25].

Studies carried out in Poland in the late 1980s and early 1990s within the POL-MONICA program, revealed overweight in 38% of women aged 35–64 years and obesity in 30% [30]. The results of the present study show overweight and obesity in 70% of non-physically active women aged 40–59 years. Among their physically active counterparts 34–50% of women were overweight and 5–12% were obese. It can be concluded that systematic physical activity improves the BMI value and significantly reduces skinfold thickness in the group of training women as opposed to the control group. It should also be pointed out that aerobic exercises of moderate intensity reduce the level of the adipose tissue.

The study also showed an interesting inverse proportion between the skinfold thickness and the subjects' level of education, which is a confirmation of results obtained earlier by other authors [19, 22, 30]. It should also be underlined that undertaking physical activity is closely linked with the motivation to improve the image of one's own body, mostly through reduction of the body fat deposition. Thus, also overweight women participated in the organized physical exercises, which might have affected the mean values of body weight in the sample. In spite of this, the study revealed statistically significant differences in favor of the physically active group of women. It can be asserted that systematic physical activity in the productive age positively affects somatic parameters.

Physical fitness is one of the measures of health. Systematic physical activity has undoubtedly a positive influence on health and it lowers the regression of physical fitness in the middle age [12, 16, 30, 31]. The results of the study confirm this tendency and point to a higher level of physical fitness of training women and much slower decline of the mean results of individual tests in comparison with the control group.

Concurrently, the higher results of fitness tests achieved by the training subjects in comparison with the control cohorts confirm the significant effectiveness of the health training used in the study. The results of tests assessing the speed of hand movement, flexibility of the lower back and hamstring muscles, forearm muscle strength and explosive power of the legs were significantly higher in the training group than in the control group. Nowak and Wojtas-Ślubowska [32] also observed a general improvement of physical fitness of women practicing aerobics, with the exception of handgrip strength.

In both groups of women under study a decline in motor skills with age can be observed, which is closely associated with the increasing involutional processes in the body. Numerous studies indicate that increased physical activity can inhibit the aging processes and extend the period of physical fitness in one's life [12, 16, 30–34].

The results of the study point to the need of propagation, organization and planning of health training classes aimed at improvement of people's health potential.

Results and conclusions

1. Women who are physically active feature much better somatic parameters. Their BMI is within the normal range; and among the training women over 50, it slightly exceeds its upper limit. In the control group, the BMI in the cohort of 40-year-old subjects indicated overweight and obesity. This is additionally confirmed by the greater skinfold thickness in non-training subjects as opposed to their physically active counterparts.

2. Physically active women feature a higher level of physical fitness than women in the control group, in particular, in hand movement speed, muscle strength and flexibility of the lower back and hamstring muscles.

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A COMBINED SENSORIMOTOR SKILL AND STRENGTH TRAINING PROGRAM IMPROVES POSTURAL STEADINESS IN RHYTHMIC SPORTS ATHLETES

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ABSTRACT

Purpose. The aim of this controlled trial was to evaluate the effects of a combined sensorimotor skill and strength training program on postural steadiness in junior females performing rhythmic sports gymnastics. **Basic procedures.** Twenty-six rhythmic sports athletes, aged 9 to 12 years, were randomized into one of two groups; a 6-week experimental group or to a control group, (during the 2004–2005 training period). In the experimental group, a sensorimotor and back-muscle-strengthening regime was added to the everyday training, while the control group continued with their ordinary training. Before and after the intervention, and at a 12-month follow, bipedal-stance center of foot pressure (CoP) sway area was examined with a statokinesigram indicating amplitude of vertical pressure fluctuations after stimulation of the vestibular system, and the distribution of body weight between legs. **Main findings.** At the 6-week follow-up, the experimental group had a larger decrement in CoP sway area (–59%, $p = 0.004$) and in asymmetrical body weight distribution (–58%, $p < 0.001$) compared to the control group (–0.1% and 2.3%, respectively), but not at the 12-month follow-up. **Conclusions.** The present sensorimotor skill and strength training program indicated short-term improved postural steadiness in rhythmic sports athletes. Exercises that specifically emphasize somatosensory and back strength aspects of training for postural steadiness may advantageously be integrated into their training routines.

Key words: Body weight distribution, CoP sway, motor control, sensorimotor skills, training regime

Introduction

In rhythmic sports gymnastics accurate and well-trained balance and control of postural steadiness are important for the gymnast's ability to accomplish good performance [1] as well as for injury prevention [2]. Studies indicate that gymnasts have particularly developed the ability to integrate relevant information from sensory systems for regulating posture [3, 4]. Results also indicate that postural skills are affected by threats to posture [5] and that different training strategies may improve postural stability [6–10]. However, repeated asymmetric training of the spine seems typical, and a high incidence of scoliotic spine has been found in female rhythmic sports athletes [11]. Experience from our group is also that rhythmic sports gymnastics training – especially in young females – often leads to asymmetric development of the back musculature. One sees a "weak diagonal", with weaker low-back muscles above the unpreferred stance leg and weak contra-lateral shoulder musculature. Here, our preliminary stance-postural observations indicate that young rhythmic sports athletes distribute their body weight unevenly between their feet in quiet bipedal stance, seeming to load the preferred-stance leg more than the other. Moreover, a Bulgarian study [11] indicated that rhythmic sports gymnastic training involves asymmetric loading for the upper limbs as athletes mainly use their "strong" hand during rhythmic sports gymnastics to ensure better control and performance. This asymmetric loading of the spine and extremities may hypothetically alter the sense of positioning and perhaps increase the risk for injuries. It seems reasonable, however, that sensorimotor skill program may enhance or normalize postural steadiness and sense of stance positioning. Hitherto, little is known about the effects of such exercise skill programs in rhythmic sports athletes. We therefore evaluated the efficacy of a specific sensorimotor and muscle-strengthening regime on postural steadiness and body weight dis-

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tribution. Our hypothesis was that the present intervention might improve postural steadiness, expressed as decreased postural sway area and normalization of body weight distribution between legs in bipedal stance.

Material and methods

Study design

This study was a prospective controlled trial with unblinded treatment and blinded outcome assessments. An initial power calculation at 80%, to detect a potential 30% ($\alpha < 0.05$) reduction in center of pressure (CoP) sway area, (based on our preliminary measurements), revealed that a sample of 13 subjects in each group was needed. Posturographic evaluation measurements of CoP and body weight distribution were done before and directly after the intervention, and 12 months later. Intention-to-treat analyses were performed, that is, the analysis procedure and the conclusion were based on all participants originally assigned to each of the groups. The Research Ethics Committee at the Technological Educational Institute of Thessaloniki approved the study protocol. Together with their parents, the subjects were informed about the study and prior written consent was obtained.

Subjects

Twenty-six healthy, junior rhythmic sports athletes from three rhythmic sports gymnastic clubs in Thessaloniki, Greece, volunteered and were enrolled. Subjects were included if they had had at least three years of intensive training (> 6 hrs $\cdot wk^{1}$) and no record of previous severe injuries or other relevant pathology. Mean (SD) for age, weight, height and number of years of participating in rhythmic sports gymnastics were: 10.9 (1.52) years, 33.2 (7.5) kg, 1.42 (0.10) m, and 5.1 (1.29) years participating in rhythmic sports gymnastics, respectively. After baseline measurements, an independent observer first matched the subjects pair-wise by age and years of participating in rhythmic sports gymnastics. In each matched pair, the subjects were then assigned to either the experimental group or the control group by chance (the observer tossed a coin). The experimental group underwent a multimodal training regime, including sensorimotor-skill and back-muscle-strengthening exercises, while the control group had no additional intervention.

Intervention

During a study period of 6 weeks a senior physiotherapist, not involved in the pre- and post evaluations, supervised all intervention training in the experimental group. The program was run four times a week after daily rhythmic sports gymnastics training and consisted of five exercises lasting 30 min in total. Three of the exercises were designed to "manipulate" the vestibular system, possible changing (reweighing) the central processing of the somatosensory signals. These exercises are part of a vestibular training program described by Gans [12]. The exercises, to the best of our knowledge, have not yet been evaluated in other studies. However, clinical experience has shown that the exercises were very useful for increasing the vestibular capacity of both patients and healthy individuals. A high vestibular capacity is thought to be crucial for good performance of rhythmic sports athletes. The other two exercises were designed to strengthen the back and shoulder musculature of the "weak diagonal". These exercises are common excercises in other sports, but have not yet been used regularly in rhythmic sports gymnastic training. The exercises were as follows:

Sensorimotor skill exercises

Horizontal head movements. Starting in quiet bipedal stance, with arms relaxed along the body, head facing straightforward. While keeping the trunk still, the gymnast quickly turned her head to the right, then to the left and then returned to forward-looking position, which was maintained for 2 seconds. In all movement directions, the gymnasts were told to maintain eye focus on a point on the wall directly ahead. This procedure was repeated 16 times, for three sets.

Head circles. In the same starting position as the first exercise, the gymnast started to move her head in a fluid circular motion: chin on chest, then left ear on left shoulder. She then moved her head to a backward (looking up) position, right ear on right shoulder, finally returning chin to chest. This circular movement was repeated 10 times, two sets clockwise, two sets anti-clockwise (10 repetitions). After the four sets of head circles with eyes open, the same procedure was repeated with eyes closed.

Gait with head movements. After three steps at normal speed the gymnast was instructed to turn her head rapidly and look to the right and then back to the forward position while continuing to walk straight

ahead. After three more steps she turned her head and looked to the left, still walking straight ahead. The gymnast walked with turning head 15 m, 10 times.

Strengthening exercises

Prone contra-lateral arm and leg lifting. From prone position on the floor, with her arms extended above her head, the gymnast lifted the "unpreferred-side-arm", and the contra-lateral leg a few centimeters from the floor, in a cross-lifting movement ("weak side diagonal"). She held for 10 s, and then returned to the starting position. This movement was repeated 10 times, four sets.

Quadruped contra-lateral arm and leg lifting. From quadruped position on the floor, with body weight distributed to both knees and hands, the gymnast extended the unpreferred-side arm and the contra-lateral leg in a cross-lifting movement, held for 10 s and returned to starting position. This movement was repeated 10 times, four sets.

Instrument and test procedure

Foot pressure was recorded and analyzed on a vertical posturographic digital platform (Foot Checker 3.0 Comex S.A. / LorAn Engineering Srl; Castel Maggiore, Bologna, Italy), on the floor. The 700 × 500 mm platform contained 2304 resistive sensors. Measuring accuracy was 0.001 kPa. The vertical force was sampled at a frequency of 60 Hz and the sway density curve analyzed in an integrated software module (Foot Checker, 3.2). In a quiet stance, postural steadiness can be quantified in healthy subjects in which decreased (CoP) oscillations have been associated with improved postural skill [4, 9, 13, 14]. The advantage of CoP posturographic recordings using a mobile platform is that it is easy to use for empirical measurement in environments familiar to the subjects.

The subjects stood upright, barefoot on the platform (bipedal stance). They were told to stand with their feet as they wished. Their foot positions were then symmetrically corrected for anteroposterior direction, and the distance between their feet was recorded for accurate reproduction in the follow-up measurements. They held their arms at their sides, the central resting position. Before the body weight distribution was recorded, the subjects were told to distribute their body weight as evenly as possible between their feet, to be relaxed and to breathe normally; and then to signal when they were ready for the test leader to record the distribution. The body weight distribution was sampled over 20 s and percentage of body weight distribution (% BW distribution) was defined as the average deviation from 50% over the 20 seconds' interval. Still standing on the platform, the subjects were then familiarized with the subsequent CoP sway recording procedure. They were instructed to perform ten circular head movements with their eyes closed. Each circle took 1 s, governed with a metronome (tuned by electronic chronometer). Immediately after the tenth circle, the subjects were told to open their eyes and focus on a point on the wall directly ahead, at eye level, and to stand as still as possible for 20 seconds' sway sampling. The sway area gives an indication of the amplitude of postural sway [4] and here represents the ability of postural steadiness. The CoP sway area (statiokinesiogram (cm^2) was defined as an ellipse containing 90% of all displacement points. All measurements were performed with a blinded examiner.

Data management and statistics

Two dependent variables were included in the analysis: (1) CoP sway area and (2) % BW distribution. As these outcomes were mainly non-symmetrically distributed around the mean, the data were log-transformed to approximate a normal distribution before being statistically analyzed. To test our hypothesis, a repeated-measures mixed-model analysis of covariance was chosen, to examine whether follow-up recordings of CoP sway and % BW distribution differed significantly between the two subject groups. The between group factor was group (experimental, control) and the within group factor was follow up (6 weeks and 12 months). Baseline values were set as continuous covariate [15], thus eliminating potential effects of initial differences in the follow-up examinations. Wherever significant main or interaction effects were detected, a group difference was further estimated with post hoc tests for each follow-up occasion. A significance level was set at $p \leq 0.05$. Statistical analyses were performed using procedure Mixed in SAS®.

Results

All 13 subjects in the experimental group completed every session during the intervention period, and all 26 subjects completed the six-week follow-up. Twenty-three subjects (88.5%) completed the 12-month follow-

up measurement. Two subjects had quit rhythmic sports gymnastic training (one withdrawal from each group) and one had moved abroad (dropout from control group). There were no injury or pain experiences, or other complications reported from the present intervention. The athletes reported no difficulties in performing the exercises correctly.

CoP sway area

Fig. 1 shows how the CoP sway area for the two subject groups developed. Compared to baseline, the CoP sway area in the experimental group decreased with –59% (md) compared to –0.1% in the control group at the six-week follow-up, and –39% in the experimental group compared to 0.0 % in the control group at the 12-month follow-up. A repeated-measures mixed model analysis revealed a statistical interaction effect for follow-up and group (follow-up · group): $F_{1,21} = 8.87$, $p = 0.007$. Results for each follow-up showed that the experimental group had significant CoP sway decrement at the six-week follow-up, $p = 0.004$. There were no such remaining effects at the 12-month follow-up ($p = 0.699$).

Percentage of body weight distribution

Fig. 2 shows the course of the % BW distribution. The variances were not homogeneous within and/or between the groups. The covariance structure heterogeneous compound symmetry together with between subject heterogeneity was considered most desirable and gave the smallest value of the Akaike's Information Criterion (AIC). Compared to baseline, % BW distribution in the experimental group decreased with –58% (md) compared to 2.3% in the control group at the six-week follow-up, and –14% in the experimental group compared to –19% in the control group at the 12-month follow-up. The mixed model procedure revealed a statistical interaction effect for follow-up × group; $F_{1,21} = 24.08$, $p < 0.001$. Results for each follow-up showed significant improvement in the experimental group (reduction of deviated % BW distribution) at the six-week follow-up, $p < 0.001$. Again, the effect was no longer significant at the 12-month follow-up ($p = 0.957$).

Discussion

The results of this study support our initial hypothesis that the rhythmic sports athletes who practiced the present multimodal training program would improve their postural steadiness in quiet standing, measured as decreased CoP sway area and asymmetric body weight distribution. However, the 12-month follow-up indicated that the effect was not maintained in the long term.

The present sample of gymnasts represented three Rhythmic Sports Gymnastic Clubs of Thessaloniki,

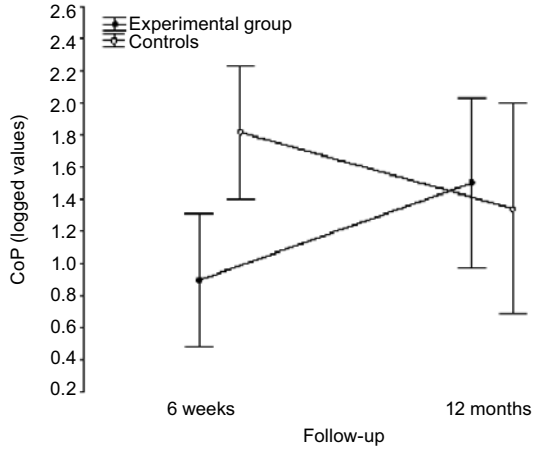

Figure 1. Changes in center of foot pressure (CoP) sway area (cm^2) during quiet standing for experimental group (filled circle) $n = 13$ and for controls $n = 13$, respectively. Values are presented as longitudinal follow-up at a 6-week and a 12-month assessment after baseline measurement. Baseline values were set as continuous covariate. Error bars show mean and 95% confidence intervals using procedure Mixed in SAS® (analysis based on logged values)

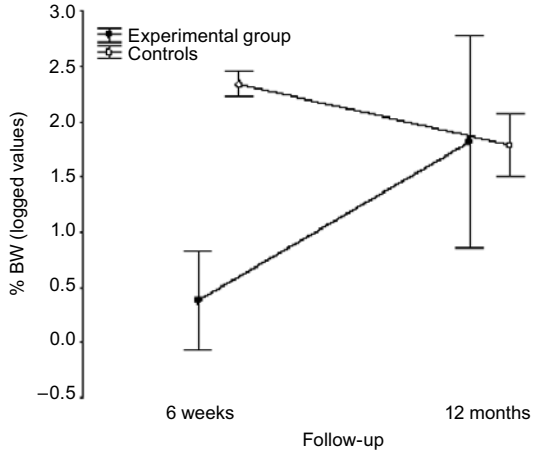

Figure 2. Changes in percentage of body weight distribution (% BW) for experimental group (filled circle) $n = 13$ and controls $n = 13$, respectively. Values are presented as longitudinal follow-up at 6-week and 12-month assessments after baseline measurement. Error bars show mean and 95% confidence intervals using procedure Mixed in SAS® (analysis based on logged values)

Greece, and was considered representative for junior rhythmic sports athletes. The reason for selecting junior rhythmic sports athletes only is that the group is more homogeneous concerning adoption and learning of the postural control system, compared to a group of senior rhythmic sports athletes. The 26 subjects were age- and years-of-practice matched before random assignment to an experimental group or a control group. This procedure was followed to facilitate uniformity between the groups in our relatively small sample.

