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Human growth and development across time and space. Proceedings of the 32nd Aschauer Soirée held in Krobielowice, November 23rd, 2024

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Plasticity, secular trend, social signal, mobility, physical fitness

Abstract

Sixteen scientists met for the annual Auxological conference held at Krobielowice, Poland, to discuss plasticity of child and adolescent growth in historical and contemporary populations. Secular trends in body height and trends in the distribution of body weight and body mass index were discussed both in view of concurrent trends in economic variables, health, nutrition, and education, and, in view of more recent evidence of body height, as a social signal. Post-war periods of political instability associated with visions of future independence and prosperity favor upward body height trends independent of the economic and almost independent of the nutritional situation. Body height relates to social mobility and depends on education. A study on the relationship of social status, somatic characteristics of frequent horse riding, number of weapons, and body height in 6th to 8th century Avars emphasized the relevance of height as a social signal also in a nomadic medieval population. Migrants are particularly prone to plasticity in height, as the associated socio-economic-political and emotional (SEPE) burden of migration significantly interferes with the regulation of growth. Different patterns were observed in indigenous Hadza where body height does not seem to be an important social signal that influences preferences regarding both in-camp and out-of-camp activities. Indigenous populations are vulnerable and prone to notable decline in their health status. Taking a decolonial view on the historical well-being of the Xavante, the overall health status of this Brazilian population has significantly worsened despite changes in the administrative frameworks, including reductions in mortality rates and increased hospital service usage.

In addition to height, the alterations in body weight, the effects of fat mass on physical fitness, lifestyle, sports, and general health in Polish, Czech, and Turkish populations were discussed. Modern body weight distributions are skewed, but the weight of historical urban and contemporary rural populations of developing countries is symmetrically distributed. The skewness of the contemporary weight references leads to underestimating overweight and overestimating the prevalence of wasting. Seasonality was an important factor for growth outcome and health in historical populations. The session was terminated with contributions on body proportion charts, and nutrition in autism spectrum disorders.

Introduction

Sixteen scientists met for the annual Auxological conference (Hermanussen et al. 2023) held at Krobielowice Castle, Poland, to discuss various aspects of human growth and development across time and space. The meeting started with the contribution of **Michael Hermanussen** and **Christiane Scheffler** showing the secular trend in body height of more than 14 million German men born 1865–1975. During this period, absolute height had increased from 165.8 (SD 6.51) cm to 180.1(SD 6.96) cm and apparently followed the incremental trends in gross domestic product (GDP), meat and milk consumption, infant mortality, births per woman, income inequality, household wealth share, relative number of students, and population density. Yet, though absolute height correlated with absolute values of living conditions, the relation between the dynamics of the trends in height and the dynamics in the living conditions was ambiguous. The fastest secular trends in height were observed during periods of political instability. Substantial height increases of more than 2mm/year were observed after 1916 in an era of famine, hyperinflation, economic failure, and political radicalization; and again after 1947 in an era of post-war social rearrangements, foreign occupation, and the formation of two new German countries. The fastest secular trend of 4mm/year was observed among East German conscripts after the German reunification (Hermanussen 1997). Contrary to the common perception that the first 1,000 days are crucial for a child's later development, the war-related famine periods of 1916–1919 had negligible effects on mean adult height (minus 1.5cm), and the post-war famine period of 1945–1947 had neither an effect on adult height nor on lifetime earnings (Hermanussen et al. 2017). The authors concluded that the dynamics of political and social restructuring, the abandonment of established social bonds, competition, and the prospect of individual social and economic success favor upward secular height trends independent of the economic and almost independent of the nutritional situation. Community effects within peer groups provide an explanation for the narrowness of the height standard deviation (SD) over time.

Christiane Scheffler and **Michael Hermanussen** presented a re-analyzed body mass index (BMI) of children aged 3–18 years from 13 child and adolescent populations since the early 20th century (Germany, Hungary, Poland, Kenia, India, South Africa, and Indonesia) and compared them with the WHO reference. Contrary to the general assumption that in all populations, BMI and weight show skewed distributions, evidence suggests that this is only true for modern weight and BMI distributions, e.g., in German children since the 1980s, but not in historical European (Wilke et al. 2022) and in rural populations of developing countries, e.g., in Indonesia (Scheffler et al. 2020). In these populations, body weight and BMI show basically symmetric normal distributions. Mixed patterns of skewness are visible in societies in transition such as South Africa (1980s) and urban Indonesia.

Modern references are inherently affected by the obesity pandemic with major weight and BMI skewness that is not evident in healthy traditional societies. Modern references grossly underestimate the true prevalence of obesity, and overestimate the prevalence of wasting particularly in short people (Mumm and Hermanussen 2022).

Jana Fritsch and **Christiane Scheffler** presented the impact of migration and associated stress on the growth and development of the children of first- and second-generation migrants in Germany. The analysis utilized the KiGGS (Studie für die Gesundheit der Kinder und Jugendlichen in Deutschland, *English*: German Health Interview and Examination Survey for Children and Adolescents) dataset, conducted by the Robert-Koch-Institute, Berlin, between 2003 and 2006. The baseline survey included anthropometric, demographic, and social data from 17,641 individuals aged 0–17 years across 167 cities in Germany. Height data from first- and second-generation Turkish-origin children and adolescents and their German-origin peers were analyzed to assess differences in growth patterns. Differences in height were observed between first- and second-generation adolescents of Turkish origin compared to German-origin peers (Figure 1). First-generation migrant children were slightly shorter, while first generation adolescents were substantially shorter than their German peers. Second generation migrants, however, appeared to catch up, particularly in adolescence. The authors concluded that the process of migration and associated socio-economic-political and emotional (SEPE) factors significantly affect children's height, highlighting the complexity of generational shifts in physical growth.

