

# Networks in Auxology – proceedings of the 31<sup>st</sup> Aschauer Soiree, held at Aschau, Germany, June 17th 2023

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There are no conflicts of interest.

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## Abstract

Thirty-four scientists met for the annual Auxological conference held at Aschau, Germany, to particularly discuss the interaction between social factors and human growth, and to highlight several topics of general interest for the regulation of human growth. Humans are social mammals. We show and share personal interests and needs, and we are able to strategically adjust size according to social position, with love and hope being prime factors in the regulation of growth. In contrast to Western societies, where body size has been shown to be an important predictor of socioeconomic status, egalitarian societies without formalized hierarchy and material wealth-dependent social status do not appear to similarly integrate body size and social network. Social network structures can be modeled by Monte Carlo simulation. Modeling dominance hierarchies suggests that winner-loser effects play a

pivotal role in robust self-organization that transcends the specifics of the individual. Further improvements of the St. Nicolas House analysis using re-sampling/bootstrap techniques yielded encouraging results for exploring dense networks of interacting variables. The D-score scale, the Infancy-Childhood-Puberty (ICP) growth model and the SuperImposition by Translation And Rotation (SITAR) technique were presented, as well as customized pediatric growth references, and approaches towards a Digital Rare Disease Growth Chart Library. First attempts with a mobile phone application were presented to investigate the associations between maternal pre-pregnancy overweight, gestational weight gain, and the child's future motor development. Clinical contributions included growth patterns of individuals with Silver-Russell syndrome, and treatment burden in children with growth hormone deficiency. Contributions on sports highlighted the fallacy inherent in disregarding the biological maturation status when interpreting physical performance outcomes. The meeting explored the complex influence of nutrition and lifestyle on menarcheal age of Lithuanian girls and emphasized regional trends in height of Austrian recruits. Examples of the psychosocial stress caused by the forced migration of modern Kyrgyz children and Polish children after World War II were presented, as well as the effects of nutritional stress during and after World War I. The session concluded with a discussion of recent trends in gun violence affecting children and adolescents in the United States, and aspects of life history theory using the example of "Borderline Personality Disorder." The features of this disorder are consistent with the notion that it reflects a "fast" life history strategy, with higher levels of allostatic load, higher levels of aggression, and greater exposure to both childhood adversity and chronic stress. The results were discussed in light of evolutionary guided research. In all contributions presented here, written informed consent was obtained from all participants in accordance with institutional Human investigation committee guidelines in accordance with the Declaration of Helsinki amended October 2013, after information about the procedures used.

Humans are social mammals. We grow and mature among our peers, we show and share personal interests and needs within our community, and we are able to signal our position within our social networks. We are able to generate a variety of signals, one of which is body size. Similar to

other social mammals ([Buston and Clutton-Brock 2022](#)), we strategically adjust size according to social position. Greater size signals greater impact ([Hermanussen and Scheffler 2016](#)). Thirty-four scientists met for the annual Auxological conference held at Aschau, Germany, to discuss the interaction between social network and body size, and several related topics.

**Michael Hermanussen, Christiane Scheffler, Melanie Dammhahn, and Detlef Groth** modeled social network structures based on Monte Carlo simulations, with particular focus on the impact of winner-loser effects on network efficiency ([Hermanussen et al. 2023](#)). They simulated pairwise agonistic contests between equal-ranking competitors (equal resource-holding-power). Under random conditions ('Null variant'), random networks evolved. When, however, allowing for state-dependent feedback ('Winner-loser variant') network structures evolved that were characterized by centralized 'star-like' dominance hierarchy. These structures equalled those that evolved from competitors with an initially higher resource-holding-power (keystone individuals). The Monte-Carlo simulated dominance hierarchies following state-dependent feedback showed triad motif patterns that were very similar to those of a variety of natural dominance hierarchies ([Shizuka and McDonald 2015](#)). The authors suggest that state-dependent feedback plays a pivotal role in robust self-organizing phenomena that transcend the specifics of the individual. As the efficiency of centralized social networks benefits both, the individual and the group, centralization of social networks appears to be an important evolutionary goal.

**Detlef Groth and Cédric Moris** presented new developments in the St. Nicolas House Analysis (SNHA, ([Hermanussen et al. 2021](#))) targeting the problem of exploring dense networks of interacting variables. Showing some applications of this method

in illustrative examples on easy to comprehend datasets first, the presenter then went over to the possible improvements for the current algorithm. The problem of detecting ramifications in addition to discovering chains of associations remains a major challenge for the SNHA algorithm. As presented, possible approaches to this problem are the use of re-sampling/bootstrap techniques as well as quality checks for instance using linear models to remove spurious associations. The presented results were highly encouraging, the additional computational cost for these techniques might be acceptable for smaller networks when the researcher is interested in a more detailed view of the interactions between their variables of interest. These extensions will be fully integrated both into the next version of the R package (Groth 2023) and the Python implementation of the SNHA algorithm (Hake et al. 2023).