Postural control or postural steadiness has been well debated in recent years [e.g. 16–20] and there has been progress in understanding its complexity in relation to task and environment. In the literature, however, postural control (and balance) is defined in various ways [17, 18, 21, 22]. The use of different methodology and different aspects of postural control may explain this inconsistency. For the gymnasts studied, it is necessary to manage CoP adjustment within a small base of support. This involves controlling kinematic, or center-of-mass (CoM), displacement by motor command for CoP adjustment for upright stance equilibrium during high skill performance, for example turns, pivots, and other near-acrobatic movements. Although postural stability, defined as keeping CoM within a given surface, can be reflected by CoP sway [17], less sway area does not necessarily mean good postural control in every population. For example, a smaller safety margin between peak CoM and peak CoP in patients with Parkinson's disease tends to increase the risk of falling [23]. Nevertheless, the ability to maintain the body as still as possible can be defined as postural steadiness in *healthy* subjects and quantified by recording the variation in ground reaction forces [24, 25]. However, crucial for the present study, our mobile posturographic platform and the relative simplicity of the set-up allowed us to conduct empirical measurements on the rhythmic sports gymnastic club's premises. Studies show high reliability for body weight distribution, while for CoP sway reliability seems more limited, though acceptable [21]. While a mean of multiple sway measurements seems to increase reliability [21], repeated measures may also introduce learning effects [26]. However, in our control group, there seemed to be a small, longitudinal, within-subject variation. This was perhaps partly because all the tests were conducted by the same test leader so as to eliminate possible inter-tester variability. Important to consider, however, participating in the intervention group and being encouraged by a physiotherapist might have increased the subjects´ motivation concerning rhythmic sports gymnastic training, perhaps causing overestimation of the effect of the training regime tested.

Our results, showing improvement in postural steadiness after sensorimotor skill and muscle strength training, tally with those of other authors [6, 8] who used training regimes that involved fairly comparable exercises. Moreover, it has been discussed [17] that adoption and learning of the postural control system could have a significant effect on successful training and performance in elite athletics. The mechanism of such improvement may be increased sensitivity of feedback pathways from proprioceptive sensory input, which regulate the *expected* relationship between motor output and the environment for postural equilibrium [see for further reading 27]. By training sensorimotor skills, these gymnasts may not only improve their postural steadiness but perhaps also their gymnastic techniques. The test procedure was developed to reflect the techniques used in rhythmic sports gymnastics, that is, a better performance in the tests should also logically increase the performance in sports, e.g. one leg standing. The present study was limited in the ability to study the effects on the improvement of performance or the occurrence of injuries. The use of good technique has been proposed as one factor for reduced incidence of spinal pain in rhythmic sports athletes [2]. Thus, further studies should examine the effect of sensorimotor skill programs on other kinematic features of postural steadiness and aspects of injury prevention. Moreover, future studies should endeavour to separate the effect of each domain concerning the training, i.e. vestibular or strength training exercises.

As expected, the baseline measurement showed that the gymnasts had asymmetric body weight distribution (Fig. 2). One study found that body weight distribution was close to 50–50% in young persons [21]. Moreover, Engardt found that healthy subjects rose and sat down with good symmetric weight distribution [28]. However, the present multimodal regime seemed to temporally normalize the rhythmic sports athletes' % BW distribution. Such time-limited postural effects have also been found after a muscular training regime in patients with central diseases [28]. Although the present multimodal design did not allow separate analysis of the specific effects of the strength training, we believe that strength exercises for the "weak diagonal" of the back may with benefit be integrated in rhythmic sports gymnastic training. Also, hypothetically, such integrated training

may prevent musculoskeletal pain syndromes caused by repeated asymmetric loading. Previous results show, nevertheless, that different multimodal training protocols have been found effective concerning postural control and stability in healthy subjects [9], as well in patients with ankle instability [7]. The temporary differences between the exercise group and the control group found in the present study may be explained by the increased exercise-dosage. However, it seems that the ½ hour additional training should not have had such an impact, taken into account the total amount of training and the years of participating in rhythmic sports gymnastics.

At the 12-month follow-up there were no significant differences in maintained effect between the two groups. This indicates that in order to retain the effect in postural steadiness, as defined in this study, this type of training should be regular; for example by integrating the exercises in rhythmic sports gymnastic training routines.

Conclusions

Our results showed that the present sensorimotor skill training regime improved the rhythmic sports athletes' postural steadiness, measured as decreased CoP sway area and normalized body weight distribution between their feet. Nevertheless, the effects were limited over time. This indicates that sensorimotor/strengthening exercises may beneficially be integrated into continuous rhythmic sports training routines. Further research that includes CoP and kinematic variables is however required to provide more understanding regarding effects of postural regulation.

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INFLUENCE OF ANNUAL TRAINING CYCLE ON THRESHOLD POWER AND REACTION OF BLOOD ANTIOXIDATIVE STRESS INDICES DURING A STANDARD ROWING TEST

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ABSTRACT

Purpose. The study presents a comparative analysis of the threshold power and exercise-induced changes in the blood antioxidative stress parameters in a standard rowing test between two measurements (terms of the study). **Basic procedures.** The study comprised 15 subjects aged between 20 and 23 years, members of the Polish National Youth Rowing Team at the end of preparatory phase of the annual training cycle in 2003 (Term I) and in 2004 (Term II). At both terms selected indices of antioxidative stress and the threshold power (AT_4) induced by physical exercise with graded intensity were analyzed. **Main findings.** At the second term of the study, as compared with the first term, a higher activity of superoxide dismutase in blood samples at rest was found. At the same time a decreased activity of glutathione peroxidase in blood samples after exercise was observed. The level of lipid peroxidation products in red cells (TBARS) regarded as the marker of free radical-induced damage was also significantly lower. The results indicated that at the second term of the study the rate of anaerobic metabolism measured with the blood lactate level was lower than at the first term despite the fact that the threshold power values between both terms of the study did not reveal any significant differences. **Conclusions.** The annual training cycle in young rowers, although not contributing significantly to the increase of the threshold power, induced positive changes in their antioxidant defense systems; namely, the lower level of TBARS after exercise and the higher SOD activity at rest.

Key words: anaerobic threshold, annual training cycle, oxidative stress

Introduction

The anaerobic threshold (AT_4) is used for assessment of athletes' adaptation to exercise, level of trainedness (in endurance athletes in particular) and the intensity of training loads. It is defined as the lowest training load during progressively increased exercise, above which the increase of lactate concentration in blood becomes rapid and continuous [1]. Although the exercise model used in studies of athletes does not reflect the progression of intensity or the time of starting exercise, the anaerobic threshold is currently one of the basic diagnostic methods used for assessment of rowers' aerobic capacity in laboratory conditions [2]. An analysis of the threshold power in an annual training cycle can be useful in management of training through the choice of optimal training loads. It can also be a useful index of effectiveness of endurance training [3].

The exercise-induced oxidative stress leads to excess production of reactive oxygen species. The increased amount of free radicals, along with the insufficient antioxidant adaptation to exercise, leads in turn to significant changes in cellular and tissue functions [4]. The muscles can be protected against the harmful effects of oxygen free radicals thanks to the activity of muscular antioxidative enzymes as well as antioxidants in blood [5].

A number of researchers [6, 7] show that exercise can affect the body's antioxidative defenses. According to some authors [8], physical training, especially endurance training, can alter the adaptability of enzymatic antioxidants by increasing their activity. Mena et al. [9] compared the blood level of superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) in amateur cyclists, professional cyclists and non-training subjects. The lowest SOD level was noted in the group of amateur cyclists and the lowest in the non-training individuals. The highest levels of CAT and GPx were observed in the group of professionals. Jenkins et al. [10] noted that in vitro oxygen uptake in

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skeletal muscle was correlated with the levels of CAT and SOD, which was an indication of the growing muscle antioxidative potential along with increasing muscle metabolism.

In consideration of the above results the present study was designed to examine the threshold power and exercise-induced changes in the blood antioxidative stress parameters in rowers between two measurements (terms of the study)

Material and methods

The sample for the study were 15 rowers from the Polish National Youth Rowing Team. The subjects' basic anthropometric characteristics are presented in Tab. 1. The tests took place at the end of the preparatory phase of an annual training cycle: at the beginning of May 2003 (Term I) and in May 2004 (Term II) at a training camp in the Olympic Games Training Centre in Wałcz, Poland.

The rowers performed an ergometer test with graded intensity until refusal. The maximal power was set during a controlled run at a distance of 2.000 m. The exercise was performed on a Concept 2 rowing ergometer (USA). A rower started the test at 50% of the maximal power, and then the intensity was increased every three minutes to 60, 70, 80 and 90%, respectively. The test at 90% of the maximal power was performed by the rowers until refusal. The consecutive three-minute exercise sessions were separated with 30-second breaks, during which capillary blood samples were taken from the subjects to mark the blood lactate level and the anaerobic threshold (AT_4) [1].

Before the test, within one minute after its completion and after a 24-hour recovery the blood samples were drawn from the ulnar vein. The blood was taken on an anticoagulant containing dipotassium versenate (K2EDTA), and centrifuged to separate red blood cells from the blood plasma. The red blood cells were irrigated three times with normal saline (0.9% w/v of NaCl) and haemolyzed with ice-cold double distilled water. The hydrolysate was frozen at a temperature of –28°C. The following concentrations were marked in the hemolysate: superoxide dismutase (SOD) using the RANSOD assay (SD 125) (UK), glutathione peroxidase (GPx) with the RANSEL assay, (RS 505) with the Paglia and Valentine assay [11], tiobarbiturate reactive lipid peroxidation products (TBARS) following chromogen extraction with n-butanol with the Buege and Aust assay [12], and hemoglobin with the Drabkin hemoglobin assay. The lactate concentration (La) was marked in the capillary blood using the Dr Lange enzymatic assay (Germany).

The obtained results were statistically processed with the use of Mann-Whitney test. All calculations were made using the Statistica 6.0. software package. The subjects expressed their consent to participate in the study and the tests were granted approval of the Local Research Ethics Committee of the Poznań University of Medical Sciences.

Results

The obtained results are presented in Tab. 1–3. Tab. 1 contains the subjects' anthropometric characteristics, Tab. 2 includes the levels of measured stress parameters.

The comparative analysis of the antioxidant enzymes (Tab. 3) at both terms of the study revealed a significantly higher SOD activity at rest, and lower GPx activity following exercise ($p < 0.05$) at the second term. No significant changes in the concentration of enzymes were found after the 24-hour recovery. The results of the rowing ergometer test at the second term of the study also revealed smaller changes in TBARS concentration.

At the second term of the study the threshold power was 12 W lower, and the maximal power 17 W lower, whereas the total exercise time was 15 s longer than the time at the first term (p = n.s.). The post-exercise blood lactate concentration at the second term was more than 7 mmol/l higher; however, this increase was significantly smaller than that from the first term ($p < 0.05$).

Discussion

The values of threshold power achieved by the rowers at the end of the preparatory phase of their annual training cycle did not differ significantly from the results obtained a year earlier (Tab. 2). A small decrease in the threshold power – a recognized index of endurance training tests – was, however, noted. This tendency could have resulted from insufficient training, but it

Table 1. Subjects' characteristics ($x \pm SD$)

	Body height (cm)	Body weight (kg)	Age (years)	Training experience (years)
Term I	189 ± 9.89	79.5 ± 12.02	21.5 ± 0.71	6
Term II	189 ± 9.89	78.5 ± 7.84	22.5 ± 0.71	7

Table 2. Levels of oxidative stress parameters

Parameter	Term I			Term II		
	$x \pm SD$	Min	Max	$x \pm SD$	Min	Max
AT_4 (Watt)	319.5 ± 30.41	283	346	307 ± 80.02	249	376
HR_{AT4} (beats/min)	175.4 ± 10.92	159	192	174.2 ± 11.95	155	193
t (s)	969 ± 74.21	780	1080	984.6 ± 85.34	900	1080
Maximal power (Watt)	426.9 ± 20.74	400	450	409.4 ± 30.86	370	456
HR_{max} (beats/min)	194.3 ± 7.52	187	211	191.7 ± 5.96	180	204

AT_4 – threshold power, HR_{AT4} – heart rate at the anaerobic threshold, t – exercise time, HR_{max} – maximal heart rate

Table 3. Comparative analysis of the parameters studied at rest, after exercise and after 24-hour recovery at the two terms of the study

Parameter		Term I $x \pm SD$	Term II $x \pm SD$	Statistical significance of differences
SOD	at rest	1139.5 ± 85.84	1248.1 ± 117.39	*
(U/gHb)	after exercise	1239.3 ± 126.51	1369.5 ± 167.15	n.s.
	after recovery	1409.8 ± 89.89	1448.8 ± 113.01	n.s.
GPx	at rest	41.8 ± 12.76	45.1 ± 10.89	n.s.
(U/gHb)	after exercise	64.4 ± 10.53	48.3 ± 12.5	*
	after recovery	45.8 ± 11.49	45.1 ± 7.19	n.s.
TBARS	at rest	1.3 ± 0.22	1.2 ± 0.09	n.s.
(μmol/gHb)	after exercise	1.8 ± 0.38	1.5 ± 0.27	*
	after recovery	2.4 ± 0.61	2.1 ± 0.37	n.s.
La	at rest	1.7 ± 0.45	1.6 ± 0.32	n.s.
(mmol/l)	after exercise	12.2 ± 2.86	8.8 ± 3.31	*

SOD – superoxide dismutase level, GPx – glutathione peroxidase level, TBARS – level of lipid peroxidation products, La – lactate blood concentration, * statistically significant at $p \leq 0.05$, n.s. – statistically non-significant

also confirms earlier observations by Klusiewicz et al. [13] in their study of a six-year training cycle of Olympic rowing champions. The anaerobic threshold values of the Olympic rowers' in the consecutive years did not change significantly. Their threshold power did not increase significantly even in the years of the rowers' greatest sports successes. In training practice the absolute value of threshold power AT_4, is, in fact, far less important than the slightest fluctuations and differences between the values achieved in the preparatory and competitive periods of training.

The progression of intensity of training loads used in the test at the first and second terms of the study led to an increased production of reactive oxygen species (ROS) measured with the level of thiobarbiturate reactive substances (TBARS). At the first term of the study the increased ROS level in the blood sample taken immediately after exercise amounted to about 0.5 μmol/gHb, and at the second term to about 0.3 μmol/gHb. The increased ROS production leads, first of all, to oxidative modification of phospholipids and disrupts the cell membrane integrity [14]. An introduction of polar peroxide, ketone, aldehyde or hydroxyl groups in the areas of phospholipid molecules decreases the hydrophobicity of the lipid bilayer and increases the permeability of not only hydrogen protons but also of other polar molecules into the extracellular environment. According to many authors [10, 15–17] physical exercise, especially of high intensity, leads – on the one hand – to production of ROS, but on the other, to adaptation of the body's defenses against free radical-induced damage. In the opinion of Lu et al. [18] this adaptation consists of a direct and indirect stimulation of synthesis of multiple proteins, including antioxidants. This observation is confirmed by Marzatico et al. [19], and Ji et al. [20]. Marzatico et al. revealed that the activity of superoxide dismutase at rest was two times higher in sprinters and three times higher in marathon runners than in their healthy non-training counterparts. They also noted an increase in glutathione peroxidase for 58% and 100% in the marathon runners in comparison with the control group. Evelo et al. [16] in their study of the effects of endurance training on the antioxidative glutathione system of human erythrocytes noted, for the first time, that

the level of exercise-induced oxidative stress is related to the character of an annual training cycle. The exercise-induced adaptation of the athlete's body depends on the type, duration and intensity of exercise as well as the level of the body's "trainedness." According to Sen et al. [21], long-term training of moderate intensity increases the body's physiological antioxidant capacity. Ji et al. [20] observed that exercise-induced increase of ROS production stimulates the gene expression of antioxidant enzymes with NF-κB as the signaling pathway.

The intense physical effort involved in rowing training is related to an increase in the number and size of mitochondria and it simultaneously enhances the activity of mitochondria enzymes in the electron transport chain [6]. As shown by Mader et al. [22] from 93 to 99% of rowing training loads are exercises in which the lactate concentration in blood does not exceed 4 mmol/l, and in 80% is not higher than 2 mmol/l. Data from literature show that endurance training, in particular, increases the body's antioxidant capacity [5, 23, 24]. An increase in the level of reduced glutathione and glutathione peroxidase, a decrease in catalase concentration and a stable level of superoxide dismutase were observed in animal muscles in response to training [25]. Gunduz et al. [26] noted improved antioxidant capacity in many tissues, including muscles, in aged rats in response to one-year swimming exercise.

In our study, an increase in superoxide dismutase in red cells ($p < 0.05$) and glutathione peroxidase (Tab. 3) was noted at rest in rowers after one-year training. The ergometer test at the second term of the study contributed to the increase in the activity of both enzymes. It should be added that the increase in GPx activity at the second term of the study was significantly lower than at the first term of the study ($p < 0.05$).

The assessment of the status of antioxidant capacity can be difficult due to the fact that the expression of antioxidants can be induced in response to oxidative stress. Thus a high activity of antioxidants can be an indication of a good state of antioxidative defence mechanism as well as of increased level of oxidative stress. The high activity of both enzymes at rest at the second term of the study points to the positive influence of physical exercise. On the other hand, their higher activity during 24-hour recovery indicates an increasing ROS production but it can also be a proof of facilitation of the body's antioxidative defenses. The concurrent higher level of TBARS can also be a manifestation of expression of antioxidant proteins in response to oxidative stress. Błaszczyk et al. [27] report that submaximal exercise increases the concentration of antioxidant enzymes (SOD, GPx,) and lowers the level of malon dialdehyde (MDA) in red cells. The results of our study show that the applied exercise test after a year of training brought about different responses of antioxidant enzymes and a lower increase of TBARS, right after the exercise and after a 24-hour recovery (Tab. 3).

Conclusion

It should be concluded that physical training induces positive changes in the body's antioxidant adaptation, as confirmed by the lower post-exercise level of thiobarbiturate reactive substances. It can be assumed that among the many factors affecting the sports result, the capability of maintaining the prooxidant–antioxidant equilibrium is one of the key components of biological restitution and the capacity to take up new training and competitive loads.

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INFLUENCE OF FOOTBALL TRAINING ON ALIGNMENT OF THE LOWER LIMBS AND SHAPING OF THE FEET

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ABSTRACT
Purpose. One of the aims of football training is to enhance the musculo-ligamentous apparatus and increase mobility of the lower limbs' joints. Proper football footwear is compulsory as games are being played on different surfaces. This has direct impact on the placement of one's feet and distribution of forces within feet arcs. The purpose of this study was to compare the placement of feet and toes of boys training football with their peers who did not practise football. **Basic procedures.** This study was carried out on 72 junior football players, aged 10–14 years, who were divided into 4 groups according to age and training level. The control group included 80 boys of similar age. The examination was performed using Moiré technique. Alignment of the knees was assessed visually. Computer analysis of the results covered the following parameters: Clarke's angle, α, β and γ angles, length-to-width index and KY index. **Main findings.** Feet anomalies were more frequent in footballers. In the older players these were mainly varus knees (around 40%), while the younger one's had valgus knees more often than the non-players. Hallux valgus (over 20%), especially of the left foot, and varus toes (over 90%) were also more frequent in the non-training boys. Besides there was a decrease of curvature of the longitudinal and transverse feet arcs that was more frequent in the right feet. However, longitudinal and transverse characteristics of the left feet arcs did not differ between the exercising and non-exercising groups. **Conclusions.** The examination of the feet confirmed the impact of football training on the placement of feet and toes and curvature of the feet arcs.

Key words: football training, alignment of the lower limbs, shaping of the feet, Moiré technique

Introduction

Sport training is a long-term, dynamic and comprehensive pedagogic process and players as a part of it learn, acquire and systematically master the techniques and tactics of a given sports discipline, develop their physical fitness as well as volitional and personal traits. The impact on physical constitution and harmonious development of players is aimed at increasing their physical ability, which divides into general, directed and special. High dynamic force of the lower limbs muscles, i.e. high efficiency of the musculo-ligamentous apparatus is an absolute priority in football training. It has been confirmed that an average footballer runs a distance of over 10 km during a single game [1, 2]. The multi-stage preparation scheme for footballers lists enhancement of the musculo-ligamentous apparatus and increasing the mobility of the lower limbs' joints as the fundamental part of football training. Proper football footwear is compulsory and the games are played on various types of surface, which has impact on the placement of the lower limbs and the curvature of the feet arcs in football players.

The aim of this study was to assess the placement of the lower limbs and toes and shaping of the feet of boys training football against their non-training peers.

Material and methods

The study covered 72 boys training football aged 10–14 years. They were divided into four groups, depending on age and training experience: Group 1 included 10 and 11 year-olds with training experience less than two years; Group 2 included 11 and 12 year-olds with training experience between two and five years; Group 3 included 13 year-olds with training experience between three and four years; Group 4 included 14 year-olds with training experience between three and seven years. The control group consisted of 80 non-training boys, who were divided into analogous age groups, so that the mean age of the subjects from both groups was nearly identical.

A questionnaire concerning the training experience, training frequency, documented postural faults and dominant side of the body was distributed among parents and, in the case of players, among coaching staff.

Placement of the lower limbs was assessed individually, in habitual position and looking from the front with knees and/or ankles adhering or with knees and medial ankles astray (cm). The following placement types were distinguished: valgus limbs, when the distance between the ankles was 5 cm or more with knees adhering; normal and varus, when the distance between the knees was 5 cm or more with ankles adhering [3].

The evaluation of feet arcs curvature was performed by means of a special photogrammetric kit produced by CQ Elektronik from Wrocław, Poland. The kit consisted of glass panel with a CCD camera fixed underneath it. The subjects had to stand on the panel in order for the camera to register the image of their feet, which were illuminated with rasterized light [3]. The images from the camera were subjected to computer analysis, which provided the following parameters: Clarke's angle (Cl), alpha (α), beta (β) and gamma (γ) angles, length-to-width index (LWI) and KY index.

The alpha and beta angles traced on the plantocontourograms show the placement of the hallux and the small toe. Correct angle of valgity of the hallux, according to Wejsflog, ranges between 0° and 9°. The calcaneal gamma angle is an angle between the tangents from the external and internal edge of a foot and in normal conditions it should range between 15° and 18°. This angle is the measure of transverse vaulting of a foot [4–7]. The length-to-width index (LWI) is a length to width ratio of a foot and also is an indicator of the transverse vaulting of a foot. In normal conditions it is close to a value of 3 and in the case of excessive flattening of the foot arcs it reaches the value of 2 and thus the following classification criteria have been determined: transverse platypodia – below 2.3, depressed vaulting – between 2.3 and 2.59, normal vaulting – 2.6 or higher [4]. KY index is a ratio of the shaded part of the plantocontourogram to its overall width and Clarke's angle (Cl) is the angle between a tangent from the medial edge of a foot and a tangent from the apex of the tarsus recess measured at the point where those tangents intersect with the frontal tarsus line. Both Clarke's angle and the KY index express the longitudinal vaulting of a foot. In the case of excessive vaulting (hollow foot) the KY index is lower, whereas in feet with lowered vaulting its values are higher than the recommended ones. On the other hand, lower values of Clarke's angle indicate the flattening of a foot and higher ones show that a foot is hollowed out. Evaluation by means of those parameters should take into account the age of the subjects (Tab. 1) [3–5].

Table 1. Assumed normal values for KY index and Clarke's angle (Cl) (based on Kasperczyk and Lizis standards)

Age	KY index				Clarke's angle (Cl)			
	Hollow foot	Normal foot	Flattened foot	Flat foot	Hollow foot	Normal foot	Flattened foot	Flat foot
10–11 years	under 0.4	0.4–0.54	0.54–0.75	over 0.75	over 45	31–45	20–30.9	under 20
11–12 years	under 0.3	0.3–0.45	0.45–0.75	over 0.75	over 47	32–47	20–31.9	under 20
13–14 years	under 0.3	0.3–0.45	0.45–0.75	over 0.75	over 50	42–50	30–41.9	under 30

Table 2. Arithmetic means ($\bar{x}$) of alpha, beta and gamma angles (α, β, γ), length-to-width index (LWI), KY index and Clarke's angle (Cl)

Age	Group	n	α ($\bar{x}$)		β ($\bar{x}$)		γ ($\bar{x}$)		LWI ($\bar{x}$)		KY ($\bar{x}$)		Cl ($\bar{x}$)	
			Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
10–11 years	FG	19	3.2	**6.6**	**19.9**	**17.9**	**20.3**	17.4	2.53	2.47	0.42	0.45	38.1	40.5
	CG	24	1.0	2.8	13.7	10.0	16.3	15.4	2.58	2.47	0.39	0.43	38.1	36.7
11–12 years	FG	24	**3.1***	4.6	**21.0**	**17.9**	**18.9**	17.0	2.60	2.50	0.40	0.46	38.9	40.4
	CG	21	–0.9	1.1	15.3	9.9	16.5	15.4	2.60	2.47	0.46	0.46	37.5	37.2
13 years	FG	16	2.5	**5.6**	17.3	15.5	19.0	15.7	2.54	2.45	0.42	0.47	39.6	41.5
	CG	18	–0.1	0.5	16.0	17.1	17.5	13.8	2.59	2.49	0.48	0.48	41.2	41.4
14 years	FG	13	2.2	5.1	**21.1**	**19.7**	**20.3**	**17.1**	2.48	2.39	0.46	0.49	**37.3**	36.9
	CG	17	–0.2	3.8	16.1	15.3	18.5	14.4	2.54	2.42	0.45	0.44	43.5	41.9

* statistically significant differences between the means of footballers (FG) and control group (CG) at $p = 0.05$, statistically significant differences of means of footballers (FG) in comparison to control group (CG) in bold

Results

The assessment of the lower limbs placement indicated a high percentage of feet anomalies, mainly in 13- and 14-year old players (Fig. 1). Varus knees were not observed in non-training boys, while the 14-year old players, who had the longest training experience, showed the highest prevalence of this anomaly (approx. 40%). Valgus knees were also more frequent in younger players than in non-training boys.

Measurements of alpha angle showed that hallux valgus was more frequent in footballers (18% in the right foot, 32% in the left foot), while in the control group the hallux was in normal or varus position (Fig. 2, 3). Mean values of alpha angle were higher in footballers than in the control group and in several cases differences were statistically significant (Tab. 2). Beta angle measurements showed common occurrence of varus deformity of the small toes and it was more frequent in footballers (over 90%) than in the control group (80%). Mean values of beta angle were definitely higher in footballers, and apart from 13 year-olds, the differences were statistically significant (Tab. 2). Larger varus deformity was observed in the right feet, while valgity was more common in the left feet.

Gamma angle, which is a measure of transverse vaulting of feet, indicated a quite common depression of transverse foot vaulting (above 18). On average, 66% of footballers had depressed transverse vaulting of the right foot, 37% of the left foot, while in non-training boys those numbers were 36% and 10% respectively. Statistically significant differences were observed between the mean values, mainly in the right foot (Tab. 2). The length-to-width index (LWI) is also an indicator of the transverse vaulting condition. Readings of this parameter confirmed depression of the transverse vaulting of the feet. Depressed transverse vaulting of the right foot was more common in footballers, while in non-training boys it was equally common, but in the left foot (Fig. 4, 5; Tab. 2).

The KY index based evaluation of the longitudinal vaulting of foot showed its depression. Just as the transverse vaulting, it was more common in the footballers, but only in the right foot. In the youngest subjects, the depressed vaulting of feet was less frequent than in the

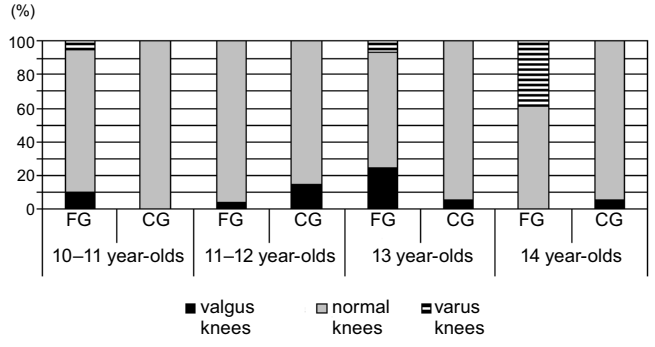

Figure 1. Placement of the lower limbs in football players (FP) and in non-training boys (CG)

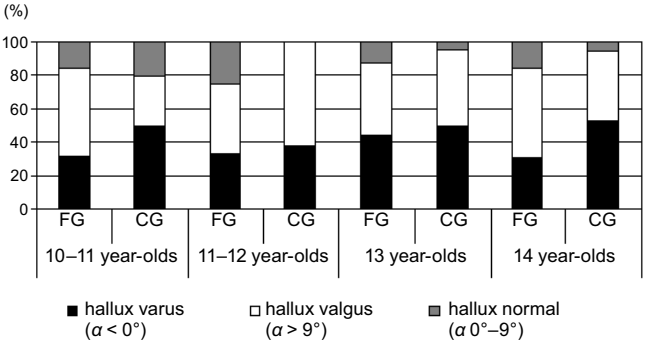

Figure 2. Placement of the right hallux in footballers (FG) and in non-training boys (CG)

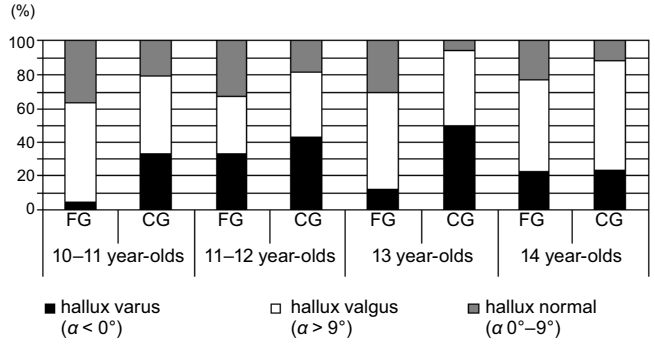

Figure 3. Placement of the left hallux in footballers (FG) and in non-training boys (CG)

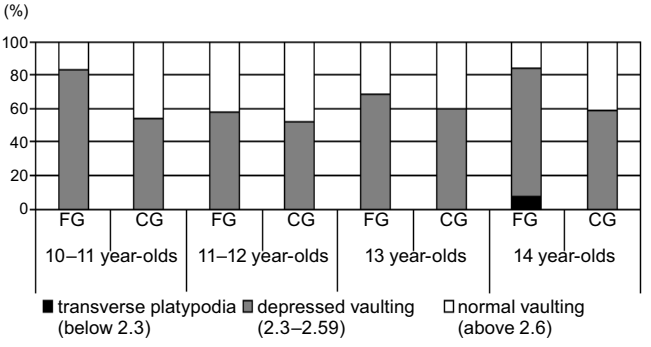

Figure 4. Transverse vaulting of the right foot in footballers (FG) and in control group (CG)

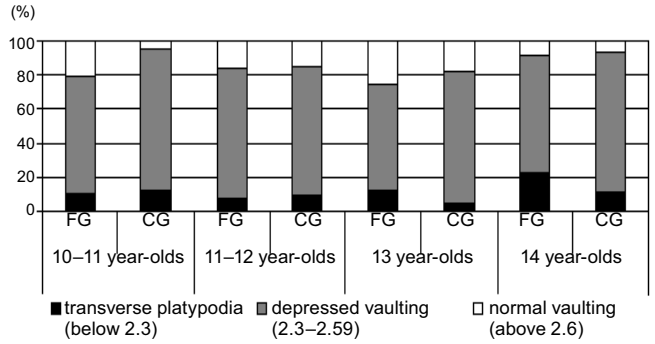

Figure 5. Transverse vaulting of the left foot in footballers (FG) and in control group (CG)

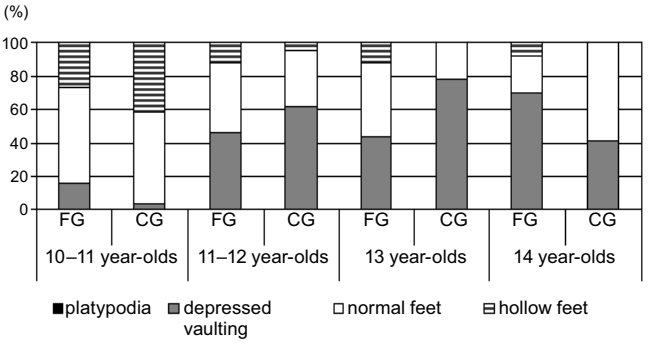

Figure 6. Longitudinal vaulting of the right foot according to KY index in footballers (FG) and control group (CG)

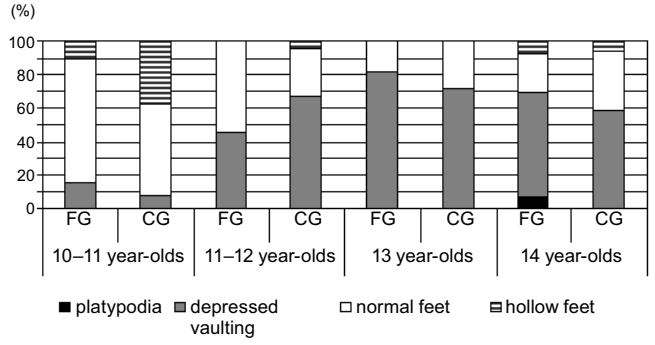

Figure 7. Longitudinal vaulting of the left foot according to KY index in footballers (FG) and control group (CG)

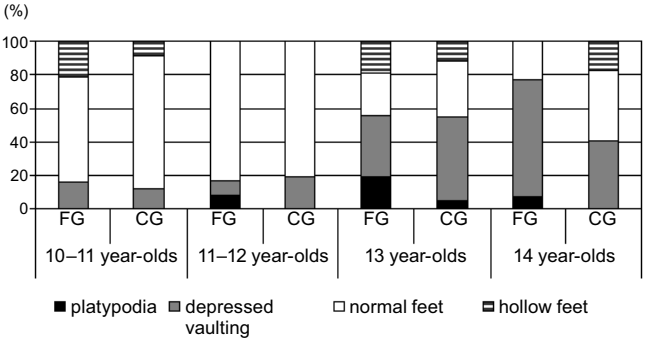

Figure 8. Longitudinal vaulting of the left foot according to Clarke's angle in footballers (FG) and control group (CG)

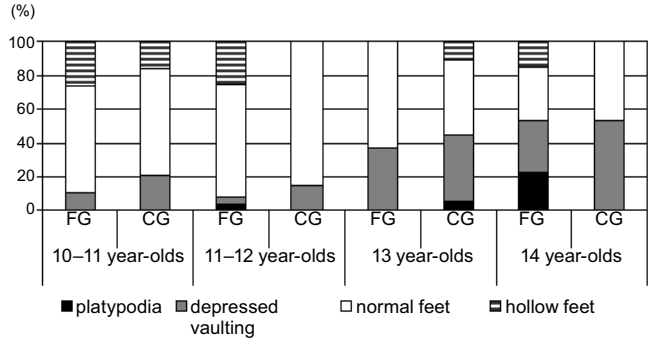

Figure 9. Longitudinal vaulting of the left foot according to Clarke's angle in footballers (FG) and control group (CG)

older ones, yet there were many cases of hollow feet (Fig. 6, 7; Tab. 2). Clarke's angle measurements showed fewer feet with depressed vaulting and fewer hollow feet. The difference between vaulting of the right and left feet was apparent, but not so much pronounced (Fig. 8, 9; Tab. 2).

Discussion

The results show that football training has impact on the placement of the lower limbs, which is confirmed by high percentage of varus knees in boys with longest training experience. Training also affects the placement of toes and vaulting of feet. Hallux valgus, varus deformity of the small toe and depressed longitudinal and transverse vaulting of feet were more common in footballers, especially those with the longest training experience, than in non-training boys.

Those observations found confirmation in results of examinations of 17–18-year old footballers done by Klata [8]. Klata observed depression of the longitudinal vaulting of mainly right feet based on KY index (20% of subjects) and transverse depression, and an increase of gamma angle (25% of subjects) [8]. Klata [8] discovered larger depression of the right foot in players of the 1st, 2nd and 5th junior league. Klata found out, based on answers to the questionnaire, that majority of the footballers examined were right-handed (92%) and right-legged (85%), therefore, one may assume that the right leg is dominant and thus much more burdened during training and games.

Plantographic examinations of 8–15-year old girls and boys indicate higher variability of vaulting of the

left feet and more regular improvement of vaulting of the right feet. Clarke's angle of the majority of feet ranged between 32° and 47°. Moreover Lizis, the author of that study indicated asymmetric distribution of Clarke's angle [5, 9]. Our own studies confirm those observations, yet only in the case of non-training boys.

Photogrammetric assessment of feet of non-training boys aged 8–13 years showed that depressed transverse vaulting of the right feet was present in 50% of boys and of the left feet in over 80% of boys. There were no visible differences in longitudinal vaulting of both feet [3].

The present examination indicates the existence of changes under influence of regular football training. Overburdening of the lower limbs during training and games is certainly one of the causes of those changes. A footballer most often marches, trots, jogs, but also runs with moderate speed or sprints, and moves backwards. The examinations revealed that an average football player runs over 10 km distance during one game [10]. Football training emphasizes enhancement of the musculo-ligamentous apparatus and increasing mobility of the lower limbs. Games are played on various types of surface. Special football footwear, characteristic movements of the front part of feet, shift weight to one of the limbs, unnatural movements of shanks affect the development of the lower limbs and feet. Shaping of feet in a child can become disturbed by intense training that mostly involves the lower limbs, resulting in characteristic placement of the limbs and vaulting of the feet of football players.

Conclusions

The examination showed correlation between football training and placement of the lower limbs, toes and vaulting of feet. The footballers examined, especially those with the longest training experience, had varus knees, hallux valgus, and varus deformity of the small toes and depressed transverse and longitudinal vaulting of the feet more often than the non-training boys. Most probably it is a result of overburdening of the lower limbs, especially of the dominant right leg, wearing special football footwear and movements of shanks characteristic of football playing.

Introduction of corrective exercises for knees and feet to the football training routine should be strongly considered. It would be advisable to order players to perform those exercises at home. It is important that those exercises involve muscles that support the longitudinal and transverse vaulting of the feet and toes.

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STIMULATION DEMAND IN SKIERS VERSUS SKIING TRAINING RESULTS*

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ABSTRACT

Purpose. The following paper aims to examine the influence of sensation seeking on training results of skiers with different needs for stimulation, and to verify the hypothesis that people with higher needs of stimulation can achieve better results in skiing technique tests. **Basic procedures.** In order to verify the research hypothesis, a number of tests were carried out, including Zuckerman's *Sensation Seeking Scale*. Forty-one participants in skiing courses were examined. The results achieved by the subjects in skiing technique trials and in sports tests during the course were taken as the dependent variable. In addition, correlations were established between the sensation seeking scale results and the skiing theory test results. **Main findings.** The results showed a gender-related diversification of the main factors of stimulation demand, such as thrill and adventure seeking, as well as differences in the general level of stimulation demand. A correlation was established between stimulation demand and skiing technique test results only among women (0.74**, 0.59**). **Conclusions.** The skiers examined – regardless of their sex – reveal a high level of stimulation needs in thrill and adventure seeking. It can also be stated that the correlation between stimulation demand and success in skiing training is statistically significant in the sample under examination (0.65*).

Key words: downhill skiing, stimulation demand, skiing training

Introduction

Some recreational activities, regardless of the kind of practiced sport, are often perceived as hazardous. One of the reasons for such perception could be increased demand for stimulation expressed by participants in recreation as well as a tendency to experience a great deal of sensations while undertaking recreational activity [1]. High-risk forms of physical recreation include rock climbing, bungee jumping, scuba diving, paragliding, car and motorcycle racing, etc. In fact, any other widely accessible kind of physical recreation may involve some elements of risk. Some seemingly low-risk sports may include extreme elements, depending on conditions of their practicing, e.g. longer distance, more challenging terrain (e.g. desert) or increased training loads. Such sports can be running, cycling, swimming, sailing or various skiing forms, including progressive recreational skiing [2, 3].

It may seem that extreme recreational activity can only be undertaken by experts in particular sports. However, risk-seekers are often amateurs, including beginning skiers. Skiing amateurs who love to race down an icy slope also do crave for excitement. Practicing high-risk recreational activity can be conditioned by one's predispositions such as age, gender, skills or individual demand for stimulation [4]. Stimulation demand manifested by conscious seeking of intense skiing sensations can, in our opinion, affect the development of skiing habits and skills.

Stimulation demand is often directly associated with the term *sensation seeking*, which is defined as a personality trait. Individuals can be categorized according to their susceptibility to undertake activities generating intense sensations [5, 6]. The readiness to seek sensations regarded as an important trait of personality was described by Marvin Zuckerman [7]. On the basis of Hebb's notion of conceptual nervous system [8], Zuckerman postulated that people can display individual differences in the optimal stimulation of their nervous sys-

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tem. It means that reaching a certain level of emotional tension is necessary to generate an efficient action to complete a given task [9].

The differences between individual demands for stimulation can be affected by a variety of conditions and situations. The source of stimulation is not so much the empirical value of stimulation as its importance for an individual. Individuals with greater needs for stimulation are strongly disposed towards seeking new, intense sensations and experiences. They are also ready to face physical, social, legal and financial risks to ensure the supply of proper stimulation [10]. Zuckerman distinguished four subcategories of sensation seeking: *thrill and adventure seeking*, *boredom susceptibility*, *experience seeking* and *disinhibition*. He also suggested application of the above theory in studies of sports activity [11], assuming that the individual choice and success in a certain physical activity depends on one's need to experience intense sensations [12].

Zuckerman's sensation seeking scale has been used as an assessment tool in studies of stimulation demand among mountaineers. Freixanet [13] observed a higher level of stimulation demand among practitioners of extreme mountaineering, both climbers and skiers. Skiers have also been subject to psychological studies aimed at determination of the level of their stimulation demand (risk taking). Following Calhoon [14] and Boutera et al. [15], it can be assumed that practicing progressive recreational skiing aimed at self-perfection and achievement of higher results is associated with adoption of a specific lifestyle which fulfills the skiers' extraordinary need of stimulation. This issue should be considered by skiing recreation and skiing training specialists in terms of selection of forms or systems of skiing training that would more effectively contribute to the fulfillment of trainee skiers' needs, achievement of top sports results and expected improvement of general life quality [16]. Several research questions can be posed: In what way do skiers' diverse stimulation demands (an independent variable) affect the outcome of their actions (a dependent variable)? Is a skier's high demand of stimulation conducive to his or her attainment of better training results? What forms of skiing activity (technical skiing, ski gates trails) are undertaken only by sensation-seeking skiers? How is the aforementioned variable affected by such factors as the skiers' sex [6]?

This study aims to answer the above research questions with the help of the following research hypotheses:

1. Progressive recreational skiers display considerable stimulation demand.
2. A higher need for stimulation can lead to achievement of good results in skiing sport tests rather than in skiing technique tests.
3. Skiers' gender can be a discriminating factor in the correlation between stimulation demand and skiing training results.

Material and methods

The study sample consisted of 41 trainee skiers practicing progressive recreational skiing, who took part in training courses organized by the Association of Skiing Trainers and Instructors of the Polish Skiing Federation and the University School of Physical Education during the 2005/2006 season. The subjects included 13 women and 28 men; their mean age was 23.1 years.

For the assessment of stimulation demand (independent variable) Zuckerman's Sensation Seeking Scale [7, 17] was used, which consisted of four subscales related to particular factors of stimulation demand:

1. *Thrill and adventure seeking* (TAS) manifested by one's fondness for outdoor activities, extreme exercises and sports.
2. *Boredom susceptibility* (BS) manifested by one's reluctance to repeat exercises, sensitivity to idleness and monotony, and feeling of anxiety in reaction to routine.
3. *Experience seeking* (ES) manifested by a non-conformist lifestyle, fondness of unplanned trips, seeking company and using stimulants.
4. *Disinhibition* (Dis), manifested by one's tendency to relieve stress and seek relaxation in a self-indulgent lifestyle, alcohol consumption or erotic sensations.

Due to the nature of the study sample and the subject of the study, only the first two subscales were used, i.e. thrill and adventure seeking and boredom susceptibility. The obtained results were used to determine four levels of stimulation demand (very high, high, average and low) on the basis of Zuckerman's categorization [7], and then they were processed using the sten scale [18]. U Mann-Whitney test and Spearman correlation coefficient were used for statistical analysis.[1] The participants'

[1] All statistical calculations were made by Elżbieta Hurnik, M.Sc. from the Computation Centre of the University School of Physical Education in Poznań, Poland.

marks from sport technique tests and skiing theory tests were used to assess the skiing training results. The marking system was standardized and consisted of a 10-point scale. The markers were professional referees. The skiing sport tests were marked using the subjects' times at particular ski gates.

Results

The discussion of the obtained results should begin with an analysis of data concerning stimulation demand among the skiers under study. Tab. 1 shows that the highest level of thrill and adventure seeking (TAS) was reached by men (8.96 pts.), which translated into a very high level on the Zuckerman scale.

Slightly lower stimulation demand (7.69 pts.), but still high, was noted among women. The difference between the men's and women's results was statistically significant (U = 2.73**), which seems to confirm the first research hypothesis.

In terms of boredom susceptibility (BS) the men's results can be regarded as average (3.68 pts.) and women's as low (2.84 pts.). The difference between the men's and women's results was statistically non-significant.

Tab. 2 presents the assessment of the subjects' skiing training level on a 10-point scale. The highest number of points was scored by the subjects in their skiing theory tests (7.6 pts.), followed by skiing technique tests (6.6 pts.) and skiing sports tests (5.3 pts.). In all tests women scored higher than men, however, the differences were statistically non-significant.

Tab. 3 reveals correlations between total stimulation demand (BS and TAS together) and skiing training results. The highest statistically significant correlation was noted in women between stimulation demand and skiing technique test results (0.74**) and sport test results (0.59*).

A statistically non-significant correlation (0.31) was also noted between the stimulation demand level and the skiing theory test results. No significant correlations

Table 1. Stimulation demand in skiers according to Zuckerman's Sensation-Seeking Scale

Factors of stimulation demand (subscales)	Women			Men			All			U Mann-Whitney test
	$\bar{x}$	SD	Mdn	$\bar{x}$	SD	Mdn	$\bar{x}$	SD	Mdn	
TAS	7.69	1.43	8	8.96	1.23	9	8.56	1.41	9	2.73**
BS	2.84	1.72	3	3.68	1.43	4	3.41	1.73	3	1.35
Total stimulation demand	10.54	2.69	11	12.64	2.09	13	11.97	2.47	12	2.39*

TAS – thrill and adventure seeking, BS – boredom susceptibility, Mdn – median, *$\alpha < 0.05$, **$\alpha < 0.01$

Table 2. Assessment of skiing training results

Assessment tests	Women			Men			All			U Mann-Whitney test
	$\bar{x}$	SD	Mdn	$\bar{x}$	SD	Mdn	$\bar{x}$	SD	Mdn	
Skiing technique test	6.73	0.99	6.75	6.45	1.26	6.54	6.54	1.18	6.7	0.75
Skiing sport test	6.07	2.32	7.00	5.57	1.79	6.00	5.73	1.96	6.00	1.21
Skiing theory test	7.80	0.76	8.00	7.57	0.60	7.61	7.64	0.65	7.75	1.13
Total assessment score	6.87	1.20	7.17	6.53	1.04	6.55	6.64	1.10	6.79	1.24

Mdn – median

Table 3. Correlations between stimulation demand and skiing training results

Stimulation demand / Skiing training results	BS			TAS			BS + TAS		
	Women	Men	All	Women	Men	All	Women	Men	All
Skiing technique test	0.70**	0.07	0.22	0.40	–0.11	–0.07	0.74**	–0.04	0.10
Skiing sport test	0.60*	–0.06	0.15	0.26	0.03	–0.02	0.59*	–0.05	0.08
Skiing theory test	0.40	0.04	0.10	0.05	–0.13	–0.12	0.31	–0.07	–0.02
Total assessment score	0.64*	–0.03	0.15	0.30	–0.04	–0.06	0.65*	–0.08	0.05

BS – boredom susceptibility, TAS – thrill and adventure seeking, *$\alpha < 0.05$, **$\alpha < 0.01$

were observed among the male subjects. Considering particular factors of stimulation demand separately, it can be confirmed that the observed correlations between the studied variables are most explicit between boredom susceptibility (BS) and skiing technique test results (0.70**) and sport test results (0.60*) in women, and to a smaller extent between thrill and adventure seeking (TAS) skiing technique test results (0.40) and skiing sport test results (0.26).

Discussion

Research into sensation seeking has been often carried out in consideration of the risk involved in particular sport activities. Different sports were classified into different categories with reference to the likelihood of accidents (traumas, injuries). Downhill skiing is classified as a sport with a high injury risk [2, 12]. There is also note that people practicing high-risk sports are susceptible to boredom and seek stimulation and adventure [14, 15]. This observation is confirmed by the results of the present study. The skiers (especially men) under study featured a high level of stimulation demand. The above mentioned authors fail to describe possible correlations between the level of stimulation demand and the level of efficiency of actions in high-risk sports. The present study revealed diverse correlations between the subjects' thrill and adventure seeking and susceptibility to boredom, and their skiing training results. In terms of total stimulation demand it can be stated that, in accordance with the first research hypothesis, the skiers under study highly valued thrill and adventure seeking, outdoor activities, physical exercise of high risk and eagerness to practice extreme sports. The skiers also showed relatively greater tolerance towards their participation in boring, monotonous and repetitive activities. The observed low and average demand for novelty and diversity might be related to their adaptation to the long-term process of development of skiing skills and technique.

The second research hypothesis was not confirmed in the study. No statistically significant correlations were observed in the group of men under study, i.e. the presumption about men being adventure-seekers and achieving higher results in skiing training is not true; however, it turned plausible for the group of women. It could be that undertaking sensation-seeking activity does not affect the effectiveness of men's participation in skiing training, but it is quite possible in the case of women. The third research hypothesis about gender-related differences was thus confirmed in the study, however, it definitely requires further research.

Conclusions

1. The female skiers under study revealed a high and the male skiers a very high level of stimulation demand in one sensation-seeking category, i.e. thrill and adventure seeking (TAS).
2. The skiers, regardless of their sex, featured a low level of boredom susceptibility, i.e. a high level of tolerance of monotonous and repetitive activities.
3. High stimulation demand is correlated with higher skiing training results in women; no such relationship was observed in the group of male skiers under study.
4. An important factor differentiating the types of correlations between selected subscales of the sensation-seeking scale (TAS and BS) and success in skiing training can be the skiers' sex.

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THE EFFICIENCY MODEL OF SOCCER PLAYER'S ACTIONS IN COOPERATION WITH OTHER TEAM PLAYERS AT THE FIFA WORLD CUP

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ABSTRACT
Purpose. The purpose of this paper is to present a simple, table-graphic model of one-to-one play in soccer based on observation of cooperation of top soccer players. **Basic procedures.** The research material consisted of audio-visual recordings from six soccer matches played by the three top teams of the 2006 World Cup finals. The data concering one-to-one plays was entered on a special form. Offensive and defensive actions were assessed with reference to the implementation of the game's objectives and players' position in the field zones. **Main findings.** It has been proven that elite soccer players are most effective at intercepting the ball down the field and in other zones of the pitch. They are also very active in breaking their opponents' offensive actions in midfield. **Conclusions.** The models reflecting elite soccer players' efficiency in one-to-one play should constitute important references for the training of novice soccer players.

Key words: soccer, efficiency, one-to-one play, model

Introduction

A sport team game consists of a struggle between players from two opposing teams, who try to secure a point lead following the rules of the game. The struggle consisting of players' actions is a process of incessant arrangement of relationships between team mates, opponents and other persons involved in competition.

The essence of team play is the interdependence of actions of all the players. The degree of this interdependence varies and is contingent on the complexity of situations during the game. The players' actions during a team game can be divided into those enabling achievement of the game's objectives (individual actions on the ball indirectly dependent on team mates; and team actions directly dependent on team mates) and those facilitating achievement of these objectives (organizational and socio-emotional facilitation) [1].

The player's individual actions with the ball against a single opponent or individual actions without the ball against an opponent in possession of the ball, which are relatively independent of the player's team mates, can be called a one-to-one play.

One-to-one play is direct interaction of two players from the opposing teams aimed at attainment of contradictory goals according to the rules of the game. One-to-one play in attack is a total of actions and reactions of a player with the ball taken against a single opponent, aimed to score a point (goal), create a goal scoring opportunity, control the field of play and/or retain possession of the ball. One-to-one play in defense consists of actions of a player against one opponent in possession of the ball aimed at interception of the ball, breaking his movement or blocking the movement of the ball [2].

The above definitions of one-to-one play do not cover struggle to take control of a loose ball, i.e. actions of two opponents to take control of the ball, or combined actions, i.e. actions commencing with a player in possession of the ball engaging in one-to-one play and then switching to cooperation with another team player, e.g. passing the ball.

The results of one-to-one play should be assessed positively or negatively in terms of attainment of the aims of the game in attack or defense. On the other hand, a player's habitual behavior in unexpected situations of struggle for a loose ball should be marked positively regardless of the results of his actions. The player's readiness and actions to take possession of a loose ball (taken without setting a definite goal and course of action) are qualities by themselves as they facilitate the synergic effects of actions of the entire team. Possible assessment can be willingness (positive assessment) or

unwillingness (negative assessment) to undertake such actions [3].

Praxeology of sport play deals with a multiplicity of its components represented as a system of sets: efficiency criteria[1], players' patterns of behavior and actions, changing situations during competition, aims pursued by players, players' performance, ontogenetic dispositions to play, and relationships within and between individual sets. Such a system is, in fact, a theoretical model of play enabling a detailed and ordered presentation of qualitative and quantitative characteristics (models) of the game components [4].

Praxeological models are constructed to understand the principles of sport play and to improve players' actions. According to Panfil, the praxeological models enable:

- improvement of actions during play by referring to objective models;
- improvement of effectiveness in play by imitating model performances;
- economization of players' actions through limitation of ineffective actions and thus elimination of the costly "trial and error" method [4, p. 151].