Piotr Fedurek discussed the extent to which social status or prestige are associated with an individual's integration in social networks and reported on height and integration in proximity networks among Hadza women. Social characteristics of an individual, such as friendship, popularity, and foraging reputation, are commonly related to the extent to which an individual is integrated in proximity networks. This was different in Hadza men. Among them, height, a physical trait commonly associated with social status, was not related to proximity networks (Fedurek et al. 2023). Based on the same dataset, the author showed that although the level of integration in proximity networks was not related to height among the Hadza women (n=35), the number of proximity partners seemed to be inversely related to height, but only while in-camp (Figures 2, 3). Although the inverse relationship between in-camp integration in proximity networks and height shows that taller women are less preferred as in-camp partners compared to smaller women (β=-0.07; p=0.01; Figure 2), the overall results suggest that height is not an important factor influencing social preferences regarding both in-camp and out-of-camp (e.g., foraging) activities.

Joanna Nieczuja-Dwojacka presented historical data on seasonal patterns in 8,147 births (1821–1888), 1,089 marriages (1821–1868), and 4,475 deaths (1821–1880) in Zelów, Poland, and potentially influencing factors. Reliability and validity of the registers were rigorously assessed. Statistical methods included standardized and relative numbers of births, marriages, and deaths. The Chi-squared test ($p<0.05$) was applied to examine the presence of seasonality. Seasonality was observed in all three biodemographic phenomena. In 19th century Zelów, there was significant seasonality of births with $\chi2=63.69$; df=11; $p<0.01$, of marriages with $\chi2=132.02$; df=11; $p<0.01$, and of deaths with $\chi2=141.45$; df=11; $p<0.01$ (Figure 4). Because these are preliminary reports, effect size was not provided. The timing of births and marriages likely re-

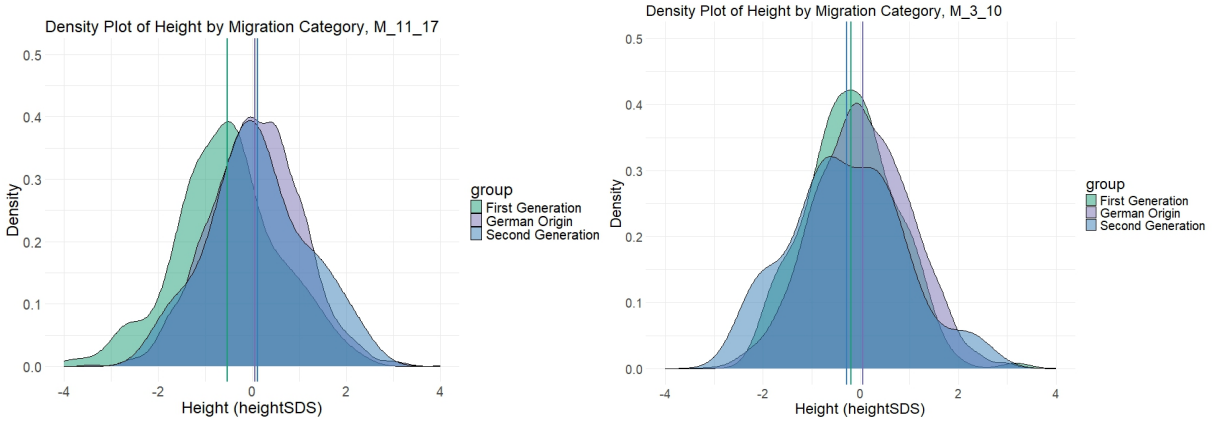

Figure 1 Density plots of height standard deviation scores (heightSDS) of Turkish and German boys grouped by age (3–10 and 11–17). Colors indicate First Generation (green), Second Generation (blue), and German origin (purple). Vertical lines indicate the mean of heightSDS of each subgroup

flected agricultural work schedules. Conversely, seasonal peaks in mortality were associated with periods of extreme temperature deficiencies. During the winter months, increased mortality rates were observed, likely due to higher incidences of illness and hypothermia. Summer months, on the other hand, witnessed elevated death rates potentially associated with foodborne illnesses and cerebrovascular events. Early spring was characterized by a risk of malnutrition-related mortality.

Maria Kaczmarek examined how birth weight and early growth trajectories in the first year of life mediate the effects of birth order on pubertal height growth in children from the Poznań Growth Study, followed longitudinal from birth to adolescence (256 boys, 267 girls). First-born children were smaller at birth than their later-born peers (mean birth weight of first-born boys was 3,407g, compared to 3,526g for those born later, $p<0.01$) and exhibited compensatory growth during infancy, characterized by accelerated weight and height gain. This rapid early growth gave them an advantage in adolescence, when they were generally taller than their later-born peers. First-born boys were taller than their later-born peers at pubertal take-off (143.9±5.6cm vs. 142.1±6.4cm, $p=0.038$), at adolescent peak height velocity (164.7±4.8cm vs. 163.1±5.4cm, $p=0.041$) and at the final age of 18 years (179.3±4.8cm vs. 178.0±5.1cm, $p=0.034$). A similar growth pattern was found in girls. The differences suggest that birth order, although related to size at birth, influences growth patterns in both early childhood and adolescence, with birth weight acting as a critical mediator. Maria Kaczmarek considered that these findings are important for the understanding how early life conditions influence long-term growth outcomes and can contribute to a broader discussion on developmental health.

