ISSN 0973-2020

Journal of Exercise Science and Physiotherapy (JESP)

(An official Journal of Exercise Fitness & Health Alliance, EFHA)

Volume 3, No. 1: 2007

Contents

Editor's Page

An official Publication of
Exercise Fitness and Health Alliance
www.efha-in.org

Journal of Exercise Science and Physiotherapy
Volume 3, No.1: 2007

Special Felicitation Issue on
Physical Activity And Human Growth

Editor-in-Chief: Prof. (Dr.) S.K. Verma

It is a matter of great pleasure in bringing to you the third issue of **Journal of Exercise Science and Physiotherapy** ***(JESP)***. This Special Volume of JESP brought out in honour of Prof. D.P. Bhatnagar contains twelve articles on various aspects of the physical activity and human growth and on related topics, plus a preface on the life and achievement of the honoree, Prof. Dr. Devinder Paul Bhatnagar, and a bibliography of his publications. Prof. Bhatnagar is a well-known Scholar, Teacher and Researcher in the field of Human Growth Studies. This publicity shy gentlemen scholar contributed his mite to the research fields from various angles. A Felicitation Volume in his honour was a long felt desideratum, in view of his solid and outstanding contributions, distinguishing him from other scholars in ways more than one. I was singularly fortunate to shoulder this responsibility to the best of my capacities. The special feature of this Volume is that it contains learned research papers, contributed by his colleagues, friends, students and well-wishers from India and abroad and embracing diverse spheres from physical growth and physical fitness patterns in childhood and adolescence to the burning issues of todays sports i.e. physical training during the growth period in children and adolescents. All the contributors are established scholars/researchers in their own fields and many are connected in some way or the other with Prof. Bhatnagar. They have rightly chosen the topics which are dear and near to Prof. Bhatnagar. This is a tribute to the scholarly work in the field of Human Growth achieved by Prof. Bhatnagar through his distinguished academic pursuits. I feel highly gratified after Editing this Felicitation Volume in Honour of an Intellectual Giant who has reached Himalayan Heights and Oceanic Depths. I am cock-sure that this Felicitation Volume will be a treasure to every one as well as a Collector's Item. As befits a scholar of Bhatnagar's stature, the contributors include several of the foremost national and international names in this field, and production and editing standards are also of an appropriate quality. The wide-ranging topics of the articles may be broadly grouped under the headings of physical growth and physical fitness patterns in normal and special populations and issue of physical training during growth period. **Bandyopadhyay and Bandyopadhyay from Malysia, Benefice from Bolivia, Mehta, P. et al from Patiala, Nath and Dwivedi from Delhi and Taylor from USA** has reported physical growth and cardiorespiratory fitness in children and adolescents. **Singh & Singh from Patiala** has given his findings on the physical growth of deaf mute boys of Punjab. **Tsolakis & Bogdanis from University of Athens, Greece,** has tried to address the issue of resistance training in Pre-Pubertal and Pubertal Males. **Armstrong et al from United Kingdom** has presented a comprehensive review of studies concerning cardiorespiratory training during childhood and adolescence. Parent-Offspring Correlations in Body Measurements, Physique and Physiological Variables among Santhals of West Bengal has been revealed in the original research paper by **Ghosh & Malik from Delhi**, and relationship between physical fitness and physical activity **Monyeki from Republic of South Africa and Kemper from Netherlands in their joint paper discusses** relationship between Physical Fitness and Physical Activity in Children**.**

The current issue of ***JESP*** contains three review articles and nine research contributions in the form of original articles from leading researchers.

S.K. Verma

FELICITATIONS TO PROF. D.P. BHATNAGAR

Prof. (Dr.) Devinder Paul Bhatnagar was borne on Oct 5, 1946 in Patiala and had his school and college education from Patiala. He did his Post graduation in Anthropology from Punjab University, Chandigarh in 1967. Thereafter he executed teaching responsibilities in Khalsa College, Patiala and Govt. Medical College Patiala from 1967-1969. His quest for research fetched him prestigious Assistant Research Officership of ICMR at the Post Graguate Institute of Medical Research, Chandigarh where he served for one year. In the year 1970, he joined M.Sc. Human Biology at Punjabi University, Patiala. After obtaining his second post graduation degree he joined the teaching faculty of Punjabi University, Patiala. Prof. Bhatnagar was the first to submit his doctrate thesis in the Faculty of Life Sciences of Punjabi University in 1977. He completed his Ph.D. under the famous orthopaedic Surgeon, Padam Shree Dr. N.D. Aggarwal and Prof. L.S. Sidhu, a pioneer of Human Biology in India. His Ph.D. work led to the dicovery of new method to diagonose CTEV at an early stage.

Prof. Bhatnagar started his regular teaching carrier as a Lecturer in the Department of Human Biology, Punjabi University, Patiala in 1977. He taught Human Biology to the students of Punjabi University. He taught Human Growth and Research Methodology at the Post Graduate level. In recognition to his research contributions, he was awarded the most prestigious National Associateship by the University Grants Commission for which any researcher or university can take pride of. His soft spoken attitude, earnest desire to help everyone and clarity of thoughts has brought him credit and is admired by his students/teachers and researchers as well. He has nearly 90 Research papers (17 in foreign journals) published in international and national journals of repute and 17 books (7 edited) to his credit and is at present working on 2 rare works which are still in the form of Manuscripts. Prof. Bhatnagar has guided 12 Ph.D., 8 M.D./M.S. and 58 M.Sc. students and all of them are already well placed. He has remained active throuhout his carrer in research that can be judged from the fact that he has presented 29 research papers during the national/international seminars/conferences held from time to time. Prof. Bhatnagar has the honour to chair many prestigious sessions during the conferences. In addition to this, he has the credit of successfully organising 29 conferences (22 National & 7 International). He has also been editing the Journal of Sports Science & Physical Education, an official publication a national body named as Indian Association of Sports Science and Physical Education.

With due recognition to his research potential, Dr. Bhatnagar was offered the position of Director (Research & Development) by Punjabi University, Patiala in 2001 and he fully justified this responsibility. Prof. Bhatnagar possesses strong administrative capabilities as is evident from the successful leadership provided by him to the department from 1992-1997. The department grew in all dimensions during his headship. In addition to this, he has also been instrumental in the smooth conduct of various state level entrance tests like B.Ed., PMT, Physiotherapy & Pharmacy entrance test of Punjabi University, Patiala etc. and has thus brought honours to the university. With vast academic and administrative experience, Prof. Bhatnagar has successfully designed and reoriented the syllabii and course curriculm of Human Biology and Foods & Nutrition by being the Chairman of Board of Studies of Human Biology and Foods & Nutrition.

EFHA family is proud of having him on its governing body and wishes him healthy and long life.

Research Papers of Prof. D.P. Bhatnagar

1 1972 J.G. Jolly, B.M. Sarup, *D.P. Bhatnagar* and C.S. Maini. Glucose 6 Phosphate Dehydrogenase Deficiency in India. ***J. Ind. Med. Ass***. 58: 196-200.

2 1974 L.S. Sidhu and ***D.P. Bhatnagar***. Some factors influencing Rh immunization in pregnant women. *Eastern Anthropologist* 27: 195-203.

3 1974 L.S. Sidhu, J. Singh, *D.P. Bhatnagar* and J.K. Pahuja. Association of ABO and Rh blood groups with pulmonary tuberculosis. *Proc. Ist Conf. Ind. Soc. Hum. Genet.Bombay* 1: 135-140.

4 1975 *D.P. Bhatnagar*. Pedigree analysis of a rare type of polydactylism. ***Z. Morph. Anthrop. