The ACDSi 2013 – The Analysis of Children's Development in Slovenia 2013: Study protocol

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Abstract
The ACDSi 2013 study is a continuation of a 40-year old decennial study on children's biological, psychological and social development. From its beginnings in 1970, the study has been characterised as an interdisciplinary study of physical anthropology, kinesiology, psychology and sociology, but in its fifth cycle, in 2013, its focus was expanded to include paediatrics and public health. The aim of the study is to follow secular trends of the somatic and motor development of children regarding the psychological, social and health determinants that shape contemporary children's lifestyles. The paper describes the protocol of the ACDSi 2013 study with regards to its organisation, sampling and methods.

KEYWORDS: children, somatic development, motor development, physical fitness, protocol

Background
Over the previous twenty years, rapid changes of children's and adolescents' lifestyles have been observed worldwide. These changes are induced by changes in the social and physical environment that directly influence the somatic and motor development of children and adolescents (Ferreira et al. 2007). Increasingly passive lifestyles among young people in developed countries have been observed (Armstrong 2007; Ferreira et al. 2007; Strel, Kovač & Jurak 2007), leading to increased life-style disorders in childhood. Therefore, studies of secular changes in physical fitness and the body composition of children and adolescents have become common. Most of these studies define physical fitness as cardiorespiratory fitness along with other health- and skill-related fitness components, such as endurance, strength and flexibility.

ANTHROPOLOGICAL NOTEBOOKS 19 (3): 123–143.
ISSN 1408-032X

Studies of secular changes show that changes in the lifestyles of children and adolescents in developed countries result in increased subcutaneous fat (Olds, Ridley, and Tomkinson 2007; Strel, Kovač & Jurak 2007), in a higher proportion of the overweight population (Hills, Andersen, and Byrne 2011; Ogden & Freedman 2012; Wijnhoven et al. 2013) and in the deterioration of their motor performance, particularly endurance and strength (Froberg & Andersen 2010; Rychtecký 2007; Strel, Kovač & Jurak 2007; Tomkinson & Olds 2007; Westerstahl, Barnekow-Bergkvist & Jansson 2005). Olds, Ridley and Tomkinson (2007) established that increases in fatness alone explain about a half of the observed decline in aerobic fitness performance. To conclude, contemporary children are thought to be at increasing risk for cardiovascular disease and other morbidities, since low physical fitness is significantly associated with the higher prevalence of numerous health risk factors (Williams 2001).

However, most of studies of secular trends have made only informal secular comparisons, with narrow age bands, single fitness components and only occasionally rigorous statistical treatment (Tomkinson & Olds 2007). Our intention was to surpass some of the limitations of the existing studies and include a wide age band, multiple fitness components as well as a rigorous methodological and statistical treatment. Our intention was also to revive the Slovenian physical anthropology in an interdisciplinary manner, by linking it to kinesiology, paediatrics and public health.

The roots of the ACDSi 2013

In 1970, the Faculty of Sport of the University of Ljubljana started a research project focusing on developmental trends of motor performance and physical characteristics of primary school children in Slovenia (Šturm 1972). Originally it was titled Comparison of certain motor and morphological parameters in primary schools in Slovenia, which was changed into the awkwardly long title Analysis of Developmental trends of motor abilities and physical characteristics, and their relations with other spaces of psycho-motor status of Slovenian children and youth between 7 and 14 years of age. The research project has been repeated four times since 1970; first in 1983 (Šturm and Strel 1985) and every decade afterwards, in 1993/94 (Strel et al. 1996), 2003/04 (Kovač, Starc & Bučar Pajek 2004) and 2013. In the 1993/94 cycle, the high-school population between 15 and 18 years of age was added. In this sense, our cross-sectional study is one of the longest running studies on children's bio-psycho-social development in the world. In 2013, it was renamed as The Analysis of Children's Development in Slovenia (ACDSi). In 2013, the study focused on children aged 6 to 14, and in 2014 our focus will be on 15 to 18 year-olds.

The first round, in 1970, included a nationally representative sample. The sample was selected using a multistage, stratified sampling design. Ten research project sites were selected according to four types of settlements (from rural to rural-industrial, industrial-rural and industrial) and according to regions. In each site, one primary school was selected, except in the capital where additional school was added in 1993 in order to meet the population representation criteria. In 1994, the sample was expanded and included adolescents (ages 15 to 18). Participants from six high schools of different

educational programmes in three project sites were added to the national representative sample. Thereafter, a sample of every research cycle (two consecutive years, first year on elementary and second year on high school students) has included around 5,500 children and adolescents aged 7 to 18 years (around 2% of the entire population). Due to changes in the educational system in Slovenia and the consequently earlier entry into primary school, the 2013 sample included also 6- and even 5-year-old children. Each age and sex group included around 200 participants (Table 1).