Sylvia Kirchengast, **Dominik Hagmann**, and **Birgit Bühler** presented data on body height and status among the early medieval Avars. The illiterate Avars were nomadic horsemen who invaded the Carpathian basin from Central Asia in the 6th century and established an empire in what is now Hungary, eastern Austria and Romania, which lasted for 200 years. Little is known about social hierarchies and their material and somatic markers. Therefore, this study analyzed the association between social status, determined by grave goods, somatic characteristics of frequent horse riding as well as the number of weapons and body height based on 144 male-classified skeletons from the Csokorgasse cemetery

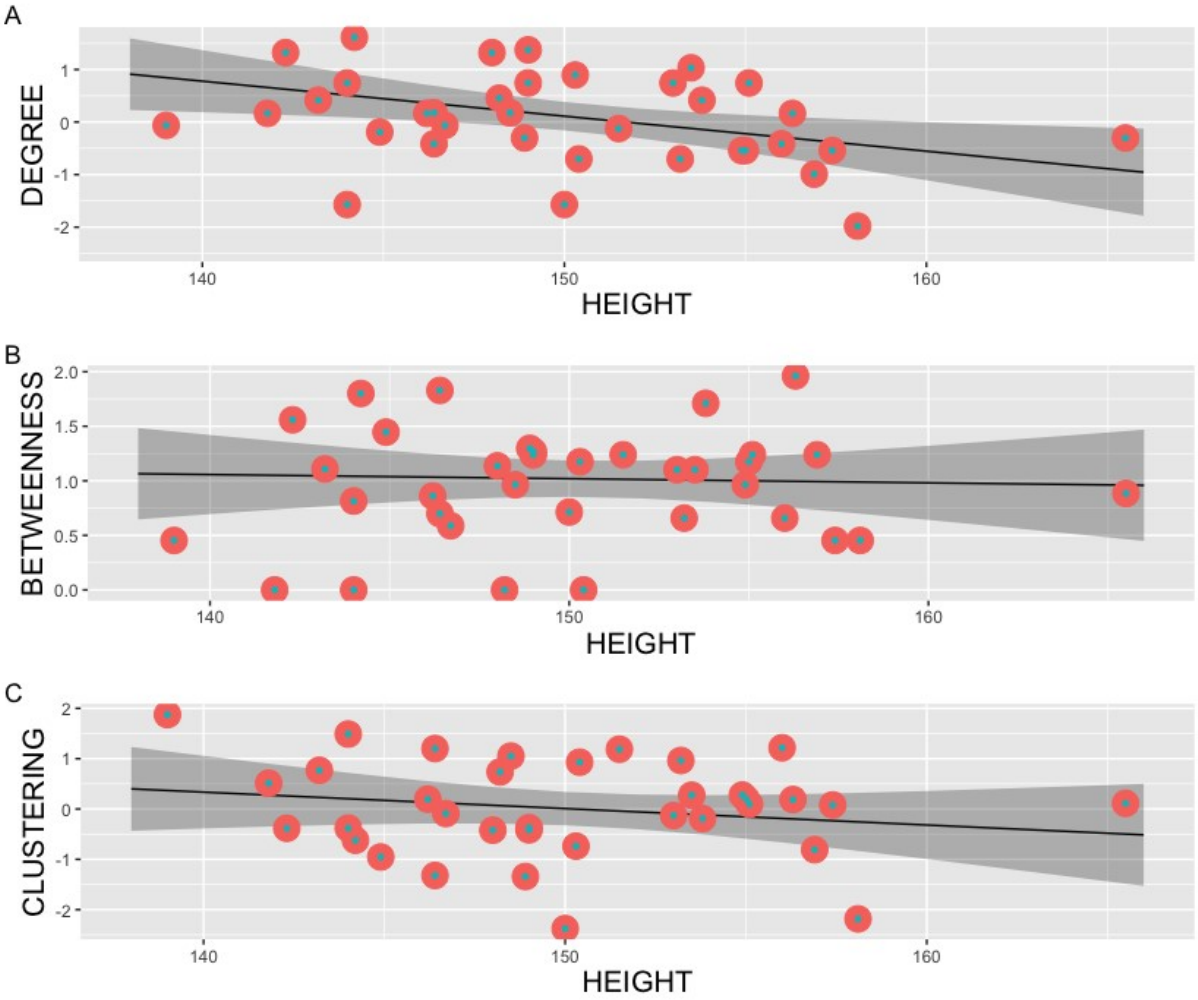

Figure 2 Predicted lm output for relationship between height and three different in-camp network measures: z-scored degree centrality (A), power-transformed betweenness centrality (B), and z-scored clustering coefficient (C) among Hadza men; the shaded areas represent 95% confidence intervals

in Vienna. Men who showed indicators of frequent horse riding had a shorter body height ($\bar{x}$=167.9cm) than men who showed no somatic evidence of frequent horse riding ($\bar{x}$=169.4cm). As the number of weapons increased, body height also increased significantly. In terms of social status, mean height increased with increasing social status. The only exceptions were the very few individuals without grave goods, who were significantly taller (Figure 5).

