PREFACE
by Claude Bouchard

It is an honor for me to be given the opportunity to contribute to this Festschrift recognizing the many accomplishments and the global legacy of Professor Robert M. Malina. Over the last 40 years, I have had the privilege of being able to observe from a front-row seat the numerous contributions made or spearheaded by Professor Malina, and this commentary is inspired by sustained contacts with him over these decades.

Anyone who has reviewed the curriculum vitae of RMM realizes that his research interests extend from human biology in the broad sense to exercise science, with a particular focus on growth and a variety of pediatric issues. His contribution to science spans a period of 50 years. He published his first research paper in 1962 in the *Journal of Bone and Joint Surgery* (Rarick et al., 1962). Since then, he has contributed to the advancement of knowledge in areas as diverse as the morphological growth of children; motor development and motor skills across the growing years; maturation, including age at menarche; skeletal age; growth and sports performance; the risk factor profile for common chronic diseases in children; and the role of social, cultural and economic circumstances as seen in developed and developing countries on growth and maturation.

Robert M Malina has published almost 400 peer-reviewed research papers and about 300 book chapters, technical papers, book reviews and other reports. He has also written several monographs and books. His publications have been cited more than 7,600 times in the world literature.
GROWTH AND MATURATION IN HUMAN BIOLOGY AND SPORTS

FESTSCHRIFT HONORING ROBERT M. MALINA
BY FELLOWS AND COLLEAGUES

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INTRODUCTION

Professor Robert M. Malina has dedicated his career to the study of human growth, development and physical performance. As such, he has always been keenly interested in the growth and development of children and the role that ethnic variation, migration and nutrition play in their ultimate adult stature, weight and associated dimensions and performance (Malina et al. 1970).

Professor Malina’s career as an active physical anthropologist resulted in the incorporation of both field studies and students in his life’s work. Beginning with United States-based population (Johnston et al. 1971), opportunity and professional inquiry led him to study the unique physical characteristics of the Zapotec native to Oaxaca in Mexico in the late 1960s (Malina et al. 1972). From the indigenous Zapotec of Latin America he investigated the mixed race or Mestizo/Ladino populations of Guatemalan Ladino children (Malina et al. 1974).

During the course of his career, professor Malina and his students returned to these field venues on several occasions, extending their original studies to significant longitudinal ones. In the case of the Zapotec, Malina’s study continues to this day. His pattern of continuous study flows throughout his career and has proved significant in providing doctoral opportunities for several generations of students (1970-2010). Additionally, this pattern of collegial mentorship, combined with his research interests, has produced a cadre of graduates who continue to collaborate with Malina well into their careers. This pattern has suited all.

In the early 1970s, Professor Malina had recently arrived at University of Texas at Austin, having completed doctoral degrees in Kinesiology and Anthropology. As such, he enjoyed departmental appointments in both of the departments representing his disciplines.

MEXICAN AMERICANS

The University of Texas, while serving as the flagship university of a State with a significant Mexican American population, in fact, admitted very few African and Mexican Americans
as undergraduates. Mexican American graduate students at University of Texas were even scarcer.

In 1971, Anthony N. Zavaleta, a Brownsville, Texas native took a course in human growth and development with Dr. Malina and that experience led him to a lifetime of collaboration and friendship. Malina’s anthropology course changed Zavaleta’s perspective on career and allowed him to fulfill a lifelong dream of studying the anthropology of the U.S.-Mexico border. Zavaleta completed the undergraduate degree in anthropology with honors and subsequently applied to the graduate program.

Zavaleta was admitted, conditionally, to the masters degree program, told by the graduate advisor that UT, “did not have a place for him and could not take a chance on him.” Meaning, the message sent was that they could not take a chance on a Mexican American from the Lower Rio Grande Valley of Texas lowering their national standing. At that time, the UT anthropology doctoral program was ranked in the top ten in the country and readily admitted only top candidates nationally. “Admitting a Mexican American from the Rio Grande Valley of Texas was too much of a risk for the program to take,” he was told by the graduate advisor.

Confident, and at the same time bolstered by the confidence and support of professor Malina, Zavaleta began his course work in physical anthropology, human growth and development, skeletal biology and human adaptation. Additionally in his studies he included a cultural focus on Latin America, Mexican Americans and the U.S.-Mexico border.

The combination of the courses, biological and cultural, led to his lifelong interests in the cultural aspects of health status and health care, which would some years later evolve into the sub-discipline today known as medical anthropology.

Zavaleta once encountered renowned medical anthropologist Arthur J. Rubel at a conference. Rubel and colleague, Madsen were among the first anthropologists to study Mexican American health status in the Lower Rio Grande Valley of Texas (Rubel 1966) (Madsen 1973). Armed with a Hogg Foundation for Mental Health grant in the early 1960s, the two pioneered a connection between physical and cultural anthropology; known today as alternative and complementary medicine. Professor Malina was always supportive of Zavaleta’s interest in cultural and medical anthropology which they discussed often.

Through the work of Rubel and Madsen in south Texas, several next generation, native anthropologists were trained, including Joseph Spielberg-Benítez who retired from Michigan State University.
Dr. Rubel pioneered the early development of the medical anthropology field, and when asked “how does one become a medical anthropologist?” Dr. Rubel replied to Zavaleta, “call yourself one.”