Table 1: ACDSi sample in different study cycles

Year of study	Principal investigators	Sample age span (years)	Sample size
1970	Šturm, J.	7–14	3,272
1983	Šturm, J. & Strel, J.	7–14	3,163
1993/94	Strel, J., Šturm, J. & Kovač, M.	7–14	3,488
		15–18	1,620
2003/04	Strel, J., Kovač, M., Starc, G.,	7–18	4,095
	Jurak, G.	15–18	1,694
2013	Starc, G., Jurak, G., Kovač, M.	6–18	3,478

The scope of research also changed somewhat over time. At the beginning, researchers were oriented towards physical fitness and physical anthropology. Valid and reliable tests that were used mainly in the former Yugoslavia and some eastern European countries were chosen (Šturm 1970, 1977; Strel et al. 1988). In 1993, some new motor tests from the Eurofit test battery (CDDS 1983) were added. The study also started to focus on correlations of somatic development with their motor, functional, conative and cognitive dimensions, and dimensions of social status and environment, which determine health and quality of life. Despite somewhat different data collection methods in different cycles of the transversal research, our dataset consists of more than 25 anthropometric variables, more than 14 motor and aerobic fitness variables (covering the majority of tests from Eurofit and other test batteries) and variables from other research areas (psychology, social economic status, parents' opinion about physical activity), which can be used for comparisons of secular trends between different cycles. Unfortunately, the data from 1970 were lost in a fire, which allows only for comparisons of summary data, published in the 1970 study report. The contents of the 2013 dataset are described in Figure 1.

Organisation of the ACDSi

The leading institution of the study is Faculty of Sport, University of Ljubljana, where all principal investigators are employed. Current research activities are carried out within the Laboratory for the Diagnostics of Physical and Motor Development of Children and Youth. The principal investigators are responsible for the entire management of the study from its concept, contacts with partner organisations, organisation of work, funding assurance, implementation, and evaluation of data.

Due to the current unfortunate socio-economic situation (austerity measures due to the economic crisis in the private and public sectors, the position of anthropological kinesiology in the Slovenian academia, etc.) we were faced with extremely low public funding, which forced us to organise the last cycle of study differently in comparison to previous ones. All research activities have been carried out as unpaid volunteer work. The limited human and financial resources and multidisciplinary goals made us look for possible research partners from other faculties of the University of Ljubljana, from other research institutions in Slovenia and from the Faculty of Kinesiology, University of Zagreb, Croatia. Many researchers were asked to participate as volunteers in the construction of area-specific research instruments, in measurements and in the analysis of the data. Amazingly, all the contacted researchers agreed to participate in the research pro bono. During the development of our research instruments, a number of experts from around the world were asked for advice; all of them kindly provided some truly useful advice and also offered their help in the analysis of the gathered data. In a joint effort, a rational set of research instruments has been assembled, and all the required measuring technology as well as human sources have been provided. Students form the Faculty of Sport, Biotechnical Faculty, Faculty of Arts, Faculty of Pedagogy and Faculty of Social Sciences also volunteered. During each testing session in individual schools, 20 to 25 student investigators participated.

All the student investigators were trained in June 2013 and in greater detail a week before the measurements started. They all had previous study experiences in anthropometric measurements and motor testing. During the training, all measuring procedures were performed several times to ensure that all the student investigators were familiar with all tests and protocols to which they were assigned. The research team was divided into three groups: the anthropometric group worked on the anthropometric measurements in a small gym or a classroom; the largest motor group worked on the motor tests measurements in the gym and outdoors, and the smallest questionnaire group worked on the web questionnaires in school computer rooms. All the members and advisors of the research team are acknowledged in Table 2.

Table 2: The research team of the 2013 study cycle

Research team members, their affiliations and their role in the study
University of Ljubljana, Faculty of Sport • Gregor Starc, Ph.D., principal investigator • Gregor Jurak, Ph.D., principal investigator • Prof. Marjeta Kovač, Ph.D., principal investigator • Maja Bučar Pajek, Ph.D., investigator • Bojan Leskošek, Ph.D., investigator • Dorica Šajber, Ph.D., investigator • Petra Zaletel, Ph.D., investigator • Maja Ulaga, Ph.D., investigator • Stanislav Pinter, Ph.D., investigator • Prof. Vojko Strojnik, Ph.D., investigator • Vedran Hadžić, M.D., investigator • Bernarda Baron, student investigator • Sebastjan Bauer, student investigator • Žan Bedenik, student investigator • Luka Dobovičnik, student investigator • Jaka Došler, student investigator • Rebeka Fink, student investigator • Petra Grmovšek, student investigator • Barbara Jantol, student investigator • Nuša Jarc, student investigator • Mateja Kragelj, student investigator • Brigita Mardjonović, student investigator • Alja Markič, student investigator • Gregor Mišič, student investigator • Monika Morato, student investigator • Boris Mujović, student investigator • Teja Papič, student investigator • Darja Petek, student investigator • Ajda Pristavec, student investigator • Maruša Pungartnik, student investigator • Tina Ribič, student investigator • Petra Sluga, student investigator • Maja Sušin, student investigator • Rok Tomazin, student investigator • Aljaž Igor Topole, student investigator • Tadej Verbošt, student investigator • Tina Zdešar, student investigator • Aljaž Železnik, student investigator
University of Ljubljana, Faculty of Education • Tjaša Filipčič, Ph.D., investigator • Franjo Krpač, Ph.D., investigator • Katarina Bošnjak, student investigator • Tina Korošec, student investigator • Katja Rožman, student investigator • Ana Tatalović, student investigator • Vida Biščak, investigator
University of Ljubljana, Faculty of Arts • Prof. Darja Kobal Grum, Ph.D., investigator • Manca Seničar, graduate student investigator
University of Zagreb, Faculty of Kinesiology • Maroje Sorić, Ph.D., M.D., investigator • Prof. Marjeta Mišigoj Duraković, Ph.D., M.D., investigator
University of Ljubljana, Biotechnical Faculty • Petra Golja, Ph.D., investigator • Katja Zdešar Kotnik, investigator • Tatjana Robič, investigator • Prof. Marko Kreft, Ph.D., advisor • Monika Biteznik, student investigator • Barbara Dekleva, student investigator • Ana Fortič, student investigator • Tanja Gačnik, student investigator • Mojca Györek, student investigator • Marko Ilić, student investigator • Eva Kocjan, student investigator • Tina Malus, student investigator
University of Ljubljana, Faculty of Medicine • Lijana Zaletel-Kragelj, Ph.D., M.D., investigator • Janet Klara Djomba, M.D., investigator • Mojca Juričič, M.D., investigator • Andreja Kukec, investigator
University of Ljubljana, Faculty of Social Sciences • Vika Kuferšin Pušnik, investigator
Institute of Public Health • Mojca Gabrijelčič Blenkuš, Ph.D., M.D., investigator • Matej Gregorič, M.A., investigator • Vida Fajdiga Turk, investigator
University Medical Centre Ljubljana • Jernej Pajek, Ph.D., M.D., investigator
College of Nursing Jesenice • Joca Zurc, Ph.D., investigator
Fitlab, Institute for Holistic Approach to Sport and Treatment of Sport Injuries • Prof. Janko Strel, Ph.D., investigator
Grammar School Bežigrad • Rok Tomazin, student investigator
University of South Australia, School of Health Sciences • Grant R. Tomkinson, Ph.D., advisor • Prof. Timothy Olds, Ph.D., advisor
Loughborough University School of Sport, Exercise and Health Sciences • Lauren B. Sherar, Ph.D., advisor
University of Bristol, Centre for Exercise, Nutrition and Health Sciences • Prof. Ashley Cooper, Ph.D., advisor
University of Waterloo, Faculty of Applied Health Sciences • Dana Zummach, advisor