Katarzyna Górka presented a decolonial view on the historical well-being of the Xavante indigenous community. From a biocultural perspective, health is a complex concept influenced by not just biomedical factors but also social, cultural, political, and economic forces. In indigenous contexts, health is particularly vulnerable, significantly impacted by external socioeconomic and cultural changes often imposed by the broader society. The Xavante indigenous community in Central-Western Brazil is one of the country's most extensively studied indigenous groups regarding health. Despite extensive literature on various aspects of their health, there is a notable lack of comprehensive studies tracing the historical evolution of their health status through bibliographic analysis. This presentation aimed to fill this gap by deeply examining the historical changes in Xavante health, situating this issue within the

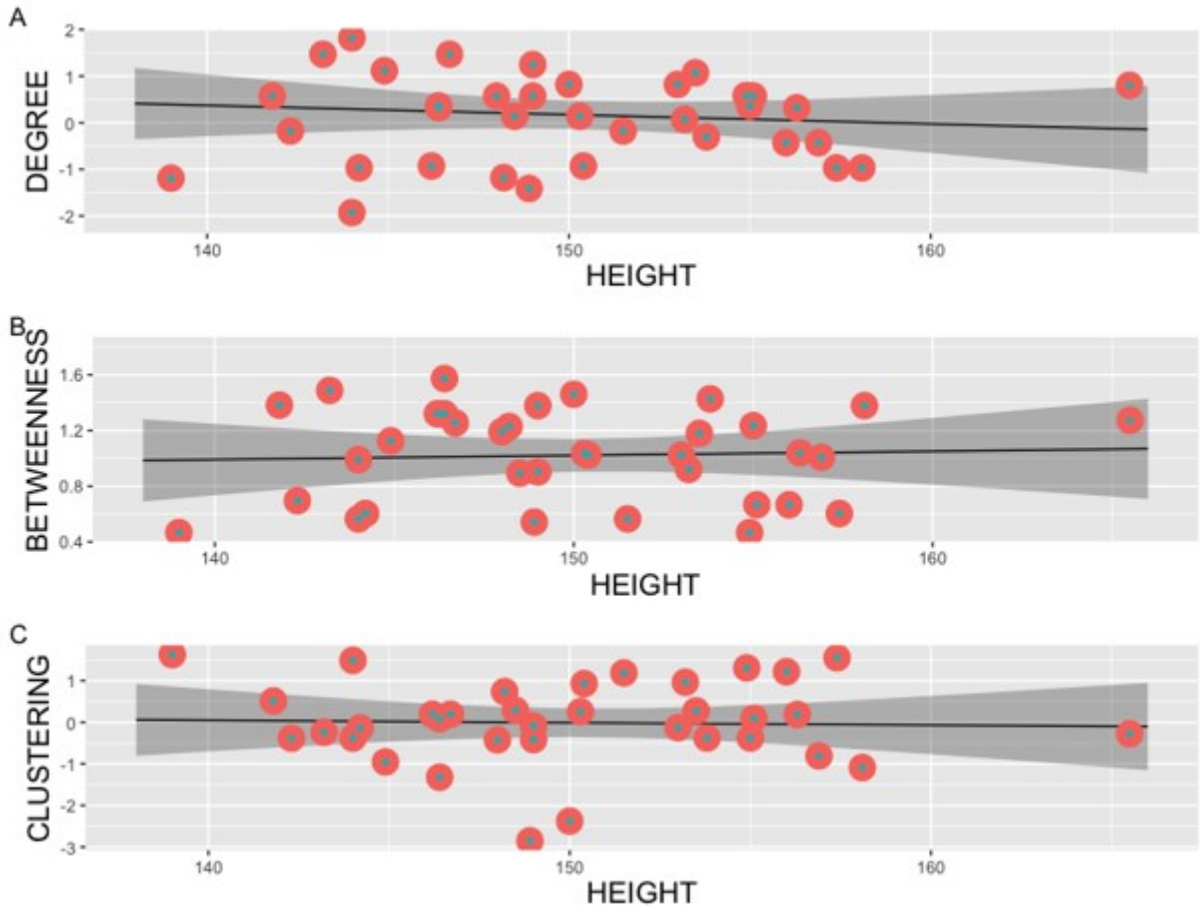

Figure 3 Predicted lm output for relationship between height and three different out-of-camp network measures: z-scored degree centrality (A), power-transformed betweenness centrality (B), and z-scored clustering coefficient (C) among Hadza men; the shaded areas represent 95% confidence intervals

broader discussion of indigenous health as a public health concern, using a decolonial perspective. Katarzyna Górka conducted a systematic bibliographic analysis to trace the historical health trajectory of the Xavante people from Mato Grosso, Brazil, and identified 109 academic publications that met the inclusion criteria. Comparing the earliest and most recent comprehensive studies highlighted a notable decline in the health status of the Xavante people over time. First reports on the Xavante health, from 1964, considered the Xavante a healthy population with a high level of physical fitness and immunological resistance. The last comprehensive studies from 2020 indicated a high level of malnutrition in children combined with an extremely high prevalence of overweight and obesity in adults, a high risk of metabolic complications, and high indices of anemia, high blood pressure, and diabetes. It was concluded that despite continuous changes in the administrative frameworks overseeing indigenous healthcare in Brazil, reductions in mortality rates and increased hospital service usage, the overall health status of the Xavante has significantly worsened. Górka critically examined this trend through a decolonial lens, highlighting the limitations and shortcomings of existing health policies and interventions. She argued that the dominant colonial approach to healthcare, coupled with the denial of culturally appropriate services, represents a clear human rights violation. She additionally emphasized the considerable impact of social determinants —