In the middle 1970s, professor Malina was able to expand his work on the diversity of Latin American populations to Mexican Americans on the border. Serving as a mentor for Zavaleta, the initial interest and studies in the growth and development and health status of Mexican American children began with a master's thesis. (Zavaleta 1973).

By developing the confidence of school administrators at the Brownsville Independent School District in 1972, Zavaleta and Malina were able to conduct the first anthropometric study of Mexican American youth in a border town.

Completing his master’s degree, and by proving himself to the anthropology faculty, Zavaleta was admitted to the doctoral program (Malina and Zavaleta 1976).

The close association of Malina and Zavaleta and their shared interest in the growth and development of Mexican American children, led to the study of their body composition and the completion of a doctoral dissertation (Zavaleta 1976).

The laboratory work on body composition was performed using the recently-completed underwater-weighing tank; constructed with the direction of Dr. Hugh Bonner. With the support and direction of professor Malina, the kinesiology department at UT was expanding into modern exercise physiology and Zavaleta’s dissertation was the first to be completed using the now old method of complete body submersion for the determination of body composition.

This study performed by Zavaleta under the direction of Malina would further their interest in the nutritional and health status of Mexican Americans and its influence on growth and development in general (Malina 1987 a; Malina 1987 b; Malina 1987 c).

Malina mentored and guided a wide array of studies examining many topics and including many different graduate students from the initial Zavaleta study onward for more than 25 years. These studies examined both Mexican-American and Mexican children, including Mexican immigrants living in the United States (Hughes 1982).

Various studies on and about Mexican Americans began appearing in the literature in the 1920s, and Malina examined the historical literature with the publication of growth status of Mexican American children and youths: Historical and contemporary issues. While the initial anthropometric studies were conducted in the early part of the 20th century, it was not until the work of Malina and Zavaleta that true growth studies were conducted on Mexican American children and connecting their status to health and
nutritional status (Malina et al. 1986). Studies containing anthropometric data on Mexicans and Mexican Americans were sustained from 1920 through the 1990s. Through the work of Malina and Zavaleta they ultimately led to dramatic improvements in child-health status along the lower Texas-Mexico border (Malina and Zavaleta 1980) (Zavaleta and Malina 1980).

An historical overview of Mexican and Mexican American growth studies was published in homage to Mexican physical anthropologist Santiago Genovés for his 33 years of service to Mexican anthropology (Tapia 1990). In their contribution, Kobyliansky and Goldstein summarized the study of two generations of Mexican and Mexican American youth including the work of Malina and Zavaleta and compared the growth of children of Mexican parents in Mexico and in the United States as well as changes in physical traits with age of adults, the parents of the children (Kobyliansky and Goldstein 1990). In the same volume, Malina and Little examined body composition of young boys from rural Zapotec-speaking villages in Oaxaca, Mexico (Malina and Little 1990).

Credit must be given to the pioneers in physical anthropology who showed legitimate interest in Mexican American children beginning with Paschal and Sullivan in 1925 who studied the relationship between intelligence and growth; H. T. Manuel in 1934 who was principally interested in the education of Mexican Americans; Whitacre in 1939 took a more traditional approach while in 1943 Goldstein examined Mexican immigrant children and in 1952 Meridith and Goldstein examined growth and socioeconomic status of Mexican American Children (Malina and Zavaleta 1980).

In the period from the earliest Malina-Zavaleta studies, to the latest in the 1990s, and others have outlined the importance of establishing Mexican American baselines for determining health status (Mendoza 1991) (Zavaleta 2000). The Hispanic Health and Nutrition Survey in the 1980s played a role but little work has been completed to link Mexican American health to growth status (Troiano et al. 1995).

Meanwhile, Malina expanded his interests to include topics such as secular trends, age at menarche, growth spurts, nutritional status, human performance, immigrant status and intergenerational advances etc. Throughout the 1990s, Malina continued his work on Latin American populations expanding to Brazilians while further exploring opportunities with diverse European populations especially eastern European (Malina 1990). Malina continues his study of many and diverse aspects of the growth and development of Zapotec children. In the last 20 years, Malina’s work as an active researcher, author and speaker is marked by its increasing universality in worldwide studies of human populations.

WHAT HAPPENED NEXT?

Zavaleta completed his doctoral degree at Texas in 1976 and returned to the Lower Rio Grande Valley. Zavaleta counts his years with Malina as the most significant in his life as they cemented the foundation for his professional career (Zavaleta 1989). While Malina
and Zavaleta were not able to continue their studies of the growth and development of Mexican American children, Zavaleta utilized what he had learned from Malina and for the following quarter of a century made a positive impact upon the Mexican Americans of south Texas. Often, this took place in consultation with professor Malina (Zavaleta 2002).

Soon after returning to south Texas, and based upon the work of Malina and Zavaleta, a Health Needs Assessment Survey of Brownsville, Texas was performed (Zavaleta 1985). This study was the first-ever in south Texas and served as the basis for tens of millions of dollars in state and federal funds applied directly to improve the health status of the local population.

Another Malina student, William H. Muller at the University of Texas Health Science Center at Houston asked Zavaleta to join its South Texas Diabetes Research Project, which led to our early understanding of obesity and diabetes in Mexican American children (Muller et al. 1984) (Muller et al. 1984).