According to our mutual agreement, the gathered data is owned by all the researchers and the database is managed by the project leaders. The compiled database with all the measurements and premise description of protocols will be accessible upon request on our web site (www.acd.si) and will be available to the international research community for comparison and analyses.

Methods

Main objectives and areas of interest

The purpose of the 2013 study cycle was to establish the somatic and motor development of the contemporary generation of primary-school children in Slovenia through specific research objectives: a) to establish contemporary children's lifestyles and their predictors, b) to establish the levels of physical fitness and body composition of contemporary children and set the national standards of somatic and motor development, and c) to quantify the secular changes in physical fitness of Slovenian children in the previous 40 years and to compare these changes to the available international data. The main areas of interest of the study were, therefore: body composition, motor performance, aerobic fitness, self-concept and motivation for physical activity, physical activity and sedentary behaviour, social and physical environment, and health.

The study was constructed to adhere to descriptive and predictive level of children's somatic and motor development. A list of more detailed descriptive research goals includes:

- socioeconomic environment of children;
- somatic development of children; national charts of growth, weight, BMI, hip-to-waist circumferences, different skinfolds, and body fat, developmental somatochart, the contemporary trends of physical maturation, the anthropometric characteristics of contemporary children;
- motor development of children; national charts of aerobic fitness and different physical fitness tests;
- secular changes in physical fitness and anthropometric characteristics of contemporary Slovenian children with data from 10, 20, 30 and 40 years ago and a comparison of these changes to those of their peers from other countries;
- shifts in the distributions of physical fitness performance over past 40 years;
- changes in biological maturation, body size and body shape over past 40 years;
- health habits of children (daily physical and other activities, commuting to school, screen time, food habits, smoking);
- active commuting to and from school index;
- sporting activity of children (frequency, organisational form, sport disciplines);
- health of children (self-perception, health problems);
- attitudes of parents about physical activity of their children (their support for sporting activity of child, their opinion about the importance of physical education);
- physical activity level of children, their sedentary behaviour and energy expenditure;
- characteristics of sleep of children;
- psychological attitudes for physical activity in children (motives and self-concept).

In addition to descriptive research goals, we also set some prediction goals:

- the influence of the socioeconomic baseline profile and home environment attributes on outcomes, such as motor performance, aerobic fitness, overweight and obesity, physical activity/inactivity habits, body composition;
- the influence of sleep on physical activity levels and sedentary behaviour of children;
- biological maturation as a predictor of physical fitness of children;
- physical fitness as a predictor for body composition, health, self-concept, academic achievements;
- health risks in children, in relation to overweight and obesity, level and type of physical activity, aerobic fitness and general physical performance;
- physical activity habits and physical fitness in relation to motives for physical activities and self-concept;
- health habits of children, such as daily physical and other activities, commuting to school, screen-time, food habits, and smoking, in relation to energy expenditure, physical fitness and body fat.

Ethics approval and ethical considerations

Approval of the National Medical Ethics Committee was obtained in June 2013 (ID 138/05/13). We visited all the schools, informed them about the research project and asked them to participate in the study. Having fully informed the children and their parents about the aims of the study and its protocol, written consents were obtained from the parents or legal guardians of all participating children. Participation of children was voluntary, and they could withdraw from the whole study or from any part of it at any time. None of the tests were in any way dangerous, and no risks were associated with any of the tests.

The compiled database does not include any personal identification, and the identity codes of the participants are kept separately and securely. All reporting of data will be anonymous. Schools, parents and children are kept informed of the progress of the study through our web pages and the personal presentations of findings on their schools.

Study design

The ACDSi is a cross-sectional, sentinel sites study that includes 11 primary schools and has been carried out every 10 years. In order to fulfil our research goals, we planned to include 3,600 children with 200 in each age- and sex-group. According to our experiences in previous study cycles, we estimated a 15% drop-out rate; hence, we sampled out 4,236 children.