Designing praxeological models requires multiple and reliable, objective observations of top class players in real competition. The assessment of individual actions performed by players must take into consideration the changing situations during play (stage and aim of the game; place, way, time and conditions of action). The ordering and valuation of observed actions according to the accepted rules allow distinction of situation patterns, i.e. representation models. The representation models can then be used to create design models which can facilitate players' actions by demonstrating classified types of situations and their solutions.

The praxeological model of sport play includes, in particular, tabular models, mathematical models (indices), graphic model (charts or computer generated models) and simplified reality models (smaller game variants, game parts, game tasks, etc). Simple mathematical models contain the main indices of effectiveness and reliability as well as auxiliary indices of activity, movement and controlling the zones of the field of play [4].

The present paper aims to demonstrate in a table-graphic form a simplified model of one-to-one play in soccer based on observation of cooperation of top soccer players. The following research questions have been posed:

1. What player's actions – indirectly dependent on his team mates – are most frequently performed in one-to-one attack and one-to-one defense plays?
2. What is the activity, effectiveness and reliability of actions of soccer players intending to score a goal, create a goal scoring opportunity, take control of the field of play and keep possession of the ball in one-to-one plays?
3. What is the activity, effectiveness and reliability of actions of soccer players intending to intercept the ball, tackle an opponent and control the field of play in one-to-one plays?
4. What is the activity of soccer players struggling to gain possession of a loose ball?

Material and methods

The research material consisted of audiovisual recordings of six soccer matches played during the 2006 World Cup finals. The games of the three top teams were examined (Tab. 1).

Table. 1. Soccer matches and their results

Competing teams*	Score	Tournament stage
1. **Italy**–Czech Republic	2:0	group stage
2. **Italy**–Ukraine	3:0	quarter-final
3. **France**–Brazil	1:0	quarter-final
4. **France**–Portugal	1:0	semi-final
5. **Germany**–Portugal	3:1	third-place match
6. **Germany**–Sweden	2:0	knockout stage (1/8)

* teams under study in bold

The gathered data concerning one-to-one plays were entered on a special observation form[2]. The analysis was concerned with the efficiency of offensive and defensive actions in one-to-one plays considering the game's objectives (goal scoring, creating a goal scoring

[1] In praxeological terms, efficiency of action is understood as a total of practical qualities of play, which includes: activity (number of actions performed by players of one team during a match), effectiveness (number of positive actions with reference to the game's aims) and reliability (ratio between the number of effective actions and the number of all actions of one type during the game). Other indices of play efficiency encompass rationality (actions cognitively justified), valuableness (value of assessment of action efficiency) and economy (loss-gain ratio) [4].

[2] Based on earlier studies concerning the objectivity of the proposed method, its reliability amounts to 97% and total accuracy to 95% [3].

opportunity, taking control of the field of play and keeping possession of the ball in attack; interception, tackling, controlling the field of play in defense) and field zones[3] (defense zone (A), midfield (B), attack zone (C)).

The following one-to-one play actions indirectly dependent on team mates were defined:

- keeping possession of the ball – action of the player in possession of the ball against an opponent within 2 m, leading to the former moving parallel to the goal line or towards his own goal or retaining possession of the ball without movement;
- taking control of the field of play – action of the player in possession of the ball against an opponent within 2 m leading to moving the ball towards the opponent's goal;
- creating a goal scoring opportunity – action of the player in possession of the ball against an opponent within 2 m, leading to the possibility of taking a shot at the goal or passing the ball to the striker;
- scoring a goal – action of the player in possession of the ball against an opponent within 2 m, leading to taking a shot or having a temporary freedom of action to perform the shot (against the goalkeeper and against a defender);
- interception – action of a player against the opponent in possession of the ball within 2 m, leading to interception of the ball and undertaking an offensive action;
- tackling – action of a player against the opponent with the ball within 2 m, leading to dispossessing the latter of the ball temporarily (clearing) or permanently (interception);
- controlling the field of play – action of a player against the opponent in possession of the ball within 2 m, leading to the latter moving parallel to the goal line or towards his own goal or retaining possession of the ball without movement, or passing the ball to a team mate.

Results and discussion

Data from Tab. 2 show that the dominant actions in one-to-one plays during the competition included keeping possession of the ball (58.2%) and taking control of the field of play (30.8%). Creating a goal scoring opportunity amounted to 8% of one-to-one play actions, while scoring a goal to only 3% (including merely one-to-one play action against a defender).

Table 2. One-to-one play in attack

Action \ Index	Number	Percentage
Scoring a goal after one-to-one play against the goalkeeper	10	2.7
Scoring a goal after one-to-one play against a defender	1	0.3
Creating a goal scoring opportunity	30	8.0
Taking control of the field of play	116	30.8
Keeping possession of the ball	219	58.2
Total	376	100.0

Tabular and graphic models (Tab. 3, Fig. 1) show that the players in the matches examined were most efficient in taking control of the field of play (14.16 actions on average during a game; with 78% reliability). On other hand, keeping possession of the ball (36.50 on average per game) revealed much lower reliability (61%).

In creating goal scoring opportunities the World Cup soccer players displayed 60% reliability (three effective actions out of five situations per game on average); however, in terms of goal scoring their reliability was the lowest and featured 45% (1.83 actions per game).

The activity and effectiveness results of one-to-one play considering the field zones from Tab. 3 lend credence to the observed tendencies among the top World Cup teams. The players' activity in creating goal scoring opportunities and goal scoring was observed only in the attack zone (C). Effective possession of the ball and taking control of the field of play were the dominant actions in midfield (B). Keeping ball possession was also most frequent in the defense zone (A). The players displayed the highest reliability of one-to-one play in taking control of the field of play, which decreased as they moved up the field (attack zone – 87%, midfield – 79%, defense zone – 63%).

Earlier research [5] revealed statistically significant differences in activity and reliability of one-to-one play in attack between winning and losing soccer teams. The former engaged in one-to-one play more frequently and efficiently, especially in the midfield (B) and attack zone (C).

[3] The defense zone (A) is the area between the player's own goal line, both touchlines and an imaginary 33 m line parallel to the goal line; the attack zone (C) is the area between the opponent's goal line, both touchlines and an imaginary line parallel to the goal line; the area between the attack zone and the defense zone is the midfield (B).

Table 3. Efficiency of one-to-one play in attack considering the game's objectives and field zones

Action \ Index	Defense zone (A)			Midfield (B)			Attack zone (C)			Entire pitch		
	A	E	R	A	E	R	A	E	R	A	E	R
Scoring a goal after one-to-one play	0	0	0.00	0	0	0.00	11	5	0.45	11	5	0.45
Creating a goal scoring opportunity	0	0	0.00	0	0	0.00	30	18	0.60	30	18	0.60
Taking control of the field of play	8	7	0.87	62	49	0.79	46	29	0.63	116	85	0.73
Keeping possession of the ball	32	21	0.66	126	81	0.64	61	31	0.51	219	133	0.61

A – activity, E – effectiveness, R – reliability

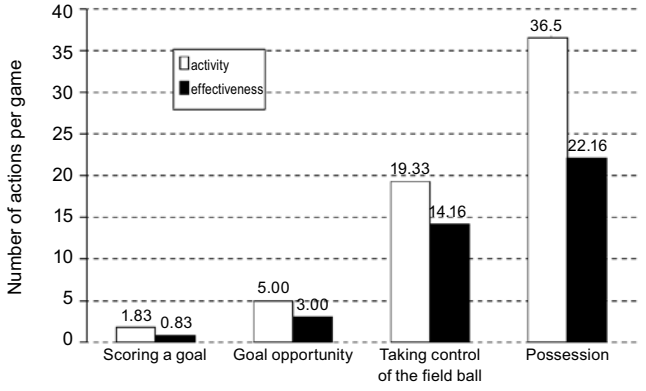

Figure 1. Graphic model of one-to-one play in attack (average number of actions per game)

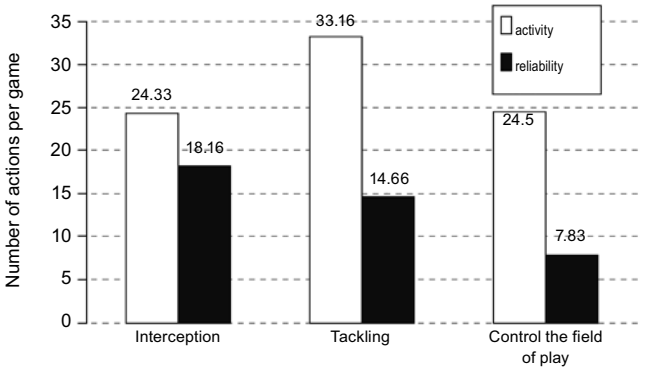

Figure 2. Graphic model of one-to-one play in defense (average number of actions per game)

Tab. 4 presents a model of one-to-one play in defense. It shows that the dominant one-to-one action in defense undertaken by the top teams under study was tackling (40.45%) followed by interception (29.67%) and controlling the field of play (29.88%).

Fig. 2 shows a graphic model of the average number of one-to-one actions in defense. It can be noted that the top soccer players under study tackled their opponents 33 times, and controlled the field of play and intercepted the ball 24 times on average per game. The number of effective actions per game amounted to 14.66, 7.8, and 18.16, respectively.

The data from Tab. 5 show that the players of the top three 2006 World Cup teams achieved the highest reliability of actions in interception (75%), and much lower in tackling (44%) and controlling the field of play (32%). Tab. 5 shows that the players' activity was the highest in midfield (tackling – 120 times, controlling the field of play – 62, ball interception – 58) and that they intercepted the ball in their own defense zone very frequently (60 effective actions out of 69 one-to-one actions). The reliability of their interception was the highest in the defense zone (87%) followed by attack zone (68%) and midfield (62%).

Table 4. One-to-one play in defense

Action \ Index	Number	Percentage
Interception	146	29.67
Tackling	199	40.45
Controlling the field of play	147	29.88
Total	492	100.00

The analysis confirmed the tendencies in the play of elite soccer teams observed in earlier research. The top European Championship and World Cup teams are greatly superior to other teams in their one-to-one ball interception activity, effectiveness and reliability in midfield [5].

It should be emphasized that the soccer players under study achieved the lowest results in tackling and controlling the field of play in their attack zone (26% and 36% reliability).

One of the characteristic elements in soccer play is one-to-one struggle to gain possession of a loose ball. Such situations are accidental plays resulting from unintended clearing, rebounding, the ball hitting the referee, corner flag, or goalkeeper's punting downfield.

Table 5. Efficiency of one-to-one play in defense considering the game's objectives and field zones

Index / Action	Defense zone (A)			Midfield (B)			Attack zone (C)			Entire pitch		
	A	E	R	A	E	R	A	E	R	A	E	R
Interception	69	60	0.87	58	36	0.62	13	13	0.68	146	109	0.75
Tackling	60	40	0.66	120	43	0.36	5	19	0.26	199	88	0.44
Controlling the field of play	74	15	0.20	62	28	0.45	4	11	0.36	147	47	0.32

A – activity, E – effectiveness, R – reliability

They involve two opponents who undertake almost simultaneous action to gain possession of the ball.

Fig. 3 shows that the top World Cup soccer players undertook on average 82 one-to-one actions in defense, 63 in attack and 70 actions to gain possession of a loose ball per game. In quantitative terms, the statistics was exemplary. Results of other studies [6–9] show that the number of one-to-one actions undertaken by top soccer players ranged from 200 to 300 per game.

Tab. 6 shows the number of one-to-one actions to gain possession of a loose ball. It can be noticed that most often the top soccer players under study undertook such actions in midfield (33.33), and then in their own defense zone (22) and attack zone (14.33). The number of actions to gain possession of a loose ball ranged from 40 (France–Portugal) to 84 (France–Brazil) per game.

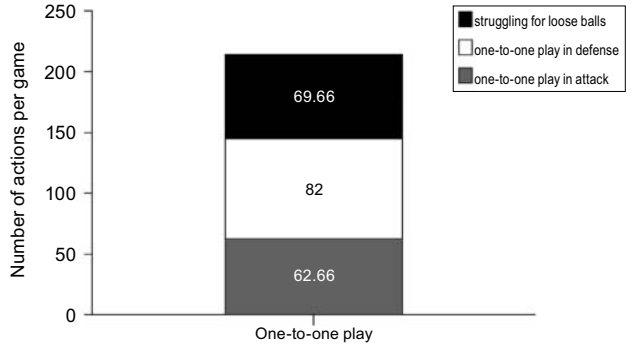

Figure 3. Graphic model of the number of one-to-one actions

Numerous studies and expert opinions point to the great significance of team work to achieve success in team games. It is often emphasized that modern soccer is dominated by offensive actions consisting of swift play without receiving the ball, involving changing positions and tasks, and controlling the opponent by "playing ball". A modern soccer team which loses the ball, quickly rearranges its defense line and coordinates all the actions to successfully intercept the ball [3].

However, the significance of one-to-one play in soccer must not be sidelined. Following Panfil, "Team building weakens individual actions. This is an adverse influence as it confines the range of means to achieve the game's aims to actions which are directly dependent on team mates. It also lowers the level of players' satisfaction and, in consequence, their motivation to act" [4, p. 75]. Panfil suggests that such influence should be avoided by considering individual aspirations within the indispensable, effective team actions.

The results of the present study indirectly confirm the above observations. Most likely the relative easiness of playing ball in one's own defense zone, forcing the highest activity from the players in midfield and their reduced efficiency in the attack zone results from the way the opposing team's defense is organized (active zone defense, off-sides, double marking, altering defense width and depth).

The above analysis revealed that the players were most effective while intercepting the ball not only in their own defense zone but also in the other zones of the pitch. They were also highly active in breaking the opponent's offensive actions in midfield. In attack, they displayed great efficiency in taking control of the field

Table 6. The number of actions to gain possession of a loose ball

Index / Loose balls	Defense zone (A)	Midfield (B)	Attack zone (C)	Entire pitch
Number of actions	132.00	200.00	86.00	418.00
Arithmetic mean	22.00	33.33	14.33	69.66
The lowest number of actions	15.00	19.00	8.00	40.00
The highest number of actions	35.00	46.00	19.00	84.00

of play and ball possession (mostly in midfield) as well as in creating goal scoring opportunities.

The results of the research show that the elite soccer players were very active in midfield. This partially confirms the well-known rule of soccer: "Who controls the midfield, wins the game."

It should also be noticed that the overall reliability of the teams in one-to-one play (all one-to-one plays regardless of the game's aims, field positions and struggles for loose balls) amounted to 60% in attack and 50% in defense, considering the relative balance between the number of offensive and defensive actions (63 one-to-one plays in attack and 82 one-to-one plays in defense per game on average). It shows that one of the major indicators of soccer play at the highest level can be a high efficiency of one-to-one play actions in attack.

Conclusions

1. The analysis of one-to-one plays in attack in the matches under study revealed a dominance of actions aimed at keeping possession of the ball and taking control of the field of play. They constituted 89% of all the actions and featured 78% and 61% reliability, respectively. Creating goal scoring opportunities and goal scoring were rarer (8% and 3%, respectively) and their reliability was lower (60% and 45%, respectively).

2. In one-to-one plays in defense the soccer players displayed the highest activity (40%) in tackling, followed by interception (30%) and controlling the field of play (30%). The actions of highest reliability included interception (75%), tackling (44%) and controlling the field of play (32%).

3. The top World Cup players engaged in about 70 one-to-one struggles per game to gain possession of a loose ball. In these plays their activity was the highest in midfield.

4. Models reflecting one-to-one actions by top level soccer players should serve as important references in training of novice players.

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DOPING IN SPORT: NEW DEVELOPMENTS

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ABSTRACT
Gene doping is defined by the World Anti-Doping Agency (WADA) as "the non-therapeutic use of genes, genetic elements and/or cells that have the capacity to enhance athletic performance." The rapid development of molecular biology has enabled not only treatment of many diseases, but also improvement of athletes' fitness. Gene therapy methods can be used to modify the athlete's body by inserting genes into the target tissue. It is very possible that in near future, many genes will be used in gene doping, e.g. erythropoietin, growth hormone, insulin-like growth hormone and vascular endothelial growth factor. Functional tests conducted by many independent laboratories proved that products of these genes exert a crucial influence on the body's adaptation to exercise. The risk of gene doping is enormous. Gene therapy is currently in the phase of clinical tests so it is impossible to predict what kind of side effects it may produce. Studies on animal models showed that the uncontrolled transgene expression and insertional mutagenesis can even lead to death. At present the detection of gene doping is very difficult for a variety of reasons. The main problem is the identification of the transgene and endogenously produced protein. The only possible detection is the biopsy of the target tissue, where the exogenous genes were inserted.

Key words: gene doping, performance enhancement, gene transfer, doping detection

Introduction

One of the most serious problems of present-day competitive sport is the increasing abuse of various performance-enhancing substances. Doping is not a product of modern times; illegal stimulants were already used in antiquity. The first recorded case of using substances enhancing athletes' physical performance dates back to the Olympic Games in the 3rd century BC. The use of doping was also known in ancient Rome and Egypt. The first banned substances were of natural origin and included, for instance, a beverage from donkey hooves, or dried figs [1]. In the 19th century long-distance swimmers and cyclists were reported to use such performance enhancing substances as caffeine, strychnine, ether, alcohol or oxygen. The state of knowledge of the human physiology and effects of different substances on metabolism of human cells was fairly limited at that time and athletes' abuse of the mentioned compounds led sometimes to death. The first recorded lethal case was cyclist Arthur Linton who died in 1896 after having taken strychnine. The absence of drug tests made many athletes enhance their performance with impunity. Taking stimulants, however, not always yielded favorable results and often led to serious health problems.

In the case of present-day athletes one may gain an impression that using "ordinary" stimulants is not sufficient. The development of medicine and molecular biology makes it possible to use doping adjusted to individual physiological parameters important for a given sport. The number of athletes ready to violate the rules of fair play to achieve better results increases constantly. Many of them are ready to risk their health, or even life, to take first place. Attaining a desired aim takes priority over health consequences of using doping substances.

At present, the list of banned substances taken orally, intravenously or intramuscularly includes a few dozen items. In recent years some recombinant substances[1] that have been successfully used in treatment of many

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[1] Recombinant substances are natural compounds present in the human body, which are manufactured synthetically, e.g. growth hormone, erythropoietin and insulin.

diseases have been often administered as illegal stimulants. The first recombinant substance was insulin, produced in bacteria host cells following the insertion of a viral vector carrying an insulin-encoding gene. It became registered in the United States in 1982 as Humulin. Recombinant substances can enhance the muscle function, aerobic capacity or the body's regeneration. They are manufactured using prokaryotic or eukaryotic expression systems. Their production consists of constructing expression vectors, which are fragments of genomes (e.g. bacterial, Saccharomyces or mammalian cell lines), to introduce and express a specific gene into a target cell. Once the expression vector is inside the cell, a protein encoded by the gene is produced by the cellular transcription and translation machinery [2]. The recombinant substances are still very difficult to detect, and an increase in their abuse by athletes can be expected in the future. The commercialization of new pharmaceuticals manufactured with the aid of biotechnology will lead to their wider accessibility.

A form of doping which has recently become very attractive to some athletes is gene doping based on gene therapy methods, which allows direct insertion of genes into the athlete's body. The products of such genes, e.g. proteins, can be used as a substance enhancing athletic performance. The long-term production of such protein in the target tissue increases its concentration and activity. Gene doping methods include:

- insertion of a specific gene into the target tissue;
- administration of substances enhancing gene expression.

The prospects of gene doping can be very attractive to athletes, as for the time being its detection remains virtually impossible.

Gene doping is becoming a serious hazard. In 2005 the World Anti-Doping Agency (WADA) defined gene doping as "the non-therapeutic use of genes, genetic elements and/or cells or modification of gene expression that have the capacity to enhance athletic performance." The list of prohibited substances tested for gene doping becomes longer each year; the most popular substances include growth hormone (GH), erythropoietin (EPO), insulin, insulin-like growth factor (IFG-I), hemoglobin-based oxygen carriers (HBCOs), alpha-actinin 3 (ACTN3), angiotensin convertase (ACE), hypoxia inducible factor (HIF-1α), delta peroxisome proliferative activated receptor delta (PPAR), and endothelial growth factor (VEGF).

Gene insertion techniques used in gene therapy can be divided into:

- biological: through viral vectors;
- physical: through injection or gene gun;
- chemical: through liposomes.

The most effective are methods using viral vectors, which can modify both prokaryotic cells (bacteria) and eukaryotic cells (yeasts, insect cells, mammalian cell lines). They usually involve deletion of a part of the viral genome critical for viral replication. Such a recombinant virus can efficiently infect cells which are capable of transgene expression. The most frequently applied viral vectors are retroviruses, adenoviruses, Herpes simplex viruses and adeno-associated viruses (AAV).

An ideal viral vector should:

- be able to penetrate both prokaryotic and eukaryotic cells;
- easily integrate into the host genome;
- not cause any responses of the immune system;
- feature a high level of expression of the carried gene;
- synthesize proteins of low toxicity;
- be capable of regulating gene expression.

The main advantages of viral vectors include long-lasting expression of the transduced gene and cellular tropism. However, such a significant intervention in the human body may lead to severe complications like:

- insertional mutagenesis, associated with the applied viral vector system, type of transformed cell, location of vector integration, and transgene expression;
- development of an infectious virus;
- excessively long or uncontrolled transgene expression.

During insertion of a gene into the organism, its expression should be controlled to prevent excessive amounts of protein from accumulating. Otherwise an uncontrolled cell division, cell toxication or poisoning of the entire body may occur.

Gene therapy involves many risks related to the ways of gene insertion into the target tissue, immunological response to the viral vector, or insertional mutations. The history of gene therapy knows cases of patients' deaths or development of leukemia, e.g. death of a patient suffering from the deficiency of transcarbamoilase due to transduction of an unmutated gene; or induction of insertional mutation by a retroviral vector resulting in leukemia in 2 out of 11 patients suffering from X chromosome-related acute complex immunological deficiency [3].

The effects of application of such methods by athletes willing to "perfect" their bodies are very difficult

to predict. There are alarming reports about studies into gene transduction into human tissues and gene expression resulting in long-lasting protein overexpression. Observing the increasing tendency among athletes to constantly enhance their performance by all means, one can expect that they would reach for gene doping, unaware of its hazards. Intensive research into gene doping detection has so far brought no successful results. Gene doping detection is exceptionally difficult as the inserted gene causes an increase in the concentration of a specific substance only in the target tissue. Thus any blood or urine tests are not able to detect it. It is also highly probable that a transgene product will be identical to a naturally synthesized protein, and the detection of differences between such two products will require a great quantity of detailed tests. Another question is whether a higher concentration of a given factor is a result of training, doping or athlete's genetic predispositions which can lead to its increased expression.

Selected non-viral techniques of gene insertion

Electroporation

Electroporation consists of application of a high voltage current to target cells. It opens the pores in the cell membrane through which exogenous DNA can enter the cell.

Gene gun

A gene gun is a device for injecting cells with genetic information. It uses particles of a heavy metal (gold, silver, tungsten) coated with plasmid DNA. The DNA coated particle is delivered to the target tissue with the aid of a helium propellant and the DNA is released into the cytoplasm. The inserted DNA then migrates into the cell nucleus where it becomes integrated into the genome DNA.

Liposomes

Liposomes are spherical vesicles composed of a bilayer membrane, whose structure resembles the membrane of animal cells. The delivery of DNA into a cell consists of a fusion between the liposome and the cell membrane. The amount of DNA delivered this way is far smaller than by using viral vectors; however, the liposomes have been considered by researchers for drug delivery in treatment of cancer and a number of genetic disorders.

Prohibited substances used in sport doping

Growth hormone (GH)

One of the most commonly abused substances in sport over the last decades has been undoubtedly growth hormone, also known as somatotrophine. GH is a protein hormone, which is secreted in large pulses from the anterior pituitary. The GH secretion is stimulated during sleep, fever, physical exercise, stress as well as by some amino acids (leucine, arginine) and hormones (estrogens and androgens). The GH level also increases in hyperthyroidism. Long and intense physical exercise can elevate GH secretion up to ten times [4]. The inhibitors of GH secretion include obesity and hyperglycemia.

The peak GH secretion takes place in puberty and then it decreases with age. GH affects a number of different tissues; however, it exerts the greatest influence on the bone tissue, cartilage, skeletal muscle, adipose tissue, liver, kidneys and the immune system. Somatotrophin has anabolic activity. Its protein synthesis potential is comparable to that of testosterone. GH promotes lipolysis, enhances calcium retention and bone growth and mineralization by stimulating chondrocytes to synthesize insulin-like growth factor (IGF-I), which in turn enhances the synthesis of collagen and mucopolysaccharides. It also promotes the synthesis of IGF-I in the liver. GH is regarded as the agonist of insulin. Some factors, e.g. stress or physical exercise, activate the central nervous system which sends impulses to the hypothalamus. Depending on the type of impulse the hypothalamus cells start synthesizing the growth hormone releasing hormone (GHRH) or growth hormone inhibiting hormone, i.e. somatostatine (SS). These factors reach the anterior pituitary and stimulate or inhibit GH secretion. GH receptors are located in the majority of human tissues. The contact between GH and a receptor results in dimerization of the former and stimulation of the intracellular domain of the receptor tyrosine kinase. The signal transduction consists of protein phosphorylation and, in consequence, of regulation of transcription of specific genes. GH secretion can be also stimulated by ghrelin – a short peptide produced in the hypothalamus, anterior pituitary and stomach.

About 50% of GH in the blood is bound to the growth hormone binding protein (GHBP). The GHBP

level in serum depends on a number of factors, e.g. age, nutritional status, and the levels of growth hormone, insulin and sex hormones.

Important mediators in GH activity are insulin-like growth factors (IGF-I, IGF-II) synthesized in the liver stimulated by GH. The activity of IGFs can be of autocrine and paracrine character, e.g. in fibroblasts, myoblasts, chondroblats, osteoblats and brain or renal cells.

In the late 1950s GH from the pituitary of deceased persons was first used for treatment of somatorophin deficiency in children. In 1989 recombinant human growth hormone (rhGH) was developed. The rhGH treatment of patients with GH deficiency increases the muscle mass and lean body mass, reduces the adipose tissue and enhances the functioning of the heart and kidneys [4].

Growth hormone became commercially available as an ergogenic aid in 1988 and soon became immensely popular among athletes who were interested in the enhancement of their training quality. The attractiveness of GH relied on a conviction that the hormone strengthened tendons, accelerated tissue regeneration, increased muscle mass and strength and reduced the fat deposition. Its main advantages were anabolic activity, accessibility, small risk of side effects and impossibility to detect [5].

Growth hormone is mainly abused by strength sports athletes, sprinters as well as endurance sports athletes and soccer players. GH is often used by women as it entails no risk of androgenic side effects [4]. A number of outstanding athletes were known to use GH doping, e.g. Ben Johnson, who was stripped of his Olympic gold medal from Seoul in 1988 after having admitted taking GH in combination with anaerobic steroids for many years [5].

Despite the conviction about the absolute safety of GH use, there are indications that a long-term administration of human growth hormone can increase the risk of diabetes, retention of fluids, joint and muscle pain, hypertension, cardiomyopathy, osteoporosis, irregular menstruation, impotence and elevated HDL cholesterol [6].

A few independent laboratory tests failed to confirm the observation of GH greatly enhancing muscle strength and mass. Taking large doses of GH does not enhance exercise-induced protein synthesis. It leads to an increase of the lean body mass in result of adipose tissue reduction, increasing total body water and the level of total protein synthesis in the body. These data concern, however, the entire body rather than individual body parts. An increase in muscle strength was not observed due to GH administration [4].

Insulin-like growth factor I (IGF-I)

The insulin-like growth factor I (IGF-I) is a mediator of growth hormone which affects almost all tissues in the human body. Six IGF binding proteins have been identified in serum as well as an acid-labile subunit (ALS). IGF-I affects the cells through the receptor tyrosine kinase but it can also bind with an insulin receptor and cause hypoglycemic effects. IGF-I plays a key role in GH regulatory processes. The local synthesis of IGF-I leading to its autocrine and paracrine secretion is an indication that IGF-I is a factor inducing a variety of metabolic processes [5]. The blood concentration of IGF-I is related to age, sex, diet (low-calorie and low-protein diet decrease the IGF-I level) as well as the levels of insulin, parathyroid hormones, sex hormones (estrogens decrease and androgens increase the IGF-I level). In diabetes and pregnancy the IGF-I synthesis decreases, but it rises in regenerating tissues (especially in skeletal muscle). A higher IGF-I synthesis was observed in the course of some malignant diseases, e.g. prostate, breast and colon cancer. The spectrum of IGF-I activity includes:

- stimulation of cell growth and development in bone, cartilage, muscle, hematopoetic system, kidneys and pancreas;
- stimulation of growth;
- activation of protein synthesis and glucose and glycogen uptake;
- inhibition of degradation of muscle proteins;
- regeneration of tissues;
- antiapoptic effects (in reaction to hypoxia);
- stimulation of acetylocholine secretion;
- regulation of the cell growth cycle;
- modulation of immunological response (affecting the synthesis of cytokines, and immune system cells) [6].

The clinical use of recombinant human IGF-I (rhIGF-I) is based on its regulatory properties. The rhIGF-I regulates glucose homeostasis through regulation of insulin activity and it has been used in treatment of diabetes mellitus type 1 and insulin resistance for about twenty years. The administration of IGF-I in patients with diabetes mellitus type 2 and acute insensitivity to insulin has also yielded positive test results. The

influence of endogenous IGF-I on glucose metabolism is not clear: it either directly lowers the glucose activity, or directly increases insulin sensitivity [7].

The control of IGF-I expression is multilevel. The IGF-I expression is controlled by hormones, mainly glycocorticoids, which cause a decrease of IGF-I expression in osteoblasts and of type I collagen expression as well as an increase of type III collagen expression. They also induce apoptosis in many types of cells. Research has shown that cortisol lowers IGF-I expression for 50%, whereas parathormone and prostaglandin E2 (PGE2) stimulate it [8, 9].

Endogenous IGF-I has three protein isoforms:

- IGF I-Ea synthesized in skeletal muscle, very similar to the main IGF-I form produced in the liver;
- Mechano-Growth Factor (MGF) produced in skeletal muscle;
- IGF I-Eb produced in the liver; its role in muscle remains unknown.

Exercise-induced MGF expression most likely leads to the activation of satellite cells responsible for the formation of new muscle fibers. MGF plays a significant role in muscle hypertrophy following training or muscle damage [10]. In young people the MGF expression occurs after the first strength training session. In older people it comes much later: only after five weeks training did the amount of mRNA MGF increase for 163%. Strength training-induced MGF expression increases even for 456% following the administration of rhGH in elderly men [11]. It proves that only the combination of physical exercise and administration of rhGH can result in muscle hypertrophy. Most studies have indicated that rhGH administered in non-training subjects fails to enhance muscle strength [10]. One of results of strength training was also the expression of IGF-Eb; however, the precise role of this protein in muscle remains unknown.

IGF-I can be abused as a stimulant due to some of its properties:

- hypertrophic adaptation of muscles to exercise, i.e. working hypertrophy;
- potential contribution to adaptation of the cardiac muscle to exercise;
- participation in glucose metabolism;
- affecting the ion balance.

IGF-I can be regarded as an attractive doping substance due to its role in the Growth Hormone/IGF-I axis in glucose metabolism. Clinically administered GH and IGF-I induce changes in glucose homeostasis and resistance to insulin. The role of IGF-I is similar to that of insulin, whereas GH is antagonistic. The precise mechanism of these processes remains largely unknown; however, an increased GH secretion lowers the insulin blood level, which leads to IGF-I synthesis in the liver [12]. Studies on mice showed that the lack of IGF-I gene resulted in a decrease of IGF-I in circulation, higher blood levels of GH and insulin and reduced or absence of insulin sensitivity. Insulin insensitivity was shown to be muscle-specific and associated with the lack of activation of insulin receptor and insulin-receptor substrate. The insertion of recombinant human IGF-I decreased the level of insulin in blood and increased insulin sensitivity [12]. These studies confirm that IGF-I is an important factor regulating the glucose concentration in blood, which significantly affects the body's adaptation to physical exercise.

Each kind of strength, endurance or speed training significantly loads the myocardium. There are currently a number of studies being conducted on rats which are to reveal whether IGF-I can influence the adaptation of the cardiac muscle to physical exercise. The insertion of exogenous IGF-I increases the amount of mRNA of the insulin-like growth factor I receptor after six weeks of swimming training. The training caused an elevated myocardial IGF-I mRNA expression in rats with and without transduced exogenous IGF-I [13]. These results point to the fact that the role of IGF-I in the body's adaptation to intensive exercise is not merely confined to the muscle tissue but is related with all IGF-I sensitive tissues.

An intramuscular, intravenous injection or oral administration of IGF-I or other doping substances is easily detectable in blood or urine tests. Thus, gene therapy researchers pointed to the fact that gene transfer could be also used for enhancement of athletic strength and performance. Numerous tests were carried out aimed at the IGF-I gene transfer via a viral vector into the muscle tissue of mice with Duchenne muscular dystrophy [14]. The inserted IGF-I gene was only expressed in skeletal muscle cells, but there was no increase in the concentration of IGF-I in blood or urine. The results were remarkable: an increase in muscle mass of 15–30% was observed in the mice infected with the recombinant virus. Other tests show that in mice with permanent IGF-I gene overexpression the skeletal muscle mass was increased for about 20–50% and their regenerative capabilities were similar to those of younger organisms. The muscle regeneration consisted of reconstruction of the

cell membrane of muscle fibers and formation of new myofibrils in an existing muscle fibre. In mice with heavy dystrophy the regenerative processes were greatly accelerated. The question appeared whether apart from the increase in muscle mass an increase in muscle strength can be also achieved. H. Sweeney's and R. Farrar's teams revealed that an insertion of a vector carrying the IGF-I gene and a few weeks strength training caused a twofold increase in muscle strength. Characteristically, after discontinuation of training the muscle with the transgene returned to its original state much slower than the one without it. Additionally, an increase in muscle strength of 15% was observed in rats unable to move after the IGF-I transfer [14]. These results are very promising as they point to the great significance of IGF-I in muscular hypertrophy and regeneration. For the time being, the conducted tests do not allow clinical application of gene therapy using IGF-I. An insertion of the IGF-I gene into a human body followed by its uncontrolled overexpression may lead to:

- excessive growth of muscle mass inadequate to the strength of bones, tendons and ligaments;
- hampering of blood circulation related to muscular hypetrophy;
- cardiac and thyroid diseases.

Insulin

GH, IGF-I and insulin are the most significant factors in anabolic processes. These proteins act in a synergistic fashion. GH and IGF-I directly stimulate the synthesis of proteins by activating amino acids transporters in the cell membrane. Insulin, on the other hand, inhibits the degradation of proteins and acts synergistically in relation to steroids [5, 15]. The effectiveness of GH activity depends on insulin activity. Administration of GH to patients with a lowered insulin level (suffering from diabetes mellitus type 1 or undergoing hunger cure) was discovered to stimulate catabolic reactions which may lead to diabetic ketoacedosis [5]. Insulin is a substance with a significant impact on the anabolic processes; it is often regarded by many athletes as a drug enhancing training effects through:

- facilitation of glucose uptake which can make the amount of glucose delivered to the cell exceed the cell's physiological demand for glucose, and make the synthesis and storage of large amounts of glycogen possible during physical deconditioning, which would then enhance muscle work during competition;
- transportation of amino acids into muscle cells;
- enhancement of general endurance;
- acceleration of regeneration processes;
- enhancement of the anabolic activity of growth hormone;
- increasing muscle mass and performance through glycogen storage and inhibition of degradation of muscular proteins [5].

Insulin is therefore a highly effective performance-enhancing drug and it can significantly influence an athlete's sport results. Insulin was included in the Prohibited List by the International Olympic Committee. Diabetics are, however, exempted.

Statistical research shows [15] that about 25% of athletes using anabolic androgenic steroids take them in combination with insulin to improve their effects. To avoid hypoglycemia following an intake of insulin athletes consume high-carbonate products. Very few athletes using insulin are aware of the hazards related to its abuse. Taking high doses of insulin may cause hypoglycemia, which if untreated, can lead to a coma or even death.