**Tim Hake** presented three methods to expand the parameter free SNHA algorithm (Groth et al. 2019; Hermanussen et al. 2021) in Python (Hake et al. 2023), which predicts edge directions in an undirected network. The SNHA algorithm ranks absolute bivariate correlation coefficients in descending order according to magnitude and creates hierachic "association chains" defined by sequences where reversing start and end point does not alter the ordering of elements. Association chains are used to characterize dependence structures of interacting variables by a graph. The preliminary SNHA analysis reconstructs an undirected network based on association chains. These chains are characterized by a sequence of ranked bivariate correlation coefficients, which do not permute if the start and end point are interchanged. The xi-corr method determines the direction of an edge by the maximum value of the asymmetric Xi correlation coefficient  $\xi(X, Y)$  (Chatterjee 2021). The xi-chain method considers the hierarchy of the association

chains, here, on edge direction determines the direction of all edges within the chain. This method identifies the direction of the chain by a majority vote of maximum  $\xi(X, Y)$  (Chatterjee 2021) values over all edges. The logic method takes also the ordering of an association chain into account, but infers the direction of the chain by logical inference of correlation coefficients between neighbours of intersecting nodes of two association chains. The three methods are applied to synthetic data (Novine et al. 2022) of a variety of graphs with different sizes and densities. The Xi related methods are random predictors for the edge direction. The direction prediction based on logical reasoning achieves the highest rate of predicting the true edge direction with a maximum of 0.93, it averages to 0.83. The performance of the direction analysis is highly dependent on the extraction of association chains.

After these rather theoretical considerations on the emergence and significance of network structures among members of social groups, **Barry Bogin** emphasized love and hope as pivotal factors in the regulation of human growth. Hope and love are well-studied themes of literature and art in many human societies (Bogin 2023). The human physiology of love and hope is less well-understood. Love and hope, from families, communities, and the political-economic systems of whole societies, intersect in promoting healthy human development. The lack of love and/or hope delays growth, maturation and even kills. Love provides a sense of security and attachment, which are necessary for healthy physical, cognitive, and emotional development. Hope provides a sense of optimism and resilience in the face of adversity. Loving relationships can foster a sense of hope in individuals and in society by providing support systems during difficult times. Similarly, having a sense of hope can make it easier to form loving relationships by pro-

viding individuals with the confidence to connect with others. Hope and love are the fundamental basis of human biocultural reproduction, which is the human style of cooperation in the production, feeding and care of offspring. Examples were given of the association between human growth in height with love and hope, including: 1) the global ‘Long Depression’ of 1873–1896, 2) ‘hospitalism’ and the abuse/neglect of infants and children (table 1), 3) adoption, 4) international migration, 5) colonial conquest, and 6) social, economic, political change in Japan between 1970 to 1990. Overall, love and hope are both critical factors in promoting healthy human development and that they intersect in complex ways to support emotional well-being.

**Christiane Scheffler and Michael Hermanussen** presented resent findings on the impact of personality on body height. The regulation of growth of body height is influenced by Socio-Economic-Political-Emotional (SEPE) factors of environment ([Bogin 2021](#)). Nutrition and genes are the biological requirements of human growth, but their influence on the regulation of growth is overestimated ([Scheffler et al. 2019](#)). The impact of emotional factors on human growth is obvious. A common psychological tool to measure individual emotions is the so called “Big Five” personality inventory. Parallel to the positive secular trend in body size, also the scores of personality traits in Western populations have changed over the last century. Scheffler and Hermanussen hypothesized

**Table 1** Infants dying in founding homes in European cities or nations and infants placed into care homes in the countryside. Data from Peiper ([Peiper 1955](#)).

City or country	year	percent dying
Irkutsk	na	100
Dublin	1701 – 1797	98
Petersburg	1772 – 1784	85
Petersburg	1785 – 1797	76
Paris	1780	60
Paris	1817	67
Vienna	1811	72
Brussels	1811	79
Brussels	1817	56
Belgium	1823 – 1833	54
Gent	1823 – 1833	62
Mons	1823 – 1833	57
Petersburg	1830 – 1833	51
Moscow	1822 – 1831	66
France	1838 – 1875	50
Dijon	1838 – 1845	61
Bordeaux	1850 – 1861	18
Infants placed in the countryside (Bordeaux)		15
Prague	1865	20
Infants placed in the countryside (Prague)		35

that personality traits are directly associated with body height. In March 2023, they studied 203 mothers (aged 19–47) on the island Java and West-Timor (Indonesia). Both islands differ in their cultural background. Personality traits were measured by a shortened version of the BIG FIVE INVENTORY-2 (openness, extraversion, neuroticism/emotionality) validated for Indonesia. Personality traits and body height were positively associated, yet differed between the islands. In West-Timor, body height was positively associated with curiosity (openness), whereas in Java, height was positively associated with extraversion indicating different emotional perception and a differential impact of the cultural background on the socio-endocrine regulation of human growth ([Hermanussen et al. 2022](#)).

**Piotr Fedurek** reported on research regarding the extent to which anthropometric characteristics of an individual, such as height, are related to social status. Height can be influenced by both environmental and genetic factors. Studies conducted in WEIRD (Western, Educated, Industrial, Rich and Democratic) societies have shown that height is an important predictor of socio-economic status, especially in men. Social status, in turn, has been linked to better indices of social integration in both hierarchical, large-scale and traditional, small-scale societies. Fedurek looked at the extent to which height is related to social integration among the Hadza men, hunter-gatherers living in Northern Tanzania ([Fedurek et al. 2023](#)). He used hunting reputation and popularity (i.e., being perceived as friend by the others) as indices of social status and integration in GPS-derived proximity networks as proxy for social integration. The study showed that among the Hadza men height is not associated with the level of social integration in proximity networks. The findings suggest that in an egalitarian society, exhibiting

neither formalised hierarchy nor material wealth-driven social status, height might not necessarily translate into a better integration in social networks.

**Jesper Boldsen** presented data from the village of Lading, Eastern Jutland, Denmark, between 1665 and 1740, and discussed the abrupt change in infant mortality during this period. Based on a parish death register, the village Lading experienced a dramatic decline in period mean age at death around 1690 (from 37.3 to 30.0 years). This change was primarily brought about by an increase of infant mortality from 25 – 33%. Aspects of the early period mortality were more like the pattern of mortality as it is known from paleodemographic analyses of village skeletons from the 12th – 14th centuries than mortality in later periods. Both parish registers and samples of skeletons provide information on period mortality; but mortality in one age group of a cohort affects mortality in later age groups of the same cohort. This pattern of mortality dependency makes it difficult to interpret demographic data from the past. The Lading data provides a basis for a discussion of competing factors in cohort mortality around AD 1700.

**Takashi Satake** reviewed Japanese Societies on Auxology. In the late 1950s, Prof. Fujita, T. (Anatomy, Tokyo University) asked researchers to discuss auxology and organized a research group whose specialties were a wide variety of the field, e.g. anatomy, physiology, pediatrics, hygiene, anthropology, zoology, psychology, etc. ([Fujita 1961](#)). Prof. Funakawa, H. (Child Health, Tokyo University) and other members of the group once again organized an auxology group in 1984 with altogether 18 people. In 1994, this group created a sub-committee in the Anthropological Society of Nippon, Prof. Ashizawa, K. (Otsuma Women's Univ.) being its first representative. Meetings were held at least once annually, abstracts were submitted to the

Anthropological Science (Japanese Series). Several members studied in Europe or the USA and invited foreign researchers to their meeting for personal communication. Simultaneously, a pediatric group of auxology was initiated with regular annual meetings and published meeting records. Yet, the number of the anthropology groups dropped and dissolved in 2007. Several members of both groups had studied with Dr. Tanner at the London Univ. Institute of Child Health ([Hauspie et al. 1995](#)). And the Japanese Society of Human Auxology was founded in 2005 and organized the 11th International Congress of Auxology in Tokyo in 2007. Previously, the Japanese Society of Human Growth and Development that had developed from a subcommittee in the Japanese Society of Physical Education, Health and Sports Sciences since 1961, was founded in 2002.

**Stef van Buuren** addressed the problem that 150 techniques for measuring child development produce scores that cannot be compared. As a solution, he presented the D-score scale for child development ([Jacobusse et al. 2006; Weber et al. 2019](#)). The scale quantifies child development on an interval scale, it is generic and covers multiple domains, it is defined across all ages, and independent of the measurement instrument and of the population to be measured. Current work is based on 102,512 child-age combinations and 66,672 children from 51 cohorts using 22 different instruments. The WHO elected the D-score as the quantitative backbone of the new Global Scales for Early Development (long form) GSED LF and GSED SF (short form) instruments for comparing child development worldwide ([2023](#)). The long-term goals are to create a WHO Child Development Standard and to estimate the proportion by sex of children under 5 years of age who are developmentally on track in health, learning and psychosocial well-be-

ing (Sustainable Development Goals (SDG) indicator 4.2.1).

**Jani Söderhäll** presented a first approach towards a Digital Rare Disease Growth Chart Library. Child growth monitoring in specialist clinics increasingly relies on a digital charting system integrated with the patient record. Until recently, the availability of digital charts for patients with rare conditions has been limited. For the widely-used application GrowthXP an additional module now offers users the option to access disease-specific charts for over 50 rare conditions. The development of this comprehensive library has resulted from a systematic search of the literature and contributions of published data from many growth specialists. For many of the conditions data was unavailable in the original articles, with only charts were displayed and in widely different formats. In order to render the charts in an accurate and uniform way, and allow percentiles and Z-scores to be calculated, unique technology was used to scan the chart image, overlay scaling and automatically detect the growth curves. The series of data points derived were then saved in the GrowthXP reference data library, which now contains over 6,500 data sets, out of which more than 550 represent growth charts for rare conditions. GrowthXP presents these sets of data in a uniform way to allow paediatricians to track a patient's growth on the desired chart and visualise automatically calculated values.