Measurement site setting

The school principals and local mayors were first contacted about a year before the start of the study, and we asked the principals for their consent to include their schools in the study. We then visited each school to explain the details and arranged the coordination of activities in each school. All the schools agreed to participate in the study. Six months before the measurements, we set the exact dates of measurements and the schools integrated the measure-

ments in their yearly work plans. A month before the measurements, the schools received precise organisational instructions and the measurement schedule for each class. A few days before the measurements, we finalised the organisational specifics with each school.

In every school, one of the physical education teachers was assigned to serve as a coordinator. The coordinators helped with the distribution and gathering of consent forms and parents' questionnaires, with informing other teachers and personnel in school about the goals and organisation of the measurements, with setting up the measurement schedule, with making reservations of required facilities, with arranging the meals for the measuring team and the meal schedule for the measured children, and with arranging sleeping facilities for the measuring team, if required. Coordinators were in the constant contact with the principal investigators and were informed in detail about the operational level of the study. Half of the coordinators had previous experiences because they had already served as coordinators in the previous cycles of the study.

Sample

The primary sampling unit was schools and the secondary unit was the classes within each school. We acquired the numbers of classes and pupils in each school from the Information System of Number of Pupils in Slovenia. The numbers of pupils from every school was set according to the size of settlement; the ratio of pupils from each location corresponded to the ratio of inhabitants of Slovenia, coming from the same types of settlements (according to the Statistical Office of the Republic of Slovenia's data). In this way, we assured also national representativeness according to the sizes and types of settlements in which the schools are located.

We then randomly selected the required number of classes from different school years. If the number of pupils from selected classes in an individual school did not correspond to the required number, we randomly selected pupils from other classes of the same schooling year. After the required number of pupils from each school was set, the consent forms were distributed to their parents.

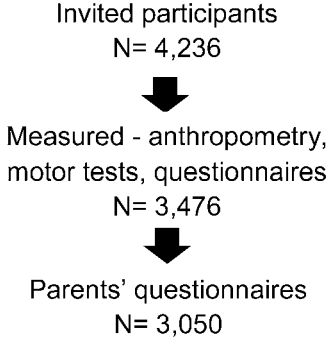

Figure 1: Flow chart of the ACDSi 2013 study

All parents of the sampled children were asked to sign the consent form about the participation of their children in the study. Each parent also received a description of the study and was instructed to check the details of the study on the Slovenian web page of the study (www.arto.si). Parents were also instructed to contact one of the principal investigators if they needed any additional information. Since the first response rate in some schools was unsatisfactory, we sent additional consent forms to parents. Some children who had consent (the consent rate was 87.7%) were not present on the days of the measurements, were injured, or were not sufficiently healthy to participate. Overall, 3,476 children completed all motor tests and anthropometric measurements, which is 82.1% of all children who were originally sampled, and represents around 2% of the entire population of children aged between 6 and 14 in Slovenia in 2013.

Table 3: The ACDSi 2013 study sample by sex and age

Age*	Boys	Girls	All
5 y	54	62	116
6 y	234	248	482
7 y	217	221	438
8 y	210	206	416
9 y	169	192	361
10 y	177	170	347
11 y	197	193	390
12 y	163	136	299
13 y	182	162	344
14 y	162	115	277
15 y	4	2	6
All	1,769	1,707	3,476

*Age is truncated to integer, e.g. 6.0 to 6.9 is 6

Children from grades 7 to 9 were asked to fill in web questionnaires, and the parents of younger children were asked to fill in the paper versions of similar questionnaires. The return of the questionnaires from parents proved to be a difficult task; after a few interventions we ended up with 3,050 completed questionnaires (87.7% of all measured children). A subsample of 11-year-olds from all schools was also asked to participate in a physical activity study and wore the SenseWear Armband during three weekdays and during the weekend.

Main methods of data collection

All of the tests and protocols utilised in the ACDSi are standard procedures and have been well validated for children of this age (see Table 4). Due to developmental divergence within the sample, different methods were sometimes used to collect the data for the same variables.

Table 4: Summary of the data collection undertaken in the ACDSi 2013

Method of data collection	Target group	Research area
Physical fitness examination: SLOFIT and EUROFIT protocols	Children 6–14 years	Aerobic fitness, Motor performance
Physical measures: standard anthropometric procedures	Children 6–14 years	Anthropometry, Blood pressure, Biological maturation
Web-based questionnaire: SHAPES physical activity questionnaire	Children 12–14 years	Physical activity habits, Sedentary activities, Social influences, Social-economic environment, Commuting to school
Web-based questionnaire	Children 11–14 years	Sporting activity, Health, Sleep, Academic achievements
Questionnaire: CLASS parental proxy questionnaire	Parents of children 6–11 years	Physical activity habits, Sedentary activities, Commuting to school, Social-economic environment, Parents attitude to physical activity
Questionnaire	Parents of children 12–14 years	Commuting to school, Social-economic environment, Parents attitude to physical activity
Multiple-sensor body monitors	Children 11 years	Physical activity levels, sedentary activities and energy expenditure, Sleep
Medical examination	Children 6, 8, 11 and 13 years	Health problems

Organisation and performance of testing

Motor testing, anthropometric measurements and questionnaire testing were carried out between September 6 and October 11, 2013. The measurements were organised between 8.00 and 14.00 and lasted two or three days, depending on each school's sample size. Each of the three groups was managed by a group leader, and the coordination between all three groups (anthropometry, motor testing and questionnaires) was managed by a measurement leader. All the measuring equipment that is not standard school gym equipment was brought to school by the research team. All testing equipment was routinely calibrated each day throughout the testing period. The web questionnaire for children was previously pilot-tested twice in a school not that was not included in the sample.