In his work with Malina, it became obvious that maternal and neonatal mortality rates in Cameron County, Texas were the highest in Texas. Further examination of this problem led to the creation of a Texas law regulating the practice of lay midwifery and ultimately saving hundreds of lives. This fact led to Zavaleta joining the board of directors of Su Clinica Familiar, a federally funded community and migrant-farmworker clinic in south Texas. Zavaleta served 20 years on the board and developed the clinic into a highly regarded system for the delivery of primary care as well as a birthing center for the indigent of south Texas.

Working with the University of Texas Medical Branch’s Department of Pediatrics, a major multiple-year grant was awarded by the State of Texas for the development of a community oriented primary care facilities around the state. These projects were intended to deliver primary health care to poor Mexican Americans and other poor living in the colonias in and around Brownsville, Texas. The project treated many thousands and lasted 18 years until legislation changed directions (Zavaleta, et al. 1992).

In the 1990s Zavaleta began work with health-education professor Nell Gottlieb whom he had met through Malina, and the pair received a grant from the Texas Higher Education Coordinating Board to develop health-education material for the prevention of breast and cervical cancer among maquiladora (cross border factory) workers in Matamoros, Mexico (Gottlieb et al. 1996). Two Latina doctoral students were supported and trained through this project.

By the late 1990s, the COPRIMA project at UTMB had collected sufficient data under the supervision of professor Malina to conduct several studies which examined the relationship of Zinc to Mexican American growth status (Egger et al. 1999; Penland et al. 1999; Sandstead et al. 2000; Sandstead et al. 2008).
SUMMARY

It is clear that any examination of Robert Malina finds a career full of diversity of investigation as well as support of students. This overview must also focus on the tangible projects that developed along our southern border during the last 35 years and to place those projects as points of light in Malina’s list of accomplishments. It is with great respect and honor that I am able to point out these unparalleled accomplishments for the record of this great man’s life. Professor Malina had total faith in what a Mexican American student from Brownsville, Texas could and would accomplish. Zavaleta’s career varied somewhat from his colleagues (Zavaleta and Salinas 2009). However, through the work and vision of Malina, the lives of Mexican American children have and continue to be changed through the delivery of health care. Malina and Zavaleta set out to examine the health status of Mexican American youth through their growth status and those studies eventually led to the creation of tangible projects which operate today.

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INTRODUCTION:
Lead and Child Growth, Development, and Maturation

Environmental pollutants and toxicants associated with industry and power generation and have potentially negative consequences for the growth, maturation and development of youth. Lead is one of a variety of toxicants with such potential effects. Lead and lead compounds are common in the earth’s crust, ~70 ppm (Baselt, 2002) and are associated with power generation and several industrial processes. Lead and lead-compounds are well-known to be toxic to developing humans, causing growth retardation, delayed sexual maturation and neurobehavioral developmental deficits.

Lead and Growth. Elevated levels of blood lead adversely affect prenatal growth (Andrews et al., 1994; Dietrich et al., 1987), but this has not been noted in all studies (McMichael et al., 1986; Factor-Litvak et al., 1991). A frequent finding among children is reduced length/stature in association with increased blood lead levels. Age at exposure, duration, and nutritional status are related to the degree of growth stunting, with younger, chronically exposed, undernourished children at greatest risk (Ballew et al., 1999). The estimated stunting effect of blood lead level on linear growth appears to follow a dose-related pattern of reduction in height by ~1-3 cm for each 10.0 $\mu$g/dL increase in blood lead level (Table 1).

Lead and Maturation. Information on the influence of elevated blood lead levels on indicators of biological maturation commonly used in growth studies is limited largely to age at menarche and to a lesser extent stages of puberty (breast and pubic hair development in girls, genital and pubic hair development in boys).
Table 1. Estimated decrements in height per 10 µg/dL blood lead levels in children 3 months (mos) to 14 years (yrs).

<table>
<thead>
<tr>
<th>Study</th>
<th>Age range</th>
<th>Stature decrement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cincinnati Lead Study (Shukla et al., 1989)</td>
<td>3 - 5 mos</td>
<td>2.0 cm</td>
</tr>
<tr>
<td>Cincinnati Lead Study (Shukla et al., 1991)</td>
<td>33 mos</td>
<td>1.5 cm</td>
</tr>
<tr>
<td>Dallas Lead Project I (Little et al., 1990)</td>
<td>1 - 10 yrs</td>
<td>1.6 cm</td>
</tr>
<tr>
<td>Dallas Lead Project II (Little et al., 2009)</td>
<td>2 - 12 yrs</td>
<td>2.1 cm</td>
</tr>
<tr>
<td>Three Greek Cities (Kafourou et al., 1997)</td>
<td>6 - 9 yrs</td>
<td>0.9 cm</td>
</tr>
<tr>
<td>NHANES II (Schwartz et al., 1986)</td>
<td>1 - 7 yrs</td>
<td>1.2 cm</td>
</tr>
<tr>
<td>NHANES III (Ballew et al., 1999)</td>
<td>1 - 7 yrs</td>
<td>1.6 cm</td>
</tr>
<tr>
<td>Lower Silesia, Poland (Ignasiak et al., 2006)</td>
<td>7 - 14 yrs</td>
<td>3.1 cm</td>
</tr>
<tr>
<td><strong>Unweighted Mean</strong></td>
<td>3 mos - 14 yrs</td>
<td>2.5 cm</td>
</tr>
</tbody>
</table>

Blood lead levels > 3 µg/dL were associated with later estimated attainment of stages of breast and pubic hair maturation in American girls from the Third National Health and Nutrition Examination Survey, 1988-1994 (NHANES III). Later attainment of stages of puberty was most apparent in American Black girls and to a lesser extent in Mexican American girls with ≤ 3.0 µg/dL of blood lead compared to those with >3.0 µg/dL. Later pubertal maturation was noted in American White girls with 3.0 µg/dL of blood lead, but the effect was not significant (Selevan et al., 2003). Corresponding data for lead levels and sexual maturation of boys are limited to a prospective study of testicular volume and stages of pubic hair and genital maturation in Russian boys. Later onset of puberty was associated with blood lead levels ≥5.0 µg/dL compared to boys with <5.0 µg/dL (Hauser et al., 2008; Williams et al., 2011).