Erythropoietin (EPO)

Erythropoietin (EPO) is a glycoprotein hormone produced in the renal cortex which significantly stimulates the process of erythropoiesis. It has been one of the most commonly abused drugs by athletes for a few decades. In 1989 the IOC introduced a new category of prohibited substances – protein hormones, which includes recombinant human erythropoietin (rhEPO).

The main function of EPO is regulation of red cells production. Human erythropoietin was the first clinically applied recombinant hematopoetic growth factor [16]. rhEPO is most often manufactured with genetic engineering and biotechnological methods using animal cell lines with a transduced human EPO gene [17]. It is produced in four forms: alpha, beta, omega and delta [16].

The activity of rhEPO rises the quantity of red cells, enhances the uptake of iron, calcium and glucose ions by maturing erythrocytes and elevates the hematocrit level.

The use of rhEPO can significantly affect:

- aerobic capacity;
- VO_{2max};
- ventilatory threshold (VT).

The level of endurance following the insertion of EPO can increase for about 20% [18]. The use of EPO

as a performance-enhancing drug is particularly significant in endurance sports (cycling, swimming, cross-country skiing). After a subcutaneous injection, 20–30% of rhEPO can be detected four days later, and following an intravenous injection 2–3 days later. The EPO level is most likely unrelated to age, sex or the phase of the menstrual cycle, thus setting physiological standards for EPO is not difficult [19]. The erythropoietin abuse can cause a number of serious disorders:

- functional iron deficiency (FID) resulting in a release of hypochromic red cells (HRC) [19];
- increasing risk of thrombosis and pure red cells aplasia (PRCA) [20].

The administration of recombinant erythropoietin from animal cell lines is just one of possible applications of molecular biology methods to enhance the body's aerobic capacity. A number of tests are currently carried out on a possible insertion of homological cDNA via a viral vector into skeletal muscles. Functional tests on macaques revealed that such a transgene featured different patterns of expression than the endogenous form. It resulted in a change of EPO isoelectric mobility requiring higher pH. So far, only animal tests have been conducted, but it can be assumed that the gene expression in a genetically modified human tissue will be different from the endogenous pattern. Since the skeletal muscles constitute a perfect target tissue for the gene transduction, and the effectiveness of its overexpression is very high, the use of rhEPO as a form of gene doping seems vary plausible. The impact of the EPO transgene on the human body requires further research. It may seem that the formation of transgenic muscles should be relatively simple in the age of such remarkable developments in molecular biology, however it still requires a great number of tests on the influence of overexpression of a given protein on the human body. Functional tests carried out in 1997 and 1998, consisting of the transduction of the EPO gene into macaques led to heavy thickening of blood, which can be a cause of myocardial infarction. The EPO transduction can have many possible side effects. On the other hand, the detection of virally inserted EPO may not be that difficult due to the availability of the target tissue and considerable differences between the endogenous and transduced EPO forms [17].

Most recent studies concerning methods of increasing of the EPO level in the body show that stimulation of EPO synthesis may result not only from the insertion of exogenous EPO but also from the activity of hypoxia-inducible factors (HIFs). Hypoxia inhibits the activity of enzymes degenerating HIF-1α and HIF-1β – which permeat to the cell nucleus and stimulate the transcription of EPO gene – as well as of glycolitic enzymes taking part in cellular responses to a lower oxygen concentration. The HIFs can be of potential use in clinical treatment of cancer, inflammations or myocardial infarctions. They can also be used as performance-enhancing drugs increasing the EPO level in blood and thus improving tissue oxygenation. The detection of recombinant HIFs would be very difficult, especially in the case of transduction via viral vectors. The results of insertion can be very severe as the HIFs activate the expression of angiogenic genes and genes modulating cell growth, division and survival. The changes in HIFs expression may also cause tumors.

Potential substances enhancing athletic performance

Apart from the substances discussed above there are many other chemical compounds, whose properties can lead to their abuse as performance-enhancing substances in the near future (Tab. 1)

Table 1. Factors affecting the body's adaptation to exercise

Factor	Function
ACTN3	Structural protein of muscle fibres taking part in regulation of muscular contractions
ACE	Vasoconstriction
HIF-1α	Switching between aerobic and anaerobic metabolism
PPAR delta	Transforming of fast twitch fibres into slow twitch fibres

Alpha-actinin 3 (ACTN3)

Alpha-actinin is a protein belonging to a diverse group of cytoskeletal proteins which also includes dystrophin. Two genes enconde alpha-actinin in humans and are expressed in skeletal muscles: ACTN2 (expressed in all skeletal muscle fibres) and ACTN3 (expressed in fast twitch fibres only). Alpha-actinin 3 is the main structural element of the sarcomere Z-line. It stimulates the formation of fast twitch fibres by cooperating with the signaling pathway – calcineurin. It also stimulates glucose metabolism in fast twitch fibres by binding with an gluconeogenic enzyme (fructose-1,6-

diphosphate). The genetic structure of ACTN3 [21] displays a considerable polymorphism of the stop codon in:

- sprinters,
- endurance sports athletes,
- control group.

The mutation in ACTN3 is a nonsense mutation (CGA – TGA): the arginine codon translates into the stop codon (R577X), which results in the absence of ACTN3 synthesis in fast twitch fibres, which occurs often in endurance athletes. In sprinters the sequence of ACTN3 lacks R577X. It is estimated that this variant is present in both gene copies in about 18% of the world population. These results suggests that the absence of ACT3 is a predisposition to slow but effective muscle contractions, whereas its presence increases the speed of muscle fibre contractions [21]. ACTN3 then is a factor affecting muscle adaptation to exercise, and its polymorphism determines the morphological and functional differences in muscles.

Angiotensin convertase (ACE)

Angiotensin convertase activates angiotensin responsible for vasoconstriction. The ACE gene has two isoforms: D and I. Isoform I was shown to be present in both gene copies in mountaineers who were able to reach the elevation of 7.000 m above sea level with no difficulties, more often than in the general population. A study of rowers also revealed a high incidence of isoform I. These results show that the presence of isoform I of the ACE gene enhances the body's adaptation to strength and endurance training [22].

Hypoxia inducible factor HIF-1α

This transcription factor is a sort of switch between aerobic and anaerobic metabolism. HIF-1α induces modifications in cells so they can adapt to anaerobic conditions. It stimulates glycolysis, angiogenesis and erythropoiesis. The body's endurance depends to a great extent on its adaptation to physical effort in hypoxia conditions. HIF-1α is capable of inducing such adaptation. Knockout studies in mice with removed HIF-1α genes from their skeletal muscle cells revealed exercise-induced tissue-specific changes: decrease or absence of HIF-α, changes in the activity of glycolytic enzymes, low level of lactic acid and muscle damage [23, 24].

Peroxisome proliferative activated receptor delta (PPAR delta)

PPAR delta is a nuclear hormone receptor that bind peroxisome proliferators and control the size and number of peroxisomes produced by cells. It acts as a transcription factor affecting gene expression in muscle fibres. It induces transformation of fast twitch muscle fibres into slow twitch muscle fibres, and is responsible for enhancement of fat oxidation. A transduction of the PPAR delta gene into the skeletal muscle of mice induced:

- an elevated PPAR delta level in slow twitch fibres;
- an increased level of myoglobin in slow twitch fibres;
- an increased concentration of contractile proteins specific to slow twitch fibres;
- a reduced concentration of contractile proteins specific to fast twitch fibres;
- reduced number of fat cells (intensification of oxidative processes, increased tolerance to glucose).

In result, the running endurance of transgenic mice was increased: the running time was longer for 67% and the running distance for 92% [25]. It can be stated that PPAR delta is a significant enhancer of aerobic metabolism of skeletal muscle, which in turn improves the efficiency of muscle work and reduction of the adipose tissue and fatigue.

Vascular endothelial growth factor (VEGF)

VEGF induces:

- proliferation and growth of endothelial cells;
- cell migration;
- an increase in permeability of blood vessels;
- inhibition of apoptosis.

The activity of VEGF leads to a proliferation of blood vessels in organs, which increases the distribution of oxygen to tissues. Clinical tests showed that a transduction of the VEGF gene in patients with atherosclerosis and following myocardial infarction led to formation of new blood vessels. These are preliminary results and the problem of control of VEGF-stimulated proliferation of blood vessels and associated risk of development of neoplasms still remains. An increase in the concentration of VEGF in blood may enhance the performance of the cardiac muscle, improve training effectiveness and delay fatigue. Although the VEGF effects seem very interesting to athletes, research showed an elevated

VEGF level in patients with prostate cancer. The management of risk related to the transduction of the VEGF gene still requires much time and research [26].

Studies on the effects of the above factors on training effectiveness seem to confirm the hypothesis about genetic predispositions to practice a specific sport. Certainly, the environmental factors (appropriate diet and training) determine the athlete's preparation. The identification of genes affecting the crucial parameters in the training process may yield positive results and led to development of training programs specific for individual athletes. On the other hand, gene research may lead to gene doping consisting of transduction of genes whose expression would enhance athletic performance.

Detection

Growth hormone (GH)

Growth hormone (GH), which is a strong anabolic substance, was included in the Prohibited List by the IOC, although no reliable GH detection method has been developed. The biggest problem with GH detection is the fact that GH is an endogenous substance which is very hard to differentiate from its exogenous form. The main form of somatothropin is a 22kDa isomer, however, due to the gene transcription and post-transcription modification new forms emerge. One of them is a 20kDa isomer, constituting 10% of the 22kDa isoform. Using this information Bidlingmaier et al. [27] developed a test detecting non-pituitary exogenous GH. The test used a mixture of nonspecific monoclonal antibodies and two specific monoclonal antibodies identifying epitopes of the 22kda and 20kDa isoforms. They showed that the absence of the 20kDa form in a blood sample containing a considerable quantity of the 22kDa isoform is evidence of an exogenous administration of rhGH.

The development of a test detecting rhGH requires establishment of the basic GH concentration norms. This could be very difficult as the GH is secreted by the pituitary gland in pulses in response to different kinds of external stimuli and changing physiological and biochemical status of the body. The GH concentration depends on:

- age,
- sex – women feature a higher GH concentration than men; this elevation can be caused by the use of oral contraceptives, different body composition, lower body mass and greater quantity of estrogens; the highest GH concentration is observed in women during the follicular phase of the menstrual cycle,
- "trainedness" status of the body,
- exercise – the blood concentration of GH may increase up to fifty times following intense physical exercise; this level is, however, maintained for about 60 min after the completion of the exercise [27].

A relationship was observed between the amount of released GH, applied training load, general efficiency and the type of sport. It should be remembered that in persons with an elevated basal GH, exercise does not stimulate the pituitary secretion of GH. A study of 96 athletes representing different sports revealed post-exercise elevated GH in middle-distance runners, rowers, swimmers and cyclists [28]. In defining the GH concentration norms it should be remembered that GH secretion can also be affected by such factors as diet, stress and exercise.

As GH features a high biological activity influencing a number of metabolic processes, a reasonable prospect may seem an analysis of substances directly dependent on GH, which can serve as GH markers. Certainly, only such markers must be identified whose concentration increases due to administration of considerable amounts of rhGH, but remains stable following intense exercise. This way the development of a drug test detecting exogenous GH might be possible [29]. There are two types of substances interacting with growth hormone:

(1) components of the GH/IGF-I axis, i.e. GH, IGF-I, and binding proteins of IGF-I:

- acid-labile subunit (ALS)
- IGFBP-2
- IGFBP-3

IGFBP-3 and ALS are modulators of IGF-I in blood serum; ALS increases the affinity between IGFBP-3 and IGF-I.

(2) markers of bone and collagen turnover:

- C-terminal cross-linked telopeptide of type I collagen (ICTP) responsible for bone resorption;
- amino-terminal propeptide of type III procollagen (PIIIP) responsible for formation of calluses;
- carboxyterminal propeptide of type I procollagen (PICP) responsible for bone remodeling;
- bone-specific alkaline phosphatase (BS-ALP) responsible for bone mineralization;
- osteocalcin responsible for bone mineralization.

A number of independent research teams have recently studied the effects of rhGH abuse and physical exercise on the blood concentration of the above markers in athletes representing various sports. The obtained results show that the level of these substances increases due to physical exercise but they feature a greater sensitivity to rhGh activity which enhances the effects of the exercise. The GH level rises following exercise and administration of rhGH, however, the level of the other components of the GH/IGF-I axis increases slightly and returns to its original value 30–60 min after exercise [30]. A higher concentration of IGF-I was only noted in the urine [30], despite the fact that physical exercise is known to induce the expression of the two main IGF-I isoforms, i.e. MGF and IGF-IEa) present in skeletal muscles. Also the level of markers of bone turnover increases insignificantly or remains unchanged, and returns to its original value or slightly decreases within 120 min following the completion of exercise. Only in the case of BS-ALP was a significant exercise-induced increase noted, and its concentration remained unchanged following an administration of rhGH [30]. It is commonly suggested that the blood concentration of these markers can be genetically determined [5].

The influence of rhGH on the markers of the GH/IGF-I axis and the markers of bone turnover is different: a significant increase of GH, IGF-I, IGFBP-3, PICP, PIIIP, ICTP, and a decrease of IGFBP-2 were noted. Also rhGH elevates the IGF-I/IGFBP2 ratio and lowers the IGFBP3/IGFBP2 ratio [30, 31]. Physical exercise in combination with rhGH administration was observed to enhance the response of the markers, whereas discontinuing rhGH administration inhibits the growth of GH, even in the same training conditions [29].

These results can be used in studies on development of drug tests. The markers discussed above feature a characteristic sensitivity to rhGH and a relatively poor response to physical exercise. A good chemical detector should be characterized by:

- stability in physiological conditions, during training, recovery period and after injuries;
- relatively long half-life.

The markers of bone and collagen turnover are present in the blood for at least 96 hours after administration of rhGH; some sources claim they can remain up to several weeks, i.e. for much longer than the markers of the GH/IGF-I axis.

In the process of development of effective drug tests the physiological norms of the markers must be established. They would then allow the assessment of GH blood and urine concentrations. An excessive level of GH concentration may be indicative of an administration of exogenous GH. However, the concentration of markers may depend on a number of different factors, e.g.

- type of sport,
- age,
- sex,
- place of origin,
- past diseases and injuries,
- taken medicines,
- disorders (undiagnosed acromegaly),
- training period (regeneration, preparatory, pre-competitive),
- marker's time of response to rhGH [29, 5].

No correlation has been found between the concentration of the studied markers and body height, body weight, BMI or VO_{2max}. The reference values of the markers have not been established yet, but the collected data was used in the international project GH-2000. The reference values of each marker were set for both sexes in conditions of maximal intensity exercise [29]. The changes in the level of a given marker during an athlete's annual training cycle can also yield important information.

The analysis of the markers of the GH/IGF-I and of bone and collagen turnover led to identification of two substances which can be very significant in development of GH abuse detection methods: PIIIP and ICTP. Their useful properties include:

- insignificant changes in response to intensive, long-term training;
- strong response to even most insignificant doses of rhGH;
- increased concentration up to 96 hours after discontinuation of rhGH administration, before and after exercise [29].

The main regulator of IGF-I synthesis in the liver is GH. IGF-I can thus act as a marker of GH activity in the liver and of the presence of rhGH in the body. Studies show that administration of rhGH significantly increases the blood level of IGF-I [10], and contributes to lower IGF-I secretion in the urine. This seems interesting since one of results of physical exercise is proteinuria, i.e. the presence of an excess of serum proteins in the urine. Studies of athletes in conditions of intensive exercise revealed an elevated post-exercise concentration of

IGF-I, creatinine, and protein in the urine [10]. The origin of post-exercise IGF-I in the urine is unknown; it may come from:

- circulation (directly),
- glomelural filtration rate,
- direct renal synthesis.

The identification of the IGF-I source and its normal concentration in the urine before and after exercise could be a basis for development of a test detecting rhGH abuse [10].

IGF I

An oral, intramuscular or intravenous administration of IGF-I significantly changes its blood and urine concentrations. The IGF-I levels can be easily established using common immunological tests. More difficult is the establishment of IGF-I physiological reference values in blood and urine. As mentioned earlier the IGF-I level varies, depending on a number of physiological and environmental factors. Its amount in blood and urine increases after exercise. Thus IGF-I concentration norms should be established before and after exercise at different intervals, as well as after taking exogenous IGF-I [10]. A reliable, positive drug test result is an individual matter. The IGF-I concentration in the blood and urine should be correlated with other physiological parameters, body weight, body height, intervals between exercises, diet and other factors affecting directly and indirectly the IGF-I concentration.

Equally difficult is the detection of a tranduced IGF-I gene inserted via a viral vector to the muscle tissue: the expressed gene is almost identical with the endogenous protein. The development of a drug test capable of identification the endogenous form from the exogenous one has so far proven unsuccessful. The difficulty in detecting IGF-I gene doping is also due to the fact that this protein is only produced in the target tissue in which the gene was expressed and it does not occur in the blood or urine. Detection of extra IGF-I molecules would be only possible by way of muscular biopsy [32].

Insulin

Detection of insulin abuse remains very difficult due to the impossibility of discrimination between its exogenous and endogenous forms [15].

EPO

The development of a drug test detecting rhEPO has been subject of intense research for several years. It will become possible after all differences between the endogenous and exogenous EPO forms are thoroughly analyzed. These differences are due to variable isolectric mobility resulting from different post-translational modifications of glycoprotein [18]. The main agents determining the differences are oligosaccharide molecules on the surface of erythropoietin, which participate in the plication and protection of the protein against proteases and influence its activity [16]. The synthesis of oligosaccharides as well as the saccharides of recombinant glycoproteins (rhEPO) is tissue- and cell-specific. Venke S. et al. [16] carried out a thorough analysis of endogenous and exogenous EPO forms and revealed that the altered structure of rhEPO is caused by the absence of tissue-specific synthesis, which does not take place in cell lines (due to lack of appropriate enzymes). Thus the two forms of EPO differ in type, structure and quantity of saccharide residues. Endogenous EPO contains more neutral sugars, whereas rhEPO contains numerous extra acidic saccharide residues which increase its molecular mass and extend the half-life of glycoprotein affecting its biological activity. The observed differences are also related to the sensitivity of both proteins to proteases [16]. The study focused on an analysis of serum EPO (sEPO), urinary EPO (uEPO), and rhEPO, revealing a lower molecular mass of sEPO than uEPO and rhEPO. Another study [16] proved that uEPO contained more acidic saccharides than sEPO. It indicates the existence of structural differences between the two forms, which can result from their different renal re-absorption patterns. Therefore a more detailed analysis of uEPO properties seems necessary as they may constitute a basis for detection of recombinant human erythropoietin doping.

Another promising study into detection of rhEPO abuse is concerned with the influence of rhEPO on the expression profile of erythrocyte marker genes: hemoglobine β (HBB), ferritin light chain (FTL) and ornithine decarboxylase antizyme (OAZ) (Tab. 2**)** [33].

An analysis carried out during rhEPO administration as well as three weeks after its discontinuation revealed an increasing level of expression of the aforementioned markers. As the effect of rhEPO activity is significantly shorter in the case of hematological changes as opposed to gene expression, it is indicated that

Table 2. Functions of erythrocyte markers

HBB (hemoglobin β)	FTL (ferritin light chain)	OAZ (ornithine decarboxylase antizyme)
Binding hemoglobin polypeptide chain	Storage of iron ions in a nontoxic state	Degradation of ornithine decarboxylase, control of the concentration of polyamines

these genes can serve as markers of rhEPO doping [33]. The detection of rhEPO in the body becomes increasingly difficult several days after discontinuation of its administration, even in case of taking small doses and enhancers of rhEPO activity (GH, IGF-I) [33].

Generally, rhEPO detection methods are classified as direct and indirect.

The direct methods, i.e. immunological tests, mark the concentration of EPO in the urine and blood serum. The main difficulty lies in discrimination between the exogenous and endogenous EPO forms and in detecting EPO only 2–3 days after the discontinuation of its administration. The immunological tests can detect immunoreactive protein forms but they are not always bioactive forms. Another difficulty in detection is a very short half-life of protein hormones, which makes it necessary to run drug tests in a very short period of time.

Functional studies [19] using electrophoretic and immunological analysis of EPO in the blood and urine revealed that the probability of rhEPO detection three days after rhEPO injection was less than 50%, and was almost impossible after 1–3 weeks. Some methods, e.g. High Performance Liquid Chromatography (HPLC) in combination with mass spectrometry and capillary electrophoresis, can yield interesting results but they require more detailed research.

Indirect methods of rhEPO detection include assessments of the following blood parameters:

- hematocrit
- hemoglobin (quantity),
- reticulocytes (quantity),
- erythrocytes (quantity, shape, size),
- serum transferrin receptor (sTfR),

as well as markers such as functional iron deficiency leading to the formation of hypochromic red cells. This deficiency is not neutralized, even if it is simultaneously supplemented with iron, and occurs immediately in response to rhEPO. It should be noted, however, that some athletes may feature elevated post-exercise HRC [19].

The use of hematocrit as a marker of rhEPO doping has brought negative results. Although its higher concentration might follow an administration of rhEPO, it depends on a variety of factors such as plasma volume, loss of fluids, dietary habits, training, iron metabolism, age, sex, body weight and circulating blood volume. The level of hematocrit also depends on the type of sport [19]. Overall, it is not a reliable detector of rhEPO abuse.

Also testing the quantity of reticulocytes does not yield satisfactory results either, due to the vast discrepancy between the reference values of their concentration [19].

The level the serum transferring receptor can be elevated in cases of:

- iron deficiency;
- increased demand for iron during stimulated erythopoesis;
- administration of rhEPO.

The sTfR was also regarded as a potential rhEPO marker, however, research results showed that it can act as a drug detector only in the case of administration of large doses of rhEPO without iron supplements [19].

Reliable rhEPO detectors were also sought among urinary markers such as fibrynogen degradation products (TDPs) resulting from the fibrinolytic activity of rhEPO. One study revealed the presence of TDPs in the urine of 10 out of 76 athletes. However, these results still require further analysis. There is no persuasive evidence either that an increased level of TDPs indicates the presence of rhEPO in the body [19].

The majority of researchers have focused on the impact of rhEPO on individual molecules being biochemical and hematological markers, and tried to determine their potential role in detection of rhEPO abuse. However, none of these markers can provide definite evidence of the presence of rhEPO in the human body.

In the late 1990s R. Parisotto et al. attempted to develop a drug test based on a few markers dependent on exogenous EPO. The subjects in their study were divided into three groups:

- subjects given an injection of EPO and iron supplements (injection);
- subjects given an injection of EPO and oral administration of iron supplements (stronger reaction to EPO);
- subjects given a placebo.

Each assessed parameter was assigned a specific number of points, averaged for each group. The differences between the groups provided with exogenous EPO and the control group were calculated. All possible combinations of parameters were estimated using the logit function. The developed test was based on 31 possible combinations of biochemical and hematological markers; it was approved by the IOC in July 2000 and used at the Summer Olympic Games in Sydney [34].

The rapid development of the pharmaceutical industry led to manufacturing of a synthetic form of erythropoietin called epoetin delta used to treat anemia associated with chronic renal failure. Standard urine rhEPO tests have all so far failed to detect it. Epoetin delta is synthesized in human cell lines and thus its properties are very similar to those of endogenous EPO. It can be detected with a blood test but the obtained result must be confirmed with a urine test [20].

It seems that a reliable method of detection of one of the most abused substances, rhEPO, has been developed. However, recent reports show that rhEPO doping still remains largely undetectable. Dr. Mike Ashenden, head of international consortium Science and Industry Against Blood Doping presented the most recent results of studies of cyclists taking part in Tour de France. These results show that in athletes who take microdose rhEPO regiments the concentration of hematocrit is elevated but only to an accepted level. Then a gradual reduction of the doses allows maintaining a high level of hematocrit. In this case a higher concentration of EPO is undetectable. Certainly, this kind of doping is possible under the supervision of a specialist who can administer the correct doses of the hormone [35].

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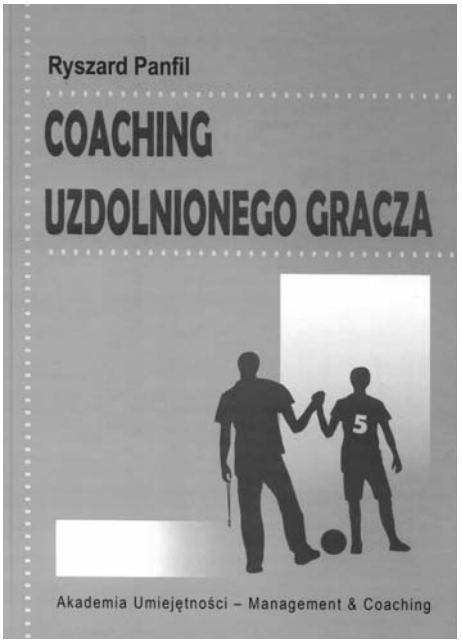
BOOK REVIEWS

COACHING UZDOLNIONEGO GRACZA (COACHING OF A TALENTED PLAYER)



Professor Ryszard Panfil in his recent book focuses on praxeological aspects of the processes of management, coaching and education of talented players for team games. Since the team games are sports games the players should possess particular dispositions to cope with the demands of any particular sports game. Thus coaching of a talented player involves organizational and specific requirements in working with talented sports players.

The book consists of three chapters. Chapters Two and Three contain important characteristics of development of player's skills to act in a game and his/her actions as the main aims of coaching.

Chapter Two focuses on player's individual actions: indirectly and directly dependent on the player's partners. The author presents examples of such actions in consideration of specific characteristics of a given game and the ways to achieve the game's objectives. It is assumed that the skills to act are developed by a player who by making use of his or her dispositions in specific conditions (offensive or defensive) is able to execute the assigned tasks. Chapter Three discusses activities in the process of coaching of a talented player. It is a process which enables the player's acquisition of knowledge and development of playing skills. The concept of personal coaching is understood here as a partnership in which a qualified coach enhances the player's development and prepares the player to compete on a professional level.

The activities involved in the process of coaching include anticipation of the player's development in the course of a given game. The following tendencies can be anticipated: development of a given sport (growing popularity, number of participants, investments, professionalization); development of the rules of the game accounting for its attractiveness; development of the game's organization involving the broad scope of players' offensive and defensive skills in their actions directly and indirectly dependent on their partners' actions; and the individualization of the coaching process aimed at recognition of the player's profile (dispositions and skills) conditioning his or her position and function in the game. The anticipation allows recognition of players' individuality and development of their skills.

The significant actions in the process of coaching include recruitment of talented players for a particular game. Subchapter 3.2. discusses three systems of player's identification (simulated, centrally coordinated and net systems) with their positive and negative sides. It is assumed that the proper recruitment of talented players ensures proper identification of their dispositions and rational planning of their further development.

One of the indispensable conditions of development of the player's talent is the player's activity. A player is active if his or her sports development is stimulated. The player's activization should involve the process of intellectualization, inspiring and motivating methods, assignment of tasks and self-assessment of task execution, and analysis of individual cases, e.g. seeking one's own profile of skills, playing simulation games to acquire the knowledge of one's own capabilities, playing games in the presence of an audience conducive to provoking correct responses. If the player responds correctly to the situations in the game then the presence of spectators will facilitate his or her task execution. The emphasis is placed on fulfilling functions of different degrees of difficulty. Only in this way can the game be properly understood and the knowledge of the opponent's and partners' capabilities facilitated.

One of the activities in coaching of a talented player is the process rationalization, i.e. selection and adjustment of training means and conditions in consideration of the player's current capabilities (skills) and knowledge of the coaching process. The effectiveness of training means should be assessed using appropriate measurements of skill development. The training means become effective when the player is able to transform his/her skills into dispositions to play. These dispositions are in turn manifested during a game. In this context the rationality of skill development consists in using training means which effectively combine individual skills, and transform them into dispositions. Once this is achieved a player can effectively execute the actions learnt during the game despite external obstacles. The author assumes that rational preparation of a player to play the game, which limits the impact of chance on the game's outcomes, requires adjustment of training means to the game's conditions. These means must account for the game's aims, current composition of forces, time and current result. The measures of skills to play a game are actions which are correct, flexible, alternate, quick and based on cooperation and surprise. These measures are illustrated in the book with numerous relevant examples. The tools used in the coaching process include coordination of cooperation with external agents (general education teacher, trainer cooperating with experts in auxiliary sciences) as well as using it and e-learning. The cooperation with these external agents in the process of development of a talented player requires alternative activities in player's training. The coordination of cooperation is aimed to promote the necessity to reach alternative solutions in the process of achievement of assigned tasks.

The main idea of the book can be best described using the author's words that coaching of a player is a rational process aimed at development of player's talent in reference to spatiotemporal, social and methodological conditions. This process is implemented by way of player's activation, selection and choice of training means, coordination of preparatory actions and anticipation of development of the player and the game.

Wrocław April 30, 2008

Prof. dr hab. Zbigniew Naglak
Chair of Team Sport Games
University School of Physical Education in Wrocław

Professor Ryszard Panfil's work *Coaching of a talented player* is an interesting book on athlete coaching combining sport and management sciences. It is a highly valuable sports publication on the Polish market.

Prof. dr hab. Ryszard Panfil is a well-known researcher and educator from the University School of Physical Education in Wrocław. In recent years he has been carrying out interdisciplinary research combining physical culture studies with management sciences. He has been a supervisor of a number of doctoral dissertations as well as the author of training programs, seminars and publications.

Coaching has recently become a key topic in management sciences following the increasing demand for instruments and techniques of active enhancement and development of human resources in the business world. However, it would still be very difficult to find valuable works on coaching of athletes among the numerous publications on management. In psychological literature one can find merely a few sources treating coaching as a promising psychotherapeutic method. Panfil's *Coaching of a talented player* fills in this gap by incorporating personal coaching (Chapter One) into the processes of sports team player's development (Chapter Two and Three).

In Chapter One – extremely useful to managers, management students and lecturers – the author sorts out the terminological mess related to the concept of "coaching" in modern literature. His discussion of coaching as a process (pp. 11–17) and clear and useful listing of coach's skills and attitudes deserve particular attention (pp. 17–18). In my opinion the future editions of this outstanding book should include such coaching facets as net coaching and knowledge coaching, which currently constitute the fundamental research prospects in management sciences.

Responding to the IT challenges of the present day the author also devoted a section of his book to the so-called e-learning coaching (3.5.3, p. 119). Selected synergic aspects of net management of sports clubs, especially in terms of HR policies, are discussed in 3.2.3.

Chapters Two and Three are mainly addressed to sports coaches and instructors, athletes and the teaching staff of university departments of sports team games, sport psychology and communications and management in sport in Poland.

Professor Panfil's book can be effectively used as a regular textbook and educational aid for students of

sports universities in Poland. The author's style of narration is easy to follow, and the book is accurately illustrated, e.g. 2.1.1, pp. 20–29.

The subject of sports coaching is thoroughly discussed in Chapter Three, which touches upon the following issues:

– individual coaching versus team coaching (Tab. 2, p. 31),
– individualization of the coaching process (3.1.2),
– intellectualization of the process of player's development (3.3.1), with useful references to the highly popular concept of management of intellectual capital,
– the use of 'case studies' (3.3.4) and simulation games (3.3.5).

In conclusion, after a brief review of *Coaching of a talented player* by Professor Ryszard Panfil it should be stressed that the publication is a breakthrough in sports training methodology. Its versatility makes Professor Panfil's book a compendium of knowledge and skills that can be very useful for managers and coaches of sports clubs as well as for sport and non-sport consulting professionals.

Wrocław March 18, 2008

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Department of Organization and Management
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CONFERENCE REPORTS

INTERNATIONAL CONFERENCE "SOCIAL AND CULTURAL DIMENSIONS OF SPORT"

The international conference "Social and Cultural Dimensions of Sport" was organized in Warsaw on September 14–16, 2007 by the Chair of Social Sciences of the Academy of Physical Education in Warsaw. The participants in the conference included a number of prominent sport philosophers and sociologists from Poland and abroad: Zbigniew Krawczyk, Jerzy Kosiewicz, Stanisław Kowalczyk, Kazimierz Obodyński, Marek Kazimierczak (Poland), Jan Junger (Slovakia) and Ivo Jirásek (Czech Republic). The conference spawned the foundation of the Polish Society for Social Science of Sport and the International Society for Social Science of Sport. Selected conference proceedings will be published.

CONFERENCE "POSITIVE AND NEGATIVE TRENDS IN SPORT AND TOURISM"

The all-Polish scholarly conference "Positive and Negative Trends in Sport and Tourism" was held in Warsaw on October 13, 2007. It was organized by the Department of Sociology of the Academy of Physical Education in Warsaw and the Salesian Sport Organization of the Republic of Poland. The conference sessions were devoted to positive development tendencies as well as to the formidable challenges and threats facing present-day sport and tourism. The conference speakers were most distinguished Polish scholars representing the areas of physical culture, sport and tourism and specializing in philosophy, sociology and pedagogy: Zbigniew Dziubiński, Zofia Żukowska, Zbigniew Krawczyk, Jerzy Kosiewicz, Józef Lipiec, Stanisław Kowalczyk, Marek Kazimierczak and Andrzej Pawłucki. The conference proceedings were published in a single volume.

CONFERENCE "CORRUPTION IN SPORT"

The all-Polish scientific conference "Corruption in sport" took place on October 19, 2007 in the auditorium of the University School of Physical Education in Poznań. The conference was organized by the Polish Association of Sports Law, Chair of Humanistic Bases of Physical Culture of the University School of Physical Education in Poznań and Faculty of Law and Administration of Adam Mickiewicz University in Poznań. The honorary patronage of the conference was taken by Minister of Sport of the Republic of Poland Elżbieta Jakubik. The opening address was delivered by Rector Magnificus of the University School of Physical Education in Poznań, Prof. dr hab. med. Tadeusz Rychlewski. The conference initiator and main animator was Prof. dr hab. Andrzej J. Szwarc, President of the Polish Association of Sports Law and Dean of Faculty of Law and Administration of Adam Mickiewicz University in Poznań. The "Corruption in Sport" conference was in fact the twelfth organized by Prof. A. J. Szwarc. The conference speakers included distinguished academics from a number of Polish institutions of higher education as well as practicing lawyers from all over the country.

The organizers prepared an attractive and diverse conference program. The papers were delivered by the majority of the lawyers, all heads of departments of the Chair of Humanistic Bases of Physical Culture and Head of the Department of Cultural Bases of Tourism Prof. AWF dr hab. Marek Kazimierczak. The conference papers touched upon ethical, philosophical, psychological, historical, pedagogical and legal aspects of corruption in sport.

The conference theme sections were:

1. Criminal responsibility for corrupt practices in sport (Prof. dr hab. Andrzej J. Szwarc),
2. Psycho-social aspects of corruption in sport (Prof. AWF dr hab. Jacek Gracz),
3. Corruption in sport in a historical perspective (Dr hab. Maciej Łuczak),
4. Ethical aspects of corruption in sport (Prof. AWF dr hab. Marek Kazimierczak, dr Tomasz Sahaj),
5. Pedagogical development of attitudes towards corruption in sport (Prof. AWF dr hab. Bożena Biniakiewicz),
6. Organizational instruments of prevention and combating corruption in sport (dr Robert Zawłocki, M. Sc. Michał Głowacki).

Dr Tomasz Sahaj
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COMPETITION

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CONFERENCES

University School of Physical Education in Wrocław

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- Muscle mechanics
- Physiotherapy
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- Stability and posture
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- Training and performance

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Rik Huiskes, Eindhoven University of Technology
Peter Konrad, DSHS, Zürich, Köln
Kornelia Kulig, USC, Los Angeles
Louis Peeraer, KU, Lueven
Alex Stacoff, ETH, Zürich
Ian Sutherland, Brunel University, London
József Tihanyi, Semmelweis University, Budapest

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For detailed information visit:
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- English and Polish are the languages of the congress.

All correspondence should be directed to:
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