Every child was present for measurements on two days. On the first day of measurements, some children completed all anthropometric measurements and the multi-stage fitness test. The other part of the children at the same time completed the motor testing. Before or after these tests the older children (12 to 14 years) completed the web questionnaires. On the second day of the measurements, the two groups of children switched roles. Anthropometric

measurements were carried out in small gyms or classrooms with room temperatures between 20 and 24 °C. The motor testing was carried out in school gyms at the same temperatures and the running tests in schools' outdoor facilities when the temperature was above 10 °C, without rain and without wind. The web questionnaires were completed in schools' computer rooms with up to 22 children, segregated by sex. Several measurement waves per day were organised with between 60 to 80 children per wave (half of children went to anthropometry measurement and the other half to motor testing) and each wave lasted up to 90 minutes.

After the first day of measurements at individual schools, the parent questionnaire was handed out to every child with instructions to return it the next day. Younger children's parents (6 to 11 years) had to fill in a longer questionnaire, and the parents of older children (12 to 14 years) received a shorter one.

The physical activity measurements have been carried out from mid-September to mid-November 2013. The 11-year-old children wore SenseWear armband from Wednesday to Sunday, 24 hours a day.

The medical records of children will be obtained from school and family physicians in 2014 after the database of other measurements is completed and cleaned.

Physical fitness tests

Our concept of physical fitness is not restricted to the limited information provided by laboratory-based measures of peak aerobic power (Macfarlane 2001), but includes a variety of well-known field-based motor performance tests, for which a good lineage of our data from previous cycles of the ACDSi study exists. Therefore, the physical fitness tests were performed and scored using SLOFit (Strel et al. 1997) and EUROFIT protocols (CDDS 1983). Some tests from these two batteries have been adjusted to younger children. All testing protocols used have been tested on a sample of Slovenian population to validate their measuring characteristics, and they have been proved to be appropriate for use on the selected population (Šturm 1970, 1977). The measurements in the ACDSi 2013 included 17 physical fitness tests (Table 5).

The 20-s tapping test was performed on an electronic armplate (Elan, Begunje, Slovenia); handgrip strength was measured with a Jamar hydraulic hand dynamometer (Bolingbrook, IL, USA); heart rate was monitored with Polar F11 heart-rate monitors (Polar Electro, Kempele, Finland); while physical activity was measured with SenseWear Pro 2 and 3 armbands (BodyMedia, Inc., Pittsburgh, PA, USA). The testing sessions began with brief (up to 10 min) light warm-up tasks. Subjects performed all the motor test barefoot (except 30, 60- and 600-m run tests) in their shorts and t-shirts. Before each test, a student investigator explained the execution of a test to a child. During the testing, the children were not additionally verbally encouraged. If a child failed to correctly perform a test, it had to be repeated. Energetically less demanding tests were repeated twice. The 60-s sit-ups and 60-metre run were performed only by children aged 12 to 14. Resting heart rates were documented 1 min, 2.5 min, and 5 min after the start of relaxed lying down.

Table 5: Measured items in ACDSi 2013

Physical fitness tests	**Anthropometric measurements**
• 20-s plate tapping test • Standing broad jump • 20-s sit-ups test • 60-s sit-up test • Polygon backwards test • Sit and reach test • Shoulder circumduction test • 20-s drumming test • Flamingo balance test • Flexed arm hang test • Handgrip strength test • 30-m sprint test • 60-m sprint test • 600-m run test • 20-m shuttle run test with heart rate monitoring • Resting heart rate test	• Self-reported height • Self-reported weight • Height • Weight • Sitting height • Age at menarche (girls only) • Shoulder breadth (biacromial) • Pelvis breadth (biiliocristal and bispinal) • Ankle breadth (bimalleolar) • Femoral breadth (biepicondylar femur) • Elbow breadth (biepicondylar humerus) • Wrist breadth (lateral-medial stylion) • Arm length (acromion-dactylion) • Leg length (iliospinale) • Foot length • Triceps skinfold • Biceps skinfold • Suprailiac skinfold • Supraspinal skinfold • Subscapular skinfold • Anterior thigh skinfold • Medial calf skinfold • Forearm circumference • Mid-upper arm circumference relaxed • Mid-upper arm circumference flexed • Calf circumference (the widest part of calf) • Gluteal thigh circumference • Mid-thigh circumference • Waist circumference (illiac crest) • Hip circumference (the widest part of hips) • Blood pressure
Physical activity	**Energy expenditure**
• 5-day physical activity measurement • SHAPES questionnaire • CLASS questionnaire • Geographic Information System	• 5-day energy expenditure measurement
Nutritional habits and smoking	
• School Fruit Scheme questionnaire	
Motivation and self-concept	
• Pictorial motivation scale in physical activity • SDQ I questionnaire	
Health status	
• Kidscreen-10 questionnaire • Medical records	

Anthropometric measurements

During anthropometric measurements, children wore light clothes and their feet were bare. Only non-invasive standard anthropometric measurements were performed. Before the measurement of body height and body mass, children were asked to self-report their body height and body mass.

Height and lengths were measured to the nearest millimetre using a GPM 101 anthropometer (Siber & Hegner, Zurich, Switzerland). Body mass was measured to the nearest 100 grams using a portable Tanita BWB-800P electronic scale (Arlington Heights, IL, USA). The electronic scale was checked for accuracy every time it was moved. Anthropometric breadths were measured to the nearest mm by GPM 106 and 108 spreading callipers (Siber & Hegner, Zurich, Switzerland). Diameters, skinfolds and circumferences were measured on the right side of the body. Diameters were measured to the nearest millimetre using a Martin-type sliding calliper (Siber & Hegner, Zurich, Switzerland). Skin-

folds were measured to the nearest millimetre with Harpenden fat callipers (John Bull British Indicators Ltd., London, UK). Three measurements were taken at each measuring site. The mean value of the two closest measurements is to be used for analysis. Circumferences were measured once to the nearest millimetre with an GPM 11 anthropometric tape (Siber & Hegner, Zurich, Switzerland). In addition to anthropometric measurements, blood pressure was taken using an automated Omron M6 blood pressure machine and paediatric cuffs (Omron Healthcare Co., Ltd., Kyoto, Japan). Each child was introduced to the machine, the cuff was chosen and adjusted according to the size of child's arm, and then the child sat quietly and alone for at least two minutes prior to measurement. Resting systolic and diastolic blood pressure were measured in the sitting position using the child's left arm. Two measurements were then taken at three-minute intervals. The mean of the two measurements will be used for analysis.

Some anthropometric data and the data on biological age were also acquired via questionnaires; girls reported the date of their first menarche, and the parents reported their children's birth length, weight and gestational age, their own body height and weight and their own birth date. They were also asked to report on their children's height and weight.

Physical activity

The assessment of physical activity/inactivity patterns and correlates for physical activity of children aged 12 to 14 were made with the School Health Action, Planning and Evaluation System (SHAPES) physical activity questionnaire (1970). The original SHAPES physical activity questionnaire consisted of 45 multiple-choice questions presented in a four-page machine-readable booklet. We created a web-based questionnaire for our study; however, the outlook of the questionnaire remained identical to the original version. Two items require a seven-day recall of vigorous physical activity (VPA) and moderate physical activity (MPA), respectively. VPA was defined as 'jogging, team sports, fast dancing, jump-rope, and any other physical activities that increase your heart rate and make you breathe hard and sweat.' MPA was defined as 'lower intensity physical activities such as walking, biking to school, and recreational swimming.' Responses were provided by indicating the number of hours (0–4 h) and 15-min increments (0–45 min) that each type of physical activity was performed for each day of the previous week. Thus, intensity, duration, and frequency data are collected, and weekday versus weekend analyses are possible. In addition to the two core physical activity items, the items asked also about participation in physical activities (e.g., physical education, strength training, intramural sports, varsity sports, commuting to school), sedentary activities (e.g., watching television, playing video games, homework), social influences (e.g., peer and parental influences), self-perceptions of weight status and athletic ability. To original SHAPES physical activity questionnaire items about dog ownership in the family and social-economic environment were added; the latter included age, education, employment status, and the physical activity level of parents. The SHAPES physical activity questionnaire has acceptable reliability and validity (Adamo et al. 2009; Chinapaw et al. 2010; Wong, Leatherdale & Manske 2006), and it is suitable for use in large-scale school-based data collections for child and adolescent populations (Wong, Leatherdale & Manske 2006).

After it was translated to Slovenian and prior to our measurements, we tested it for reliability and validity at one of the schools not included in the sample, and established that it has acceptable validity and reliability.

For younger children, aged 6 to 11, the Children's Leisure Activities Study Survey (CLASS) printed version of a parental proxy questionnaire has been used for the same purpose (Telford et al. 2004). This questionnaire consists of an extended checklist of 30 physical activities. For each physical activity in the checklist, parents were asked to mark whether or not their child does that activity during a typical week (Monday to Friday) and during a typical weekend (Saturday and Sunday). A 'typical week' was defined as a usual week during the current school term, not including school holidays. If they circled 'yes', parents were asked to report the frequency of the activity (how many times Monday–Friday and Saturday–Sunday) and the total time their child spent in that activity (minutes or hours Monday–Friday and Saturday–Sunday). The CLASS proxy instrument had acceptable reliability, but less than desirable validity (Telford et al. 2004); however, it is still one of the best proxy physical activity questionnaires for children aged 6 to 12 (Adamo et al. 2009; Chinapaw et al. 2010).

In addition, the parents were asked about some of the specifics of the social-economic environment, such as other family members (number, sex and age), family budget and parents' age, employment status, occupation, education. They were also asked about their usual physical activity levels and their own attitude to physical education in comparison to other school subjects.

We also gathered information for analysis of commuting to school. We acquired home addresses for all the children and we asked older children and parents of younger children to describe the usual commuting of children to and from school and the reasons for their choices regarding this. Children's home addresses will be linked to the Slovenian Geographic Information System (Kvamme et al. 1997), which is designed to capture, store, manipulate, analyse, manage, and present all types of geographical data. This system will be used to identify residential environmental risk factors (such as distance from home to school, type of residential area, traffic) for passive commuting to and from school.

Health status

Self-evaluation of health status was assessed in children aged 11 to 14 via the Kidscreen-10 questionnaire (Ravens-Sieberer et al. 2010). This tool proved to have sufficient validity but lower reliability; nevertheless it remains one of the simplest and most effective methods for establishing the general health in children. In addition to the questionnaire, we will use the Slovenian network of school physicians to obtain some information on children's health status from their regular medical examinations at ages 6, 8, 11 and 13 (chronic and acute illnesses, injuries, blood pressure, blood lipids, haemoglobin, blood sedimentation, sight, hearing, status of motor apparatus).