Data for age at menarche and blood lead level are limited to three investigations. Two analyses were of the same national data set for American girls from NHANES III (Selevan et al., 2003; Wu et al., 2003), and one of American Indian girls (Denham et al., 2005). The two analyses of NHANES III data showed delayed menarche with elevated blood lead levels in American girls. In one analysis, menarche was delayed by approximately 3.6 months for each 1.0 µg/dL increase in blood lead > 3.0 µg/dL (Wu et al., 2003). In the other analysis, menarcheal age was also delayed by 3.6 months with blood lead concentrations > 3.0 µg/dL in African American girls. However, blood lead and later menarche was not statistically significant in American White and Mexican American girls with lead concentrations > 3.0 µg/dL (Selevan et al., 2003). Menarche was delayed at blood lead levels >0.5 µg/dL (geometric mean) among American Indian (Akwesasne Mohawk) girls (Denham et al., 2005). This study was unique because the analysis controlled for other pollutants (p,p’-DDE, HCB, mirex and mercury) in addition to lead. In contrast to lead, four potentially estrogenic PCB congeners were associated with a higher probability of having attained menarche in this sample of American Indian
girls (Denham et al., 2005), indicating earlier attainment of menarche with higher PCB levels. Importantly, the association of blood lead level with age at menarche is likely confounded by other toxicants in the blood.

**Lead and Motor Proficiency.** Elevated blood lead levels are associated with impaired performances on tests of fine motor coordination and visual integration in children. Specifically, movement tasks that involve movement precision and coordination are adversely affected by elevated blood lead levels. Among 6 year old children, for example, elevated blood lead levels had a negative effect visual-motor control, bilateral coordination, upper limb speed of movement, dexterity and fine motor coordination (Dietrich et al., 1993), and on finger tapping speed (Winneke et al., 1994). Visual-motor integration, eye-hand coordination and spatial relations performance was poorer among 8-10 year old children with increased blood lead levels (Azcuno-Cruz et al., 2000). Of interest, high lead levels in dentin of deciduous teeth (i.e., in early childhood) were also associated with long term deficits in finger tapping rate (slower), eye-hand coordination (poorer) and reaction time (slower) at 18 years of age (Needleman et al., 1990). Neurobehavioral deficits associated with elevated blood lead levels persist across age and are apparently irreversible.

With few exceptions, tasks requiring muscular strength and endurance, speed, power, balance and coordination in gross movement tasks have not been systematically evaluated in children and adolescents with elevated blood lead levels. Gross balance at 6 years of age (Dietrich et al., 1993) and performance on rail balance tests at 8-10 years of age (Azcuna-Cruz et al., 1970) were not influenced by blood lead levels. Elevated blood lead levels were negatively associated with teacher ratings of agility defined as “…the ability to execute motor activities such as running and jumping with precision and rapidity,” in 7-9 year old children (Muñoz et al., 1993). Increased postural sway in children was associated with elevated blood lead levels (Battacharya et al., 1990, 1993), but the association between postural sway and balance was not analyzed. If postural sway is analyzed with respect to dynamic and static balance, these results may suggest a potential influence of early lead exposure on the vestibular system and/or proprioception. Elevated blood lead was also associated with hearing deficits in children (Osman et al., 1999). Apparently lead affects middle ear function (i.e., otolithic and vestibular complexes).

**THE COPPER BASIN — RECENT WORK ON LEAD EFFECTS ON CHILDREN BY MALINA AND COLLEAGUES**

The copper mine region in Lower Silesia, southwestern Poland, has major smelting and refinery facilities near Legnica and Głogów, the Copper Basin (Figure 1). Mines and smelting plants associated with the copper industry generate large amounts of industrial by-products and waste including heavy metals, including lead. Copper mining and smelting has been a primary industrial activity for about two generations or more in Lower Silesia.
Recent intensive environmental interventions by the Polish government have reduced emissions of harmful substances in areas with potential health hazards (Ignasiak et al., 2011). Interventions were targeted to maximize health-related benefits return on investment for the population resident in or close to the industrial zones (Bachowski et al., 2004). Observations from studies of the influence of elevated blood lead levels associated with industrial pollution in the Copper Basin on the growth, maturation and physical fitness of school children in the region have been conducted by Malina and colleagues (Ignasiak, Sławińska, Little).