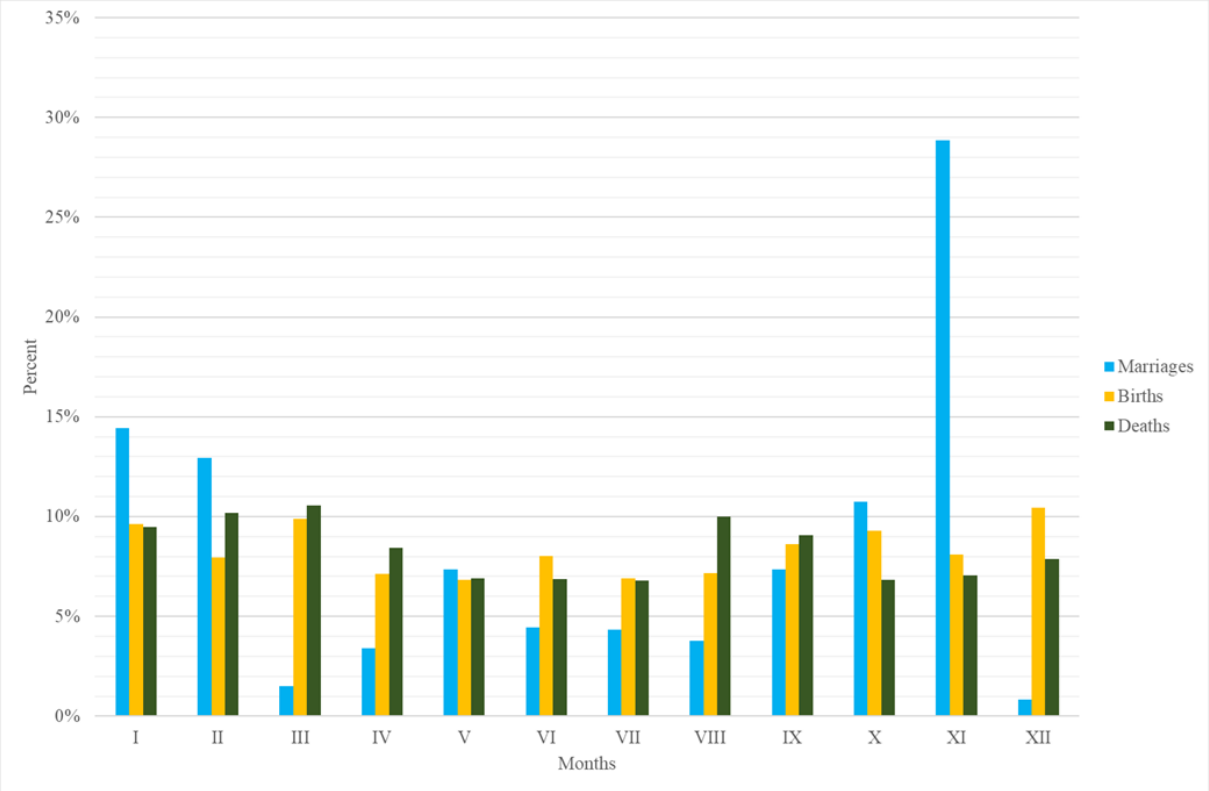

Figure 4 Percentage distribution of marriages, births, and deaths in 19th century Zelów

such as historical trauma, cultural disruption, and systemic inequality — on the health outcomes of this community. This research was supported by the National Centre For Research and Development under the Trans-Atlantic Platform for Social Innovation (Grant number: T-AP SI/CSPXMSM/2/2020).

Sylwia Bartkowiak and **Slawomir Koziel** discussed physical fitness disparities in overweight and obese Polish youth (7–16 years) and the impact of contrasting fat (FM) and fat-free mass (FFM) levels. Classification by BMI seems inadequate and should be supplemented with measurements of FM and FFM which is crucial to understanding physical fitness outcomes. They compared physical fitness parameters in 2384 overweight and obese Polish children aged 7–16 years with contrasting levels of FM and FFM. Anthropometric measurements included height, weight, FM and FFM using bioelectrical impedance analysis. Participants were divided into two groups based on FM and FFM levels above the 85th percentile. Physical fitness tests assessed speed, agility, vertical jump, flexibility, muscle strength, and cardiovascular fitness. Data were analyzed using two-factor ANOVA to assess the effect of sex and body composition on fitness parameters. Children with higher FFM showed better performance in speed, agility, power, and muscle strength compared to those with higher FM. No significant differences were observed in boys' flexibility and cardiovascular fitness between the groups. Boys with higher FFM performed better than girls, especially in terms of grip strength, and this discrepancy was not present in the group with FM dominance. The study highlighted the significant impact of FFM on the physical fitness of overweight and obese adolescents. FFM appears to mitigate the adverse effects of FM on physical fitness. Sylwia Bartkowiak concluded that interventions which promote the growth and increase of FFM, such as resistance

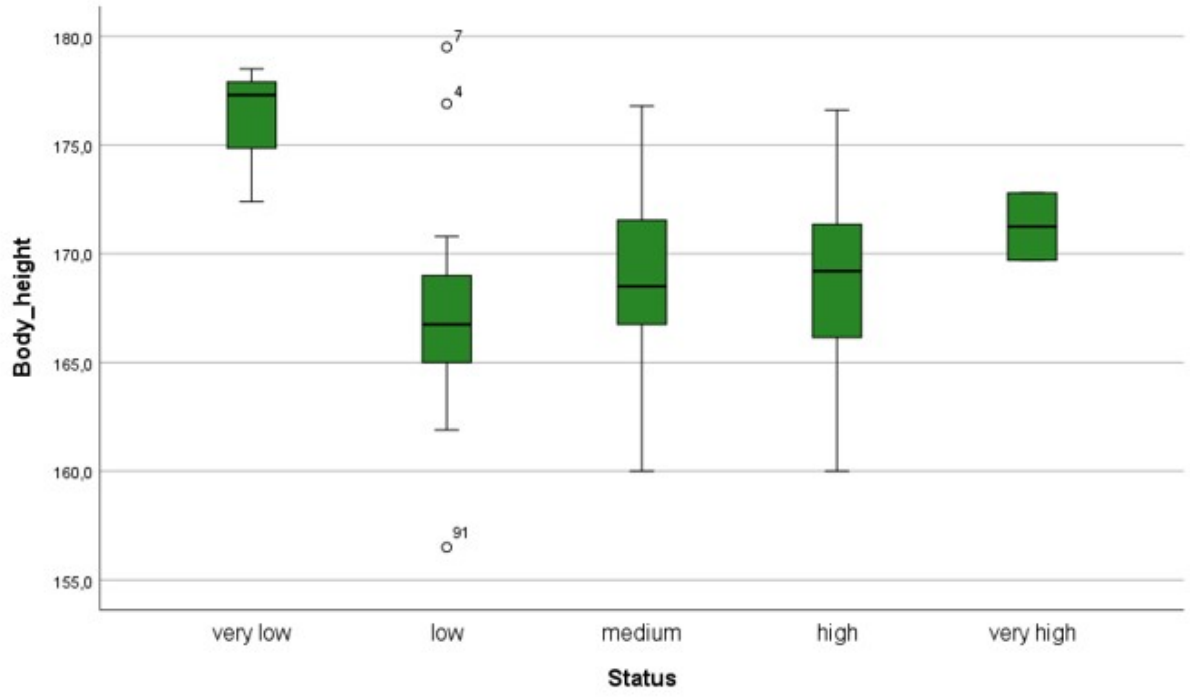

Figure 5 Body height and social status in Avar men of the 6th to 8th century

training and dietary modifications, are essential for improving adolescent fitness and health outcomes.

Başak Koca Özer, **Esin Köksal Babacan**, and **Kübra Baran** assessed nutritional health in a study of protein and fat reserves in Turkish adults compared with other European populations. The nutritional health of populations is a critical determinant of public health, yet disparities across geographic, cultural, and socioeconomic contexts remain inadequately understood. The study assessed the protein and fat reserves of Turkish adults, utilizing anthropometric measurements, and compared these findings with Turkish immigrants residing in Germany and the Netherlands. A cross-sectional survey was conducted on 478 adults (119 males and 159 females from Türkiye, 30 males and 45 females from Germany, and 53 males and 72 females from the Netherlands). Key measurements included BMI, Arm Muscle Area (AMA), and Arm Fat Area (AFA) using standardized protocols. Turkish females residing in the Netherlands exhibited the highest BMI (30.05kg/m^2) and AFA (74.56cm^2), reflecting a higher prevalence of obesity and fat accumulation compared to females in Türkiye (BMI: 25.32kg/m^2, AFA: 57.94cm^2; $p<0.001$). Turkish males demonstrated relatively consistent AMA across regions, but Turkish females in Germany and the Netherlands exhibited significantly higher AMA compared to Turkish females living in Türkiye ($p<0.001$), suggesting enhanced protein reserves among immigrant females. Multivariate Linear Regression analyses identified BMI, fat percentage, and fat-free mass as strong predictors of AMA (all variables in the models were significant $p<0.001$; adjusted R-squared value for males 0.3250 and for females 0.4521) and AFA (all variables in the models were significant $p<0.001$; adjusted R-squared value for males 0.7638 and for females 0.7461) across all groups, with age negatively influencing both parameters. Despite these trends, males showed less pronounced differences across geographic locations.

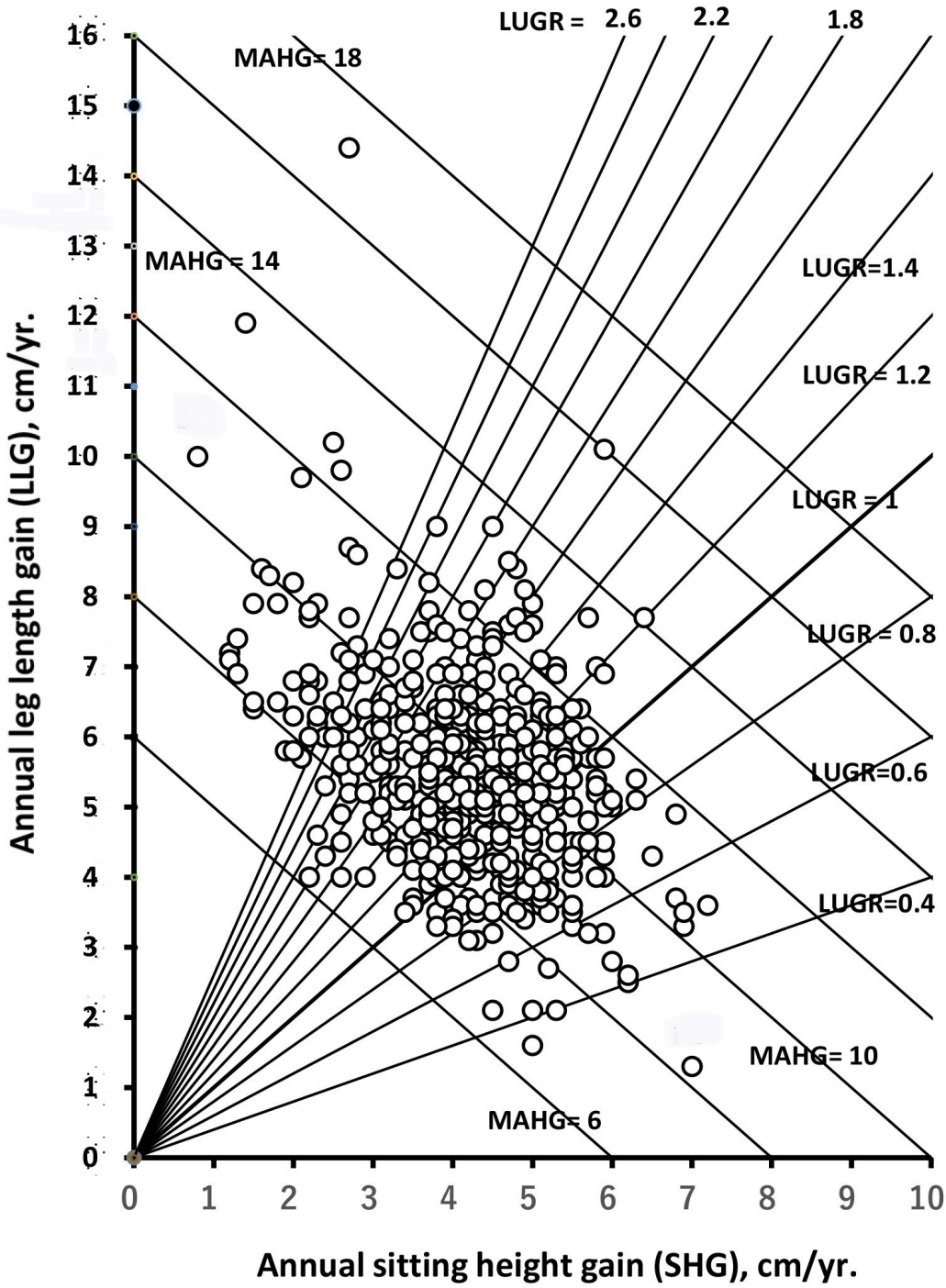

Figure 6 New body proportion chart for boys showing mean annual height gain (MAHG) and lower/upper growth rate (LUGR)

The findings demonstrate the influence of cultural, socioeconomic, and lifestyle factors on nutritional health. The elevated BMI and AFA among Turkish immigrants reflect the impact of dietary transitions and acculturation (Baran et al. 2024). The study underscores the need for culturally tailored public health strategies to address nutritional challenges and combat rising obesity.

Martin Musalek discussed biological maturation and its impact on shaping physical readiness and motor skills in youth ice hockey players. He investigated the impli-

cations of being biologically delayed (BD) or advanced (BA) on athletic performance in U13–U15 players. The sample comprised 54 athletes evaluated longitudinally in three years, measuring anthropometric traits and skeletal age (Tanner et al. 1991). Biologically advanced players consistently outperform their delayed peers in squat jumps and Illinois agility tests (with and without a puck). For instance, biologically accelerated (BA) players were approximately 0.6 seconds faster, translating to significant on-ice performance advantages. However, correcting for maturational differences highlighted a marked reversal. Biologically delayed (BD) players demonstrated enhanced relative gains in motor and coordination skills over time and were relatively faster, about 1.0s, in agility tests in comparison to BA peers. The results suggest that slower biological maturation allows BD players an extended developmental period, fostering superior long-term adaptability. The study underscores the risks of undervaluing late-maturing athletes, emphasizing the critical need to tailor training strategies to individual maturation timelines. Early specialization may disproportionately favor BA players, potentially increasing dropout rates among BD athletes before full maturation. A paradigm shift is advocated to integrate biologically sensitive developmental models, enabling equitable opportunities and optimizing long-term athletic potential across maturational spectra. Martin Musalek concluded that personalized training approaches have important transformative potential in mitigating maturation biases and fostering inclusive athlete development in youth ice hockey.

Takashi Satake, **Roshan Peiris**, **Toshie Hirohara**, and **Komei Hattori** presented a new Body Proportion Chart. They highlighted the importance of longitudinal growth studies, e.g., the presentation of maximum growth increments and ages at maximum growth based on growth curves (Scammon 1927), and the need to focus on each individual (1) to show growth variations in all children and (2) to elicit simple rules that apply to almost all children. Although much research has explored how to better fit growth curves in longitudinal studies, there has been little research into how to better represent individual variation. While research that elicits simple rules is important, it is also important to develop methods that demonstrate individual variation in growth. The authors applied the concept of Body Proportion Charts (Satake and Hattori 2013) and divided maximum annual growth gains in height into annual growth gains in the lower limb length and sitting height. On average, the growth of the lower limb length gain contributes more to the maximum annual growth gain in height than does the gain in sitting height. However, looking at individual variation, the opposite was true for about 20% of the children, both boys and girls. Growth of these 20% of the children can best be shown using the new Body Proportion Chart (Figure 6). Although it is important to clarify the range of variation using numbers (means and standard deviations, etc.), methods that appeal to the eye visually using charts have been used for some time and are worth developing, e.g., somatocharts (Carter and Heath 1990). The authors emphasized that although longitudinal survey data is valuable, it is often dispersed and lost when the person in charge of the research lab changes. This is also an issue to consider: how to pass on the data to the next generation. They finally introduced a new "Dental Proportion Chart" (Satake et al. 2021) that, in a similar way, summarizes buccolingual crown diameter, mesiodistal crown diameter, tooth index and tooth module.

Natalia Nowak-Szczepanska, **Marta Gorska**, **Anna Apanasewicz-Grzegorczyk**, and **Aleksandra Gomula** presented

nutritional status and eating habits in adult women with autism spectrum disorders (ASD). ASD is a complex developmental condition related to a variety of difficulties, including specific eating habits and food selectivity. Adult women with ASD are a particularly challenging group for diagnosis, since they often mask or even hide their symptoms. This study aimed to assess the eating habits and nutritional status of adult women with high-functioning ASD in comparison with a neurotypical control group of women. The research was conducted as an online survey, including questions about demographic information, diagnosis of ASD, a test assessing ASD symptoms (AQ= the Autism Spectrum Quotient for adults with normal IQ), self-reported anthropometric measurements (weight, height, waist, and hip circumferences), and a multiple-choice questionnaire about eating habits as well as a question about existing eating disorders (ED, such as anorexia nervosa or bulimia). The study involved N=57 women with ASD and N=40 women as the control group. In order to assess the nutritional status, BMI and waist-to-hip ratio (WHR) were calculated. The results revealed that women with ASD had much more frequently specific eating habits and preferences than women from the control group (Figure 7). However, there were no significant differences in the nutritional status between both groups, except for marginally lower BMI in women with ASD (BMI=22.27 (±4.85)kg/m2 vs. 24.09 (±5.94)kg/m2, p=0.07). Moreover, there was a significantly higher proportion of ED in women with ASD compared with the control group (36.36% vs 8.33%). The main conclusion is that women with ASD may need particular support in their therapy for specific eating habits and difficulties, since they seem to be a particularly vulnerable group in this context.

Slawomir Koziel discussed upward social mobility and social variation in height using the example of Mongolian students in Ulaanbaatar. Data on growth is probably the most meaningful measure of changes in social inequality in a society, and also differentiates the chance of upward social mobility. In this context, having growth data from Mongolia, it seemed to be interesting to estimate the social variation in height and the occurrence of selective upward social mobility. Height data of 197 male and 527 female students from five different high schools in Ulaanbaatar were standardized on age and used in further calculation. Analysis of variance showed that only the height of male students significantly differed across categories of mother's education. Neither the effect of father's education nor parental education in female students on height were significant. The height of male students gradually increased with shifting up on the scale of mother's education level. Surprisingly, only in female, but not in male students, height significantly differed between the two groups defined according to social mobility. The height of female students who did not experience social mobility was significantly higher than the height of students who experienced upward social mobility. The results are in contradiction with others observed in most European countries. Probably, this effect is related to local circumstances, the amount of social inequality, the role of women in society, and other specific cultural and local social conditions.

In all contributions presented here, written informed consent after information about the procedures used was obtained from all study participants in accordance with institutional human investigation committee guidelines in accordance with the Declaration of Helsinki amended in October 2013.

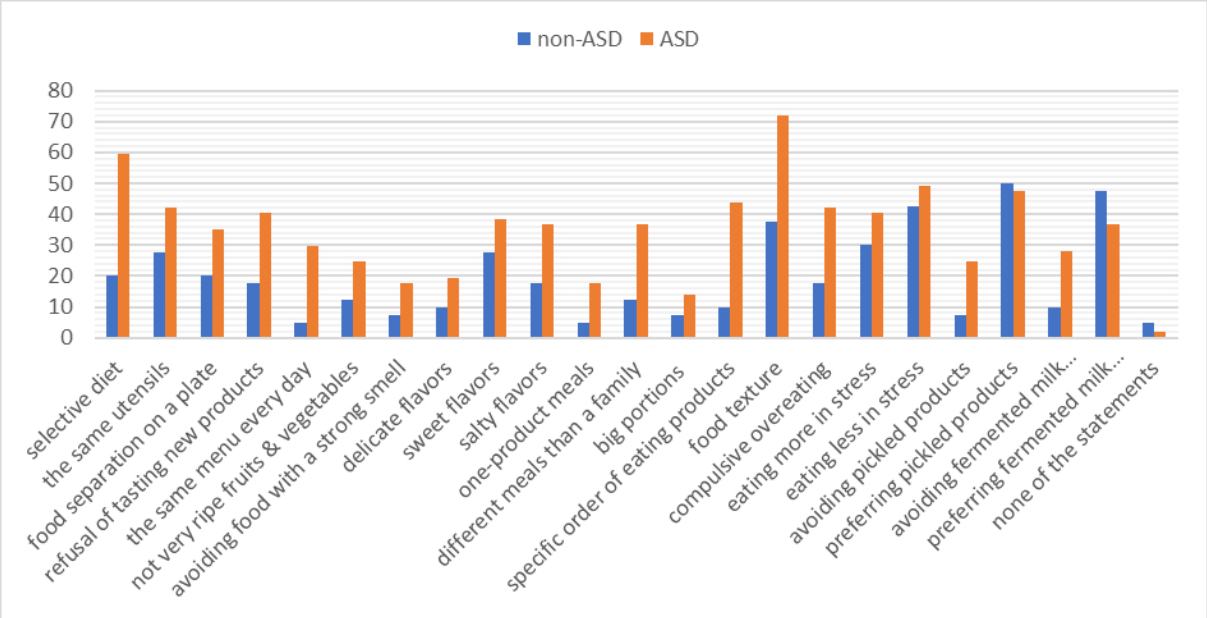

Figure 7 The percentage of responses within each group about eating habits and preferences in women with autism spectrum disorders (ASD) and a control group (non-ASD)

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