**Chris Jefferies** discussed problems related to customised paediatric references. Traditional growth references are static and based on cross-sectional data, where their applicability to a patient is determined by the population used in their construction; sex, disease, country of origin, gestational age at birth and other such age-invariant parameters. In contrast, recent studies have published dynamically adjusted reference data that respond to the unique

growth or developmental characteristics of an individual. This presentation provokes a discussion on the practicality of drawing responsive charts using these data, and the decision-making processes that may result, including when customising patient measurements are missing. Jefferies presented different reference charts constructed from publications of blood pressure adjusted for height (Rosner et al. 2008), bone composition adjusted for height z-score (Zemel et al. 2011), and height adjusted for Tanner stage (Miller et al. 2020). By including adjustment parameters, the position of an individual on dynamic curves changes and may influence clinical decisions. Further functionality, benefits, and drawbacks of such charts require more robust discussion with the clinical and academic paediatric communities to improve the decision support available to those who monitor child health.

**Yehuda Limony** highlighted the advantages of using a longitudinal growth model over cross-sectional growth charts, and presented the Infancy-Childhood-Puberty (ICP) growth model (Karlberg 1989).

He summarized several advantages: (1) Personalization: The model can be tailored to each individual child. (2) Accuracy: In a study conducted in 2004 on 204 Israeli children attending a growth clinic, 93.5% of the height measurements for boys and 91.6% of the height measurements for girls deviated by less than 2 cm from the model's predicted growth. (3) Retrospective Analysis: The model proves helpful in retrospectively analyzing growth patterns, particularly in determining the onset of the pubertal growth spurt and identifying any deviations from the model's expected path of height growth. (4) Prospective Analysis: The model is also valuable for prospective growth analysis, allowing for calculating the final adult height through extrapolation. (5) Precocious Puberty: The model aids in understanding cases of pre-

cocious puberty where the predicted adult height is near or equal to the mid-parental height. This finding provides reassurance and may eliminate the need for diagnostic procedures to rule out pathological precocious puberty. (6) Evaluation of Growth Hormone Therapy: Another application is the retrospective evaluation of the overall effect of growth hormone therapy during pubertal growth.

**Jovanna Dahlgren** explored the growth pattern of individuals with Silver-Russell syndrome in Sweden. Seventy years ago, Silver and Russell described this syndrome with intrauterine growth retardation, hemihypotrophy, triangular face, early puberty or high sex steroids and short stature. The syndrome is rare with an approximatively incidence of 1:100.000 per newborns. A couple of countries have developed syndrome-specific growth charts, but the outcome on growth hormone treatment has been debated. The reason for this is that there is a peculiar growth pattern, where most children respond well during the catch-up period, but the pubertal growth is less optimal. Based on published data we know that non-responders have an early increase in sex steroid levels despite lack of peripheral signs of puberty (Sunnergren et al. 2019). The reasons for this may be several, but one could be a peripheral dysfunction of gonads. Dahlgren evaluated the growth of 20 individuals with diagnosed Silver-Russell syndrome that previously have been referred and treated with growth hormone from pre-school age at the Queen Silvia Children's Hospital, Gothenburg, Sweden. The majority had a thin phenotype. Those that had a rapid increase in BMI standard deviation score (SDS) with or without enteral nutrition during school age were found to have increased sex steroids leading to accelerated bone maturation. A few boys were treated with additional aromatase inhibitor (1 mg) for 1–2 years if normal FSH and LH as

well as high estradiol were found. These boys reached an adult height near the mean for the population as well as near mid-parental height. The peculiar growth pattern with abolished pubertal spurt is restored if males are treated with aromatase inhibitor. It was debated whether the absence of a normal pubertal spurt may be due to nutrition and rapid weight gain or due to some hitherto unstudied social influences.

**Julia Quitmann** discussed the treatment burden and adherence in children with growth hormone (GH) deficiency. Growth failure in children and adolescents can be associated with social stigma and levels of quality of life lower than subjects with normal height (Quitmann et al. 2016). We need to acknowledge that parents and caregivers might suffer from caregiving related emotional stress and anxiety (Lackner et al. 2023) and finally there is the need for physicians to manage parental expectations, desires, and entitlement to treatment. We aimed to examine the effects of height deviation and treatment status on psychosocial adaptation outcomes and to identify clinical and psychosocial determinants of internalizing/externalizing problems in a large European cohort of short statured children/adolescents (Silva et al. 2018). While height was found to be only a weak predictor of health related quality of life (HrQoL) in both, child (11–17 years) self-report and in parent observer-report, children/adolescents with current short stature presented more parent-reported internalizing problems and lower self- and parent-reported condition-specific HrQoL. Treated children self-reported better HrQoL than the untreated group. So short stature has been associated with psychosocial impairments, but whether treatments and achieved height impact on health-related quality of life (HrQoL) and psychological functioning of children/adolescents is still controversial. We found

impairments in HrQoL compared to the reference population, especially regarding vitality/energy and social functioning/isolation (Quitmann et al. 2014). In turn, results from a prospective multicentre study showed that especially parents of children that were treated with GH report an increase in their children's HrQoL after 1 year. Changes in HrQoL were mostly explained by psychosocial predictors followed by sociodemographic and clinical variables. Specifically, the diagnosis SGA significantly predicted a greater increase in parent-reported HrQoL. A lower caregiving burden significantly predicted a decrease in parent-reported HrQoL. While treatment by GH may induce improvement in QoL through height gain, daily injections may cause a significant burden for the child and family, and may alter adequate adherence to treatment. Adherence involves mutual agreement between the patient and health care provider (HCP) to implement specific health care recommendations. Adherence is the extent to which the individual follows the agreed upon recommendations and is difficult to measure as it is often based on self-report. GH therapy requires daily injections over many years and adherence can be difficult to sustain. A study from New Zealand (Cutfield et al. 2011) revealed that 66% of patients treated with GH were non-compliant. Another study (Dommelen et al. 2018) describing the effect of suboptimal adherence in a large group of patients with GHD using a reliable method to automatically assess adherence through an electronic device (Easypod), found that the success of therapy depends mainly on the ability of the patients and their parents to carefully adhere to the recommended treatment regimen and Complex schedules should be avoided. Data from existing studies reveal that most GHD patients on treatment are strongly convinced of their need for medication and that adherence

to GH treatment is influenced by coping strategies and QoL (Quitmann et al. 2015). Patients with impaired psychological QoL are less able to translate their convictions into good adherence, a phenomenon to be addressed in future research. In addition to the children also the parents reported being substantially impacted themselves by worry surrounding treatment administration, but also by worry about causing the child pain and the medication costs. Feelings of sadness about the need for treatment, guilt, and frustration with injection administration were additional emotions reported. Long-acting GH formulations have been designed and perfected over the last two decades. We evaluated efficacy and safety of once-weekly somatotropin versus once-daily somatotropin in children with pGHD (Loftus et al. 2021). Treatment for 12 months with once-weekly somatotropin or once-daily somatotropin resulted in comparable improvements in HrQoL among children with pGHD. Lower HrQoL perceived by parents/caregivers possibly reflect children's tendency to emphasise adaptation. These results suggest that evaluation of HrQoL could help support treatment decisions in children with pGHD treated with GH. Assessments of HrQoL in clinical practice during treatment with GH further enhances the patient-centric approach to evaluating treatment effects and can help support decisions for managing pGHD in this paediatric population, which in turn are important for improving treatment adherence (Quitmann et al. 2019).

**Ingo Scheffler** presented ectoparasites on bats. Bats are the only mammals that have developed active flight ability. The low substrate contact, the frequent change of roosts outside of the maternal roosts, the lowering of the body temperature during the day (torpor) and during hibernation limit the possibility of colonization by poikilothermic ectoparasites. On the other hand, the relatively long-life span

of bats and the formation of large aggregations with close body contact is very advantageous for such co-inhabitants. Ectoparasites of bats include bugs, fleas, flies, wing-, fur- and ear mites, some of which have unique morphological characteristics. They can either survive long periods of starvation (bugs), live permanently on the hosts (fur- and wing mites and bat flies) or are extreme climbers (bat fleas). There is a wide range in host attachment from species specificity to colonization of diverse species. For all ectoparasites, ingestion of blood is obligatory for survival and production of offspring. The choice of bat on which to ingest blood is not random, but is influenced by the status of the host's immune system. Healthy bats react to bloodsucking with immunological defense mechanisms and thus become unattractive to ectoparasites. This explains the limitation of the number of parasites and their constant change of host organisms during body contact with other bats. If ectoparasites compete for the same resource, e.g., the skin under the fur, then there is usually no coexistence (bat flies vs. bat fleas vs. fur mites) (Figure 1).

**Nino Nazirishvili and Ekaterine Kvaratskhelia** presented first attempts to investigate to what extent maternal pre-pregnancy overweight, obesity and excessive gestational weight gain affect a child's motor development. The authors hoped to shed more light on this relationship with a novel study using a mobile application (software in preparation). They intended to collect data on the motor development of children of pregnant women with overweight, obesity, and excessive weight gain during pregnancy from birth to two years of age and compare the data with the motor development of children of normal-weight pregnant women, by (1) two questionnaires for mothers and pregnant women about the perinatal period with specific questions about anthropometric parame-



**Figure 1** Seba's short-tailed bat *Carollia perspicillata* with bat flies, Photography: Ingo Scheffler

ters, pregnancy data, and main problems during pregnancy and delivery. With these questionnaires, they tried to determine the weight gain, blood pressure, and blood glucose levels of women and their newborns; and (2) the free mobile application that allows parents to check the development of their children from zero to four years of age, and to collect children's motor development data and establish a mother-child linkage.