The growth status, physical fitness and blood lead levels of school children, 7-15 years of age were surveyed in 1995 and 2007. Menarcheal status of girls was obtained by interview in both years. The children resided in seven communities (officially labeled villages) in the vicinity of major copper smelting and refinery facilities in the Legnica and Głogów districts. With two exceptions, schools in the same communities were surveyed in both years. Population sizes of the communities ranged from 337 to 1424 in 1995 and 266 to 1400 in 2007. All children were born and raised in the area. They were from families of mine and factory workers in the copper industry and farmers in the communities. The latter were largely part-time farmers with <10 hectares of land; most worked in the copper industry and only tended the farms after work and on weekends.
Relationships between blood lead levels and growth status are limited to the 1995 data (Ignasiak et al., 2006, 2007). Analyses of the 2007 data for growth status and physical fitness in the context of short-term secular change are currently under way. Changes in blood lead levels and ages at menarche between 1995 and 2007 have been analyzed (Ignasiak et al., 2011; Sławińska et al., 2012).

**Growth Status**

Reduced height was associated with elevated blood lead levels in school children of the Copper Basin observed in 1995 (Ignaziak et al., 2006). The negative effects of elevated blood lead were more apparent in growth of the extremities (arms, estimated leg length) than in growth of the trunk. Greater reductions in linear growth were observed at higher blood lead levels. The observations were consistent with experimental data suggesting a major influence of lead on linear bone growth, specifically proliferation of chondrocytes, hypertrophy and matrix calcification at the growth plates of long bones (Hicks et al., 1996). Other potential targets for lead are reduced osteoblast activity and bone remodeling (Puzas et al., 1992). It was deduced from these analyses that the effect of lead was on long bone growth than upon round bones (Ignasiak et al., 2006).

**Physical Fitness**

Relationships between blood lead levels and measures of physical fitness in the school were evaluated in the context of two research questions (Ignasiak et al., 2007). Are indicators of physical fitness directly related to blood lead levels? Alternatively, is physical fitness indirectly affected through reduced body size given the influence of elevated lead on linear growth? Smaller body size is generally associated with poorer performances on a variety of physical fitness tests in youth (Malina et al., 2004).

School children of both sexes from the Copper Basin in 1995 were, on average, shorter than Polish youth in a 1999 national physical fitness survey (Przewęda et al., 2005). Children from the Copper Basin also tended to weigh slightly less than the national sample between 7 and 11 years, while differences were negligible at older ages.

Several indicators of physical fitness were measured using the EUROFIT battery (Council of Europe, 1988): right and left grip (static strength), sit-ups in 30 seconds (abdominal muscular strength and endurance), flexed arm hang (upper body functional strength), plate tapping (speed of upper limb movement), shuttle run (running speed and agility), standing long jump (explosive power of the lower extremities) and medicine ball throw (explosive power of the upper extremities). Simple reaction time was measured in a subsample.

Standing long jump performances of boys and girls from the Copper Basin were, on average, slightly lower than those of the national sample from 7-13 years, while differences at 14-15 years were negligible. A similar age-related pattern was
apparent for speed of upper limb movement (plate tapping). Performances in an agility shuttle run did not differ, on average, between children of both sexes in the Copper Basin and the national sample. In contrast, the number of sit-ups completed in 30 seconds was consistently lower in Copper Basin children of both sexes across the age range 7-15 years. Grip strength was, on average, greater in boys and girls from the Copper Basin than in the national sample. However, this comparison must be tempered because it was not clear what type of dynamometer was used in the national survey.

Results of regression and path analyses indicated that blood lead level did not directly affect the physical fitness of the school youth from the Copper Basin (Ignasiak et al., 2007). The effects of blood lead on indicators of physical fitness were indirect through a negative influence of high blood lead on growth in body size. Blood lead level was also not related with reaction time in the subsample of children. However, diet and family circumstances (except for maternal education) and level of habitual physical activity were not considered. Nutritional status and familial factors can independently influence both growth and physical fitness, while physical activity is an important correlate of fitness (Malina et al., 2004).

Age at Menarche

Age at menarche and blood lead levels were considered in the two surveys of school girls separated by 12 years, 1995 and 2007 (Slawinska et al., 2012). Blood lead level and age at menarche (estimated with probit analysis) declined, on average, over this interval (Table 2). Logistic regression analyses were done for each year with menstrual status (0 = no, 1 = yes) as the dependent variable and with age, height (linear growth), BMI (weight-for-height), and lead group (binary variable, 0 = Pb ≤ 5.00 and 1 = Pb ≥ 5.10 µg/dL) as the independent variables. The odds ratio for 1995 was not significant (p<0.48) indicating that lead group did not affect the odds of a girl attaining menarche. However, the odds ratio for 2007 approached significance (p=0.057). This indicates that increased blood lead was associated with later menarche (decreased odds of attaining menarche) in 2007.

Table 2. Blood lead levels and ages at menarche in school girls resident in the Copper Basin of Lower Silesia, Poland in 1995 and 2007.¹

<table>
<thead>
<tr>
<th>Year</th>
<th>N</th>
<th>Blood Lead Level, µg/dL</th>
<th>Age at menarche</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SE</td>
</tr>
<tr>
<td>1995</td>
<td>436</td>
<td>6.57</td>
<td>0.13</td>
</tr>
<tr>
<td>2007</td>
<td>346</td>
<td>4.24</td>
<td>0.14</td>
</tr>
</tbody>
</table>

¹Adapted from Ślawińska et al. (2012)
The major difference in the specific logistic regression analyses of the two time periods (1995 vs. 2005) was in the contributions of the covariate BMI and the main effect (blood lead group) to the probability of attaining menarche. The BMI was less important to attaining menarche in 2007 (OR = 1.18, 95% CI: 1.03-1.35) than in 1995 (OR = 1.51, 95% CI: 1.26-1.82). The opposite was true for lead, which had a smaller effect in 1995 (OR = 0.70, 95% CI: 0.27-1.85) than in 2007 (OR = 0.31, 95% CI: 0.09-1.06). It may be possible that the influence of blood lead on menarche in 1995 was through its effect on weight-for-height (BMI). The decline in age at menarche between 1995 and 2007 may thus reflect attenuation of multiple environmental stressors (chronic malnutrition, iron and calcium intake deficiencies) in addition to blood lead level. It may be possible that somewhat marginal nutritional and health conditions associated with unstable political, social and economic circumstances in Poland from the late 1970s through the 1980s (girls in the 1995 sample were born during this period) confounding the influence of lead on the process of sexual maturation in the 1995 sample such that a significant effect of lead on age at menarche was masked or diminished to statistically non-significant.