Nutritional habits and smoking

In order to obtain insight into children's lifestyles, we included a few questions on nutritional habits (breakfast consumption, frequency and contents of meals) and on possible

smoking habits, we used the School Fruit Scheme questionnaire for children, developed by the Slovenian Health Institute.[1]

Sleep quality

In order to assess sleep-related behaviours, we used the Pediatric Daytime Sleepiness Scale (Drake et al. 2003) with additional questions on the in-bed time and out-of-bed time during week days and weekends. We used SenseWear armbands to assess the quality of sleep on the subsample of 11-year-olds.

Motivation and self-concept

To examine the relationship between children's motivational regulations and their levels of leisure-time physical activity or inactivity, we used an adjusted Pictorial Motivation Scale in Physical Activity (Reid et al. 2009), which was originally designed to assess motivation in special needs children but has also been successfully used among children without disabilities (Reinboth, Oellingrath & Svendsen 2010).

We also used the SDQ I questionnaire (Marsh 1990; Marsh & Redmayne 1994; Marsh et al. 1994) to assess the self-concepts of the children. The questionnaire is based on the model of academic and non-academic components of self-conception (Shavelson, Hubner & Stanton 1976).

All the questionnaires for children from 12 years of age onward were web-based. When children came to the computer room, each child received a unique identification number that was used for login. After logging in, they started completing the questionnaire while the present investigators gave additional individual explanations if necessary.

Energy expenditure

The energy expenditure of children was assessed via multiple-sensor body monitors (SenseWear Pro armband, BodyMedia Inc., Pittsburgh, PA, USA) on the subsample of 11-year-olds. SenseWear armband device (SWA) are part of a new generation of monitors that combines accelerometry with other physiological signals and has contributed to progress in physical activity assessment (Corder et al. 2008). The monitors combine a two-axis accelerometer with heat flux, temperature and galvanic skin response sensors. These additional physiological data enable the SWA to detect and measure physical activity of the lower and upper body and to detect the change in energy expenditure associated with load carrying, change of grade and non-ambulatory physical activity, thus eliminating the drawbacks of physical activity assessment based only on accelerometer data (Fruin & Rankin 2004). Recent studies comparing the SWA with the doubly labelled water method have found that the former yields an accurate estimate of energy expenditure in both adults (St-Onge et al. 2007).

[1]Available on: http://www.shemasolskegasadja.si/uploads/datoteke/vprasalnik_ucenci.pdf.

Our research team distributed the multiple-sensor body monitors (the SWA body monitor) person-to-person at schools. Information about the SWA body monitors use was given to the children orally; the end of the information session, accelerometers were distributed. The SWA body monitor was attached to the back of the subject's upper right arm, over the triceps muscle, halfway between the acromion and olecranon processes. Children were instructed to wear the armbands during the entire day for five consecutive days (including three weekdays and both weekend days), except during bathing or other water activities. If children had to remove the armband monitors for any other reasons (sports competitions, swimming, etc.) they had to report it. In addition, children and parents received a brochure about using SWA body monitors, including instructions for children. Teachers were also informed about the procedure and were asked to remind children to wear the devices every day.

Data from all the sensors are averaged over one-minute periods, and these data were stored and subsequently downloaded to a computer. For the analysis of the SWA data, the most recent child-specific exercise algorithms were used (SenseWear Professional software version 6.1, BodyMedia Inc., Pittsburg, PA, USA). The outcome variables were total daily energy expenditure, active energy expenditure (>3 METs) and the duration of physical activity performed at various intensities. The intensity was described as metabolic equivalents (METs). Time spent in 3–5.9 METs was classified as moderate physical activity; time spent in 6–8.9 METs was classified as vigorous physical activity and time spent at or above 9 METs was classified as very vigorous physical activity. The thresholds of 3.0, 6.0 and 9.0 METs were selected as they estimate a walking pace of 4 km/h, a running pace of 7 and 10 km/h respectively (Arvidsson et al. 2007) and have been frequently used in defining physical activity intensity in children (Dencker & Andersen 2008, 2011; Pate et al. 1996; Trost et al. 2002; Riddoch et al. 1991; Sherar et al. 2011).

Statistical considerations

Data treatment

All hard copy data were manually entered into a database and checked for transcription errors. All data were entered once and then checked for outliers. Different types of statistical analyses will be performed based on research questions and type of data. A significance level of 0.05 was chosen throughout the study for analyses.

Considerations in relation to clusters within the study sample

The ACDSi study is school-based, and it is therefore possible that there are more differences in children between schools than within individual schools (cluster effect). This means that specific statistical methods are needed that take this into account.

Multilevel analyses

Descriptive and simple bivariate analyses will be performed to describe the distribution of data and to establish simple associations between potential predictor variables and the relevant outcome variables. In addition, multilevel multivariate analysis will be performed.

Discussion and conclusion

This study has several strong points. It ensures the continuation of four decades of the monitoring of changes in somatic and motor development of children on a nationally representative sample. The ACDSi has many participants, making it possible to analyse a relatively large number of variables and covariates in multivariate analyses without exhausting the dataset. The study runs over a 40-year period (1970-1983-1993-2003-2013), which makes it possible to study secular trends in life-styles, life-style conditions and their impacts to somatic development of children. The study is unique in its holistic approach to the researched phenomena with classic as well as technologically advanced non-invasive measurements, which can be used in the large sample epidemiological studies. According to the published data, few other studies have gathered such comprehensive data on somatic and motor development, and environmental factors that influence them.