**Annamaria Zsakai** presented a new integrative sport diagnostic institute – Sport Sciences and Diagnostic Research Centre, Hungarian Handball Federation – that was opened in Hungary in 2023. The institute focuses on diagnostic and research work connected with sport and exercise, both at a national and international level. The strong commitment of the personnel and the technical investment of the lab-

oratories in the integrative institute are hopefully the guarantee for our successful work. A large arsenal of equipment for body structural analysis is available in the Human Biology Laboratory (dual X-ray absorptiometry (DEXA), 3D scanner, ultrasound bone age assessment, ultrasound tissue structure and body composition analyser). In the Cardiology Laboratory echocardiography is used to provide data in abnormality screening and the analysis of the cardiac adaptation to increased exercise. In the Exercise Physiology Laboratory anaerobic muscle performance and ergospirometry are carried out in athletes. Balance and strength assessments are made in the Biomechanics Laboratory to study the influence of neuromuscular training on performance and biomechanics of the total body and the body regions.

The Institute is open to national and international collaboration proposals.

**Martin Musalek** discussed the strategies of ice hockey clubs in Czech ice hockey players, their development, and the role of the biological age. In the context of ice hockey during puberty, there exists a preference for biologically advanced players due to their typically heightened attributes such as increased stature, body mass, strength, and speed. The intensely competitive milieu and the success drive this inclination towards player selection. However, the extent to which player selection criteria and the prevalence of biologically advanced players align within the upper levels of youth competition is inadequately explored. The study endeavours to ascertain whether Czech ice hockey clubs participating in the highest tier of youth leagues exhibit proportionately mean chronological and biological ages among their players and whether chronological and biological age significantly influences the ranking of clubs based on performance outcomes in selected off-ice evaluations. Data were obtained from 1,262 players aged 13.01 to 16.98, with a mean of 15.04 years, from 28 distinct clubs, representing 89% of the population sample. Khamis Roche equations were used to estimate the biological maturation status.

The off-ice performance of players was evaluated using the part of the National Hockey League (NHL) 2019 comprehensive physical test battery. The distribution of players based on their biological maturation status was as follows: 19.3% were characterized as biologically delayed (De), 54.4% as average (Av), and 26.3% as biologically advanced (Ad). Nevertheless, there is an apparent variance in the distribution of players with different biological maturity statuses across different age cohorts. Specifically, within the age ranges of 13.00 to 13.99 and 16.00 to 16.99 years, the distribution is 22% De, 56% Av, and 22% Ad. In

the age categories 14.00 to 14.99 and 15.00 to 15.99 years, the composition changes to 14% De, 57% Av, and 29% Ad. This pattern underscores the heightened sensitivity to selecting biologically advanced players in the crucial age interval of 14 to 15.99 years. This essential time coincides with the formation of the first youth national teams. The average chronological and biological age of players varies greatly among clubs. This discrepancy amounts to 0.8 years for chronological age and 1.1 years for biological age. These differences remain even though all clubs play in the same league. When integrating this variability in physical maturation into the appraisal of club rankings based on off-ice performance, a substantial shift in the established order becomes obvious. Clubs that initially achieved a good ranking have to accept a significant drop in their ranking after considering the biological age of their players. This downgrading is even more pronounced, implying a shift of about six positions when the biological age variable is considered in the context of the countermovement jump – a crucial metric for evaluating lower limb dynamic strength and, by extension, speed skating potential. In summation, the outcomes of this study underscore the disparate player selection strategies adopted by Czech ice hockey clubs participating in the uppermost tier of youth leagues. The discrepancy is particularly accentuated within the pivotal age range of 14 to 15.99 years, a phenomenon likely attributable to the impetus of immediate success. Additionally, this study highlights the fallacy inherent in disregarding the biological maturation status when interpreting performance outcomes, potentially leading to erroneous inferences regarding the hockey understanding or, at the very least, the physical potential of players.

**Basak Koca Özer** and **Cansev Meşe Yavuz** reported on growth data of Ulupamir Kyr-

gyz children. The Kyrgyz people, revered as one of the most ancient tribes in Turkic history, trace their origins back to the 2nd Century BC when they embarked upon their nomadic lifestyle across the present-day territories of Mongolia, Kazakhstan, and Kyrgyzstan. The study focused on Kyrgyz Turks who migrated to Turkey after 1982 and settled in the Ulupamir village within the Erciş district of Van. Within the new setting, the people maintained their deeply ingrained cultural practices and distinctive ways of life. Özer and Yavuz assessed diet quality, and body height and weight, of 150 children (79 boys and 71 girls) and adolescents aged 3 to 17 years living in Ulupamir village. At all ages except at age 12, Ulupamir immigrant boys are taller and, after puberty, also heavier than their counterparts living in urban/rural and high mountain/low mountain areas of the Kyrgyzstan Republic (Abdyganiev and Belov 2020; Kochkorova et al. 2018). Ulupamir immigrant girls are also taller, but tend to have lower weight during early pubertal stages and higher weights thereafter.