Observations for girls in the Copper Basin in 1995 beg the following question. Given the elevated blood lead levels in the sample, why was an association between lead levels and age at menarche not observed in 1995? The broad range of blood lead values (2.0-33.9 µg/dL) contributed to unusually wide 95% confidence intervals and in turn a non-significant association. A much larger sample size was likely needed to sufficiently power the 1995 analyses to detect the influence of lead level on menarcheal status to reach statistical significance.

However, comparisons of estimated ages at menarche in subsamples of girls with high (≥5.1 µg/dL) and low (≤5.0 µg/dL) blood lead levels in each year provide some insights. The difference between estimated median ages at menarche (probit analysis) for girls with high and low blood lead levels in 1995 was 0.35 years, while that between estimated medians ages in 2007 was 0.69 years, an effective doubling of the difference in the latter time period. The difference between estimates of menarcheal age in 1995 was slightly greater than that noted in rural girls with inadequate vs. adequate nutrition in the 1970s, 0.2 years (Charzewska et al., 1976). The secular decline between 1995 and 2007 was due in large part to a reduction in age at menarche in girls with low blood lead group in 2007 compared to girls with low blood lead in 1995 (0.49 years), while the difference in ages at menarche in girls with high lead in both years was small (0.15 years). This implies that other environmental conditions (i.e., nutritional) among girls with low blood lead levels (≤5µg/dL), improved more than among girls in the high blood lead level group. As suggested earlier, the effect of blood lead level seems confounded by socioeconomic variation, which apparently exerts a strong effect on age at menarche in the sample of Polish school girls who grew up before and after the fall of communism, 1995 and 2007 cohorts, respectively.
Figure 1. Hazard ratios for CVD mortality across baseline quintiles of the first principal component score of the three somatotype components in 1700 men from the 1981 Canada Fitness Survey. The model includes the effects of age, smoking and alcohol consumption. All men who died in the first two years of follow-up have been eliminated from the analysis. Bars indicate 95% confidence intervals.

PHYSIQUE IN CHILDHOOD AND ADULTHOOD

The degree to which the relationships between physique and chronic disease risk factors are established in childhood and how they translate or track into elevated risk as an adult has been one focus of Dr. Malina’s interest (Malina et al. 2004). We examined the relationship between physique and chronic disease risk factors in children and youth 9-18 years of age from the Québec Family Study (Katzmarzyk et al. 1998). Canonical correlation analysis was used to quantify the relationship between the Heath-Carter somatotype and risk factor variables. The results suggest that a physique characterized by high endomorphy and mesomorphy, and low ectomorphy is associated with higher levels of triglycerides, LDL-cholesterol, and plasma glucose, and lower levels of HDL-cholesterol.

The stability or tracking of a person’s physique over time is a subject of interest. Although a person may change an individual characteristic such as their body weight through changes in their lifestyle behaviors, the degree to which overall physique changes throughout the lifespan is not well understood. Several studies using longitudinal research
designs have investigated the stability of physique over time in the same group of people (Malina et al. 2004). The most common way of expressing stability or tracking of physique is by inter-age correlations. Given that the somatotype is a three-component index, it is best not to study one component in isolation, but to consider one component after statistically adjusting for the other two components.

Data from the Leuven Longitudinal Study revealed inter-age correlations of 0.79, 0.73 and 0.82 for boys between the ages of 13-18 years for endomorphy, mesomorphy and ectomorphy, respectively (Claessens et al. 1986). Further, Hebbelinck et al. (1995) reported inter-age tracking correlations of 0.29, 0.50, and 0.55 for males and 0.60, 0.36 and 0.73 for females for endomorphy, mesomorphy and ectomorphy, respectively between the ages of 12-17 years in Belgian youth, after statistically controlling for the other two components. Among younger South African girls 4 years of age, 2-year inter-age correlations ranged from 0.75 for endomorphy, 0.52 for mesomorphy, and 0.35 for ectomorphy, after statistically controlling for the other two components, while the corresponding correlations for girls 8 years of age were 0.75 for endomorphy, 0.46 for mesomorphy, and 0.50 for ectomorphy (Monyeki et al. 2002). Overall, the results of these and other studies indicate that somatotype is a relatively stable characteristic throughout the growing years and into adulthood.

### Physique, Adiposity and Risk Factors

Given the dramatic increases in obesity observed in recent years, there has been great interest in determining the health concerns associated with excess adipose tissue. At the same time, there has been diminished interest in overall physique as an independent risk factor. The most common method of assessing physique is the Heath-Carter somatotype, which requires the measurement of several body dimensions, elaborate computations, and sophisticated statistical analyses. Thus, the degree to which knowing the somatotype improves the prediction of disease risk beyond simpler anthropometric indicators of adiposity is of interest.