Specifically, the ACDSi 2013 intends to answer some of the important questions in the understanding of secular changes of somatic and motor development of children that lead to lifestyle disorders, such as obesity, poor motor competency, low aerobic fitness, etc. The study will therefore provide credible new information on many aspects concerning childhood fitness and somatic development. Based on fitness- and somatic development-tracking studies from childhood and adolescence into adulthood (Malina 2001; Starc & Strel 2011a), the study could also give some forecast of physical fitness of Slovenian population in the future and consequently the prevalence of childhood-based morbidities.

Further, the ACDSi 2013 will enable the establishment of some new national standards of different physical and motor characteristics in Slovenia. Such standards are also extremely rare on the international level. That is to say, international standards of quality somatic development of children, normally used in epidemiological research and paediatric practice, are based on the data of old samples from decades ago, which makes them relatively inappropriate for monitoring the developmental trends of contemporary children and youth. The comparisons of research studies show that contemporary children and youth have significantly different physical characteristics than their peers from decades ago, which is visible in the tempo of their physical growth, in their body composition and anthropometric dimensions. Existing international standards are also inadequate for application on samples that have not been included in the construction of those standards, and Slovenian data has thus far not been used for the development of any of such standards (Starc & Strel 2011b).

For the improvement of future epidemiological research of the somatic development of school children as well as for adequate diagnosis of their growth deficiencies in Slovenia, we would have to construct our nationally specific growth charts, height charts and a developmental somatograph. For the assessment of health risks, we would need also nationally specific BMI charts, waist-to-hip circumferences ratio charts and body fat charts. For diagnosing health-endangering lifestyles, we also need standardised energy values of food intake and physical activity, while in the area of kinesiology we need the criteria of physical maturation for diagnosing talented children for sport and for the individualisation of the learning process in school physical education. The problems in the area of standards of quality motor development are even greater because the international standards for the paediatric population are non-existent, since there is little consensus on the methodology

and indicators of quality of somatic development, and because (despite great efforts) most countries, except for Slovenia and South Korea have not succeeded in establishing national systems for the regular annual monitoring of children's physical fitness.

In addition, with this cycle of ACDSi, we are stepping forward in inter-disciplinary cooperation in research and also in action activities on physical anthropology in children. In Slovenia, we have a well-developed system of epidemiological monitoring and evaluation of physical fitness of children and youth (Strel et al. 1997) but a rather undeveloped system of epidemiological monitoring of their physical activity, growth patterns, nutritional habits and body composition. With this study, we are correcting this discrepancy, strongly influenced by the decline of the Slovenian physical anthropology in the previous 50 years and the lack of cooperation between kinesiology, paediatrics and public health. For the first time, researchers from other fields and national policy-makers are actively participating in the study. The research results will also be directly implemented in various study courses of the Faculty of Sport, Faculty of Biotechnology, Faculty of Arts and Faculty of Medicine.

Moreover, the strength of the study lies in its transparency and the dissemination of its results because the constructed database with all the measurements and precise descriptions of protocols will be accessible upon request on a special web site and will be available to the international research community for comparison and analyses.

An issue that needs careful consideration in the ACDSi study is the interpretation of data. When many analyses are performed, even if the study sample is large, spurious results are likely to occur. Therefore, unusual, single, or unexpected results will be carefully considered in relation to the profile of other results and their plausibility.

Nonetheless, the results obtained in this study are likely to have an impact on public health in relation to physical fitness in childhood and will enrich the data on national anthropometric data and restart the development of applicable physical anthropology in Slovenia. All national standards will be directly applicable in paediatric practice (diagnostics) as well as in sport training and pedagogical practice (planning and evaluation). At the same time, the results will serve the planning and implementation of public health politics (nutrition and physical activity politics).

Competing interests

None of the authors has any competing interests regarding the ACDSi study or this manuscript.

Acknowledgements

Limited non-specific funding has been provided by the Slovenian Research Agency within the research programme P5-0142 Bio-psycho-social context of kinesiology. The study received invaluable assistance from the Olympic Committee of Slovenia and Elan Inventa, a sporting equipment manufacturer and supplier. We would like to thank also our patrons who supported the study: the Slovenian Federation of Sport Teacher Associations, the Section for School and High-school Medicine at the Slovenian Medical Association, the Ministry of Health of the Republic of Slovenia, the Ministry of Education, Science and Sport of Slovenia, the Olympic Committee of Slovenia. The study could not have

been conducted without exceptional voluntary work of all investigators (students and researchers), school coordinators and principals, and without personal financial contribution of members of the research team to cover some study's costs.

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Povzetek

Študija ARTOS 2013 je nadaljevanje 40 let stare desetletne študije o biološkem, psihološkem in socialnem razvoju otrok. Od svojih začetkov v letu 1970 je bila raziskava izvajana kot interdisciplinarna študija fizične antropologije, kineziologije, psihologije in sociologije, v svojem petem ciklu v letu 2013 pa se je razširila še na pediatrijo in javno zdravje. Cilj študije je slediti sekularnim trendom telesnega in gibalnega razvoja otrok z vidika psiholoških, socialnih in zdravstvenih dejavnikov, ki oblikujejo sodobne življenjske sloge otrok. Članek opisuje protokol študije ARTOS 2013 v zvezi z njegovo organizacijo, vzorčenjem in metodami.

KLJUČNE BESEDE: otroci, telesni razvoj, gibalni razvoj, telesni fitnes, protokol

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