**Janina Tutkuviene, Laura Kasperiunaite, and Simona Gervickaite** showed an alarming decrease in menarcheal age of Lithuanian girls during the last decade: an analysis of biosocial factors. Recent studies suggest that the declining age of menarche may be related to a stressful environment, the prevalence of endocrine disruptors, improper nutrition, etc. Early menarche has been linked to obesity, metabolic syndrome, cardiovascular disease, stroke, reproductive cancers, etc. (Kim et al. 2021; Pang et al. 2022; Pop et al. 2021; Lee et al. 2022; Yang et al. 2022). Based on a retrospective online survey in 2023 including all parts of Lithuania, the age at menarche was determined in 979 girls aged 16 to 20 years. The menarcheal age had decreased from 13.50 years in 2002 to 12.35 ( $SD \pm 1.26$ ) years in 2023. The current trend is considered wor-

risome because of the association between early menarche and numerous health risks and risky behaviours (Kim et al. 2021; Yang et al. 2022; Lee et al. 2022). There were no reliable regional differences in menarcheal age, suggesting an effect of globalization. Similar data were obtained by Pop et al. (2021). Previous studies reported earlier menarches in cities (Domaradzki et al. 2022). First-born girls started menstruating earlier than second-born girls. Girls who shared their room with siblings, spent less time on social networks and engaged in very intense physical activity had a slightly later onset of menarche. Significantly earlier menarche was found in girls exposed to passive smoking. These findings largely agree with other recent studies (Kang et al. 2020; Pang et al. 2022). Further studies are needed to investigate the complex influence of nutrition, endocrine disruptors, and lifestyle.

**Sylvia Kirchengast** discussed regional trends in the body height of Austrian recruits. Regional differences in mean body height exist within a population or a state. In addition to genetic factors, these differences in mean body height are mainly due to different social and economic developments in the various regions. Austria is well suited for such analysis due to its small size but its regionally very different topography and economic orientation. In our study, we evaluated the regional time trends in mean heights in the nine Austrian provinces over a period spanning more than four decades. Body height data of 1734569 male conscripts born in Austria with Austrian citizenship between 1961 and 2002 were enrolled in the study. The mean body height of Austrian recruits increased during the study period. However, marked regional differences could be observed. Provinces with low mean body height of the 1961–1963 birth cohorts experienced a particularly pronounced increase in mean body height. This was especially

true of the province Burgenland, where the mean body height increased by 2.2 cm during the observation period. Of particular interest is the body height development in the Austrian capital Vienna, where the highest body heights were documented for the 1961–1963 birth cohorts. In Vienna, there was a reduction in mean body height and only after a phase of stagnation a slight increase. Only a 0.77 cm increase in mean body height could be observed for the Viennese conscripts. A special increase in mean body height was found for those regions where tourism gained importance during the 1960s and 1970s such as Tyrol, Salzburg, or Carinthia. Consequently, besides a kind of urban body height penalty, a positive association between tourism and somatic growth was observed.

**Slawomir Koziel, Aleksandra Gomula, and Zbyszek Czapla** discussed the impact of World War I as a nutritional stress factor that influences growth. Under severe nutritional stress growth in utero and in the first two years could be seriously restricted, resulting in reduced adult height and/or weight. War conditions are regarded as severe detrimental circumstances related to nutrition. The aim of this study was to compare body size of adult Polish population grouped to estimated duration of their respective gestations relative to World War I. Data consisted of 29 011 individuals (14 134 males and 14 877 females) measured in a frame of 1st National Anthropological Survey conducted in 1955–56 years in Poland. Participants were born between 1896–1938 and were at the age between 18–60 years in time of survey. Height, BMI and waist measurements were used in the present study. Body Mass Index (BMI) and waist-to-height ratio (WHtR) were calculated and used in further analysis. From the whole sample three groups were defined and extracted: 1 – born between 1911–12 years and spent first 2 years of life before WWI; 2 – spent gestations and

first two years during WWI, born between 1915–16; 3 – spent gestations and first two years of life after WWI, born between 1919–20. The analysis showed that individuals in the three groups, in both sexes, did not show significant differences in mean height. BMI showed significant differences between groups and sex, with significant second order interaction between them. Means of BMI gradually decreased from group 1 to 3, in both sexes, however the sex differences where the highest in first group and after diminished gradually. Waist-to-height ratio indicated significant decrease from group 1 to 3, but did not show sex differences. It was concluded that process of height growth is resistant to relatively short deterioration of nutrition and psychological conditions; whereas fatness and fat distribution are much more sensitive to short term changes in nutrition conditions. WWI mainly affected nutrition status of people.

**Antonia Rösler** described the influence of psycho-social strain on children of families forced to migrate in Poland after World War II ([Rösler et al. 2023](#)). In view of the fact that migration is omnipresent and comes hand in hand with emotional stress which is known to influence the growth of children, Rösler analyzed whether the type of migration (forced or voluntary) and the geographic direction influenced the growth of Polish children after World War II. A sub dataset of 2208 individuals between the ages of 2–20, obtained from the 2nd Polish Anthropological Survey carried out in 1966–1969 with anthropometrical data and social- and demographic information based on questionnaire was used to analyze migration effects. Contrasting common notion, Rösler failed to detect any association between the direction of migration and the height of the children. The confidence intervals of the means of all classified migration categories overlap significantly and the effect size of the influence of migration

category on height is  $ds=0.140$ , which is too low to see any effects, even if there were one. Neither forced nor voluntary migration in Poland after World War II led to a change in height in children of migrating families.