We undertook a study in the Québec Family Study to determine the independent roles that indicators of body adiposity (sum of skinfolds, trunk-to-extremity skinfold ratio) and somatotype might play in relation to CVD risk factors (blood pressure, lipids, glucose) in children and young adults (Katzmarzyk et al. 1999). A modest amount of the variation (up to 16%) in CVD risk factors was explained by the indicators of adiposity and the somatotype components. Indicators of adiposity and the somatotype components entered the stepwise regression models as predictors a similar number of times, explaining a similar proportion of the variance. Overall, the results of this single study do not appear to suggest that computing somatotype components adds value to the prediction of risk factors beyond measures of adiposity, but further research is required to better determine the independent nature of these associations.
In a recent report on somatotype and blood pressure in 980 boys and 922 girls, 6 to 13 years of age, from Ellisras, South Africa, systolic blood pressure was found to be weakly and negatively associated to ectomorphy (Makgae et al. 2007). No relations were observed between systolic or diastolic blood pressure with endomorphy and mesomorphy, even though the prevalence of hypertension reached 6% in boys and 11% in girls.

SUMMARY

Studies of the relationship between physique and health have a long tradition in human biology and medicine. Overall physique, often operationalized as the three-component somatotype, demonstrates a significant amount of familial resemblance, suggesting that there is a substantial genetic effect on human variation in ectomorphy, mesomorphy and endomorphy. A body of data supports the concept that a physique characterized by high levels of endomorphy and mesomorphy and low levels of ectomorphy, is associated with an increased risk of CVD and mortality. The somatotype and its relationship with chronic disease risk factors appears to begin in childhood, and evidence from several longitudinal studies has demonstrated that a person’s physique is a relatively stable trait through childhood into adulthood. The degree to which the somatotype adds to the predictive ability of more common indicators of body composition, overall adiposity and adipose tissue distribution remains to be determined. Studies comparing ectomorphy, mesomorphy and endomorphy against direct measures of lean mass, fat mass, abdominal fat depot, visceral fat level, and hepatic and intramyocellular fat deposition would be helpful in evaluating a potential role for global measures of physique and body type, particularly as risk factors for common chronic diseases and premature mortality.

REFERENCES


SECTION III:
YOUNG ATHLETES
TRACKING AND PREDICTION OF TRACK AND FIELD EVENTS IN UNTRAINED ADOLESCENT BOYS FROM 12 TO 17 YEARS OF AGE

Johan Lefevre
Paul Ponnet
Albrecht Claessen
Martine Thomis
Gaston P Beunen

In this study tracking of track and field events (high jump, shot put, 60 m sprint and 6 minute endurance run) during adolescence (12 to 17 years) is studied and the predictive power of a variety of biological characteristics is verified. This interdisciplinary approach has demonstrated that track and field performances in late adolescence are, to a fairly high degree, predictable by the additive contribution from track and field performances, motor performances, somatic dimensions, and progression in track and field events, motor performance and/or somatic growth over a one year period (12 to 13 years).

INTRODUCTION

Many children and adolescents participate in sports and for a majority it is the major context of their physical activity behavior (Malina, 2010). Most likely only a limited number of youth participating in sports already show the characteristics of expert sports potential and only a very small minority will succeed and attain international excellence in their sport. Most countries, however, attempt to develop systematic structures and programs to identify and promote talented youth (Vaeyens et al., 2009).

If talented adults can be identified at younger ages it raises the question if physical performance later in life can be predicted from characteristics earlier in life. This refers to the concept of tracking and prediction used in auxological research. Tracking is the maintenance of the relative position within a group over time (Clark et al., 1976; Foulkes & Davis, 1981; Malina, 1990; McMahan, 1981). In exercise science it is mostly quantified by calculating inter-age correlations. Malina (2001) summarized the available evidence and concluded that most physical performance characteristics track reasonably well from childhood to adolescence and from adolescence to adulthood. In general, with increasing time interval the tracking coefficients decrease. Only a few studies tried to predict future physical performance from observations made earlier in life (Beunen et al. 2004).

In the present study it is hypothesized that: (1) three track and field events (high jump, shot put and 60 m sprint) and the 6 minute endurance run demonstrate
moderate to moderately high tracking during adolescence and (2) that physical fitness and somatic dimensions contribute significantly to the prediction of results in these events in late adolescence.

METHODS

Subjects were sampled from two secondary schools in Flanders (Belgium). At the start of the study boys were between 10 and 13 years old. These boys were followed at annual intervals for six consecutive years. In total 144 adolescents (from 156 possible participants) gave their consent for participation. At the start of the study, they were placed into four groups, with a respective mean chronological age of 10, 11, 12 and 13 years. A total of 94 boys (65% response rate) completed the study and had complete records. For this manuscript, only data from the third group are used. Boys ($n = 41$) were about 12 years old ($11.99 \pm 0.15$) at the onset of the study. Final age at follow up was about 17 years of age ($16.92 \pm 0.17$).

The project was approved by the Medical Ethics Committee of the Faculty of Physical Education and Kinesitherapy (presently Faculty of Kinesiology and Rehabilitation Sciences) of the KULeuven. The parents of the boys received a letter with an explanation about the main goals of the study, the reason why their son was included in the sample, and a brief description of the tests and measurements. Since the study design required a collection of longitudinal data, parents and youngsters were asked if they were willing to participate during six consecutive years. In addition, it was clearly stipulated that yearly an X-ray of the left hand and wrist would be taken, to assess skeletal maturity. Parents had to complete a form and gave their informed consent by signature.

Performances in high jump, shot put (4 kg), 60 m sprint and 6 minute endurance run at the age of 17 years were chosen as dependent characteristics. Independent variables at the age of 12 years were the track and field events (high jump, shot put, 60 m sprint, 6 minute endurance run) and 20 somatic variables (lengths, breadths, circumferences, skinfolds and Heath-Carter somatotype components), 15 motor fitness tests, and skeletal maturity.

Skeletal age was estimated according to the TW2 method (Tanner et al., 1989). Relative skeletal age was calculated by subtracting chronological age from RUS-age (radius, ulna and short bones). Measurement procedures of all somatic variables have extensively been described by Claessens et al. (1990).

The choice of the motor fitness variables was based on the available evidence of biological characteristics that correlate with track and field events (high jump, shot put, 60 m sprint and 6 minute endurance run) (Burwitz et al., 1994; Thomas, 1989). Three tests of static strength were included (arm pull, leg extension, bench press), five tests of explosive strength (vertical jump, vertical jump running approach, standing broad jump, multiple jump, reactive jump from a bench of 30 cm), two speed tests (plate tapping, 50 meters shuttle run), and one test of respectively muscular endurance of the lower body (leg lifts), muscular endurance of the upper body (bent arm hang), hip flexibility (sit and reach), total body balance (flamingo balance) and cardio-vascular endurance (6 minutes endurance run). Testing procedures of all tests...


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SECTION IV:
FROM THE DESK OF ROBERT MALINA
GASTON P. BEUNEN (1945-2011)

Robert M Malina

The pediatric exercise science community lost a beloved colleague and scholar with the untimely passing of Gaston Beunen in August. Gaston collapsed while playing tennis and subsequently died of coronary complications.

Gaston anticipated participating in the Pediatric Work Physiology conference in Exeter in September continuing his long term involvement with the group. He participated in 18 of the 26 meetings organized by the European Group for Pediatric Work Physiology between 1973 and 2010, including two jointly hosted with the North American Society for Pediatric Medicine.

Gaston devoted his entire academic career to the Katholieke Universiteit te Leuven in Belgium. He completed his baccalaureate and master’s degrees in physical education at the university in 1965 and 1967, respectively, and his doctoral degree in 1973. He was intimately involved in the mixed-longitudinal study of Belgian boys 12-20 years of age, part of which formed the basis for his doctoral dissertation. He formulated and directed the comprehensive analysis of the longitudinal component of the study, specifically the adolescent growth spurts in body dimensions and motor performances. After several years, Gaston directed a follow-up study of the longitudinal sample which developed into the Leuven Longitudinal Study of Lifestyle, Fitness and Health, marking a shift (albeit to some extent) to interest in factors affecting adult health. The project is still ongoing. The study of boys was followed by a cross-sectional survey of the growth, maturation and physical fitness of girls 6-18 years of age, the Leuven Growth Study of Flemish Girls.

With the sport sciences moving in many directions, Gaston developed an interest in quantitative genetics and with several colleagues he initiated the Leuven Longitudinal Twin Study. Interests in the genetic domain continued in the Leuven Genes for Muscular Strength project. Finally, Gaston served as coordinator of the Flemish Policy Research Center for Sport, Physical Activity and Health between 2002 and 2006. He became an emeritus professor in 2006, but continued his research activities and collaborations at the university and elsewhere.

Gaston has published extensively not only in English but also in his native Flemish. He regularly reviewed manuscripts for many scientific journals and also served on the editorial boards of several journals. Gaston was a member of the editorial board of Pediatric Exercise Science since the inception of the journal in 1988.
Involvement in professional organizations was important to Gaston. He was a Fellow of the American College of Sports Medicine and the recipient of a Citation Award of the College (2001), a Fellow of the European College of Sports Science, and an International Fellow of the American Academy of Kinesiology and Physical Education and the recipient of the Lynn Vendien Outstanding International Fellow Award of the Academy (1986). More recently, Gaston was the recipient of the Medal of Honor of the University of Ghent (2007).

Gaston was both a student and scholar of human growth, maturation and performance in the context of physical education, the sport and physical activity sciences, and human biology. He consistently asked good questions and more importantly had the scientific and quantitative skills to address the issues. He excelled in analyses of longitudinal data and more recently in applications of advanced multivariate methods to studies of growth, performance and genetics.

Although Gaston’s academic career and accomplishments were outstanding and unparalleled by many in our field, he will be remembered for his friendly and human demeanor and his willingness to share knowledge and experiences not only with colleagues but also with many students and emerging professionals throughout the world. Gaston’s commitment to students was especially evident in the promotion or co-promotion of 163 master’s theses and 14 doctoral dissertations at the Katholieke Universiteit te Leuven.

To me personally, I lost a dear friend, perhaps a younger brother. Gaston and I first met, albeit briefly, at the pre-Olympic Scientific Congress in Quebec in 1976. We subsequently met at several meetings which culminated in an invitation to be a visiting professor at the Katholieke Universiteit te Leuven in 1981, during which time we collaborated on the mixed-longitudinal study of Belgian boys. This marked the beginning of our research collaboration and more importantly a long friendship not only for Gaston and me, but also for our families.