**Leslie Lieberman and Stephen Lieberman** reported on recent trends in gun violence affecting children and adolescents in the United States, and examined potential human growth influences related to online social group associations and gun violence. Gun violence in the United States causes more deaths per capita than in any other developed nation, and is currently the number one cause of death among US children and adolescents. Within the first 7 months of 2023, there had been more than 389 mass shootings, and more than 23,320 total deaths by firearm, including 10,319 homicides and 13,020 suicides. During this period, firearms killed 154 children aged 0–11 and 834 adolescents aged

12–17. An uptrend in gun violence over the last decade follows the increased availability of firearms, and sustained periods of loosening regulations on their purchase, transfer, and ownership. Between 2018 and 2022, more than 4,420 children and 15,320 adolescents died from gun violence in the US ([Gun Violence Archive 2023](#)). The differential influence of social group associations on gun violence has not been well documented for children and adolescents ([Chapman et al. 2022](#)). However, several studies demonstrate that US teens spend an average of 9 hours per day online, and examinations of activities undertaken in groups via social media sites have elucidated the roles that these associations may have in gun violence, and suicide in particular. Online bullying about body size and shape, gender identity, sexual orientation, race, and ethnicity has been shown to lead to depression, hopelessness and suicidal ideation that precede suicides ([2023](#)).

**Table 2** Characteristics of fast and slow life history strategies. HRV (heart rate variability).

	"Fast" LHS	"Slow" LHS
Cognition/emotions	Low empathy Heightened threat sensitivity	High empathy Low threat sensitivity
Neuropsychology	Low tolerance of frustration Poor executive control	High tolerance of frustration Good executive control
Personality	Neuroticism ↑ Agreeableness ↓ Conscientiousness ↓	Neuroticism ↓ Agreeableness ↑ Conscientiousness ↑
Temperament & character	Novelty seeking ↑ Harm avoidance ↓ Impulsivity ↑ Risk proneness ↑	Novelty seeking ↓ Harm avoidance ↑ Impulsivity ↓ Risk proneness ↓
Interpersonal behaviour	Opportunistic Low parenting effort Unstable intimate relationships	Altruistic High parenting effort Stable intimate relationships
Stress physiology	High cortisol Reduced HRV	Low cortisol High HRV
Other biol. Markers	Early sexual maturation High "allostatic load"	Late sexual maturation Low "allostatic load"

There is emerging evidence that adolescents, and in particular young adult males, influenced by white supremacist groups online have sought social recognition and approval by committing mass murders and other gun violence against racial, ethnic, and religious minority groups ([The impact of gun violence on children and teens 2023](#)). Chronic stress related to gun violence can lead to the suppression of insulin-like growth factor 1 (IGF1,) the hypothalamic-pituitary-gonadal (HPG) and thyroid axes and behaviours (e.g., anorexia) that have adverse effects on human growth. Research shows that anxiety linked to gun violence is widespread among children and adolescents, with one study documenting that 28% exhibit post-traumatic stress disorder (PTSD) following exposure to gun violence ([Holloway et al. 2023](#)). While US attitudes are varied about gun violence, the factors that precede it, and what should be done about it, recent actions by US legislators do not appear to align with the overall sentiment to take definitive action to reduce gun violence. The political atmosphere of state and federal governments does not adequately address the escalating gun violence epidemic or its harmful effects on human growth.

**Martin Brüne** presented aspects of life history theory (LHT) ([Otto et al. 2021](#)) in the clinics and discussed promises and pitfalls. “Borderline Personality Disorder” (BPD) is the most frequent personality disorder in the general population. It is characterized by fear of abandonment, difficulties in emotion regulation, including increased impulsivity, irritability, risk-taking behavior, chronic feelings of emptiness, self-injurious behavior and instability of interpersonal relationships. An LHT perspective suggests that BPD features are compatible with the idea that the syndrome reflects a “fast” life history strategy (LHS) (Table 2), though this has never been tested directly. In his study, 95 women (44

of whom were diagnosed with BPD) were examined using the Arizona Life History Battery (ALHB). In addition, allostatic load, personality traits, childhood trauma, chronic stress, aggressiveness, and borderline symptom severity were assessed. In line with predictions, BPD patients differed in all measures from controls in ways that are compatible with hypotheses from LHT. That is, patients scored significantly lower on the ALHB (suggestive of a faster LHS), they had higher allostatic load scores, and questionnaires also indicated higher aggressiveness, and greater exposure to both childhood adversity as well as chronic stress. Notably, neuroticism was the best predictor of a “fast” LHS in this sample. Brüne concluded that consistent with LHT, the study showed, for the first time, direct evidence of traits associated with the fast end of the LHS spectrum in females with BPD. He discussed findings with regard to clinical implications of this evolutionarily-guided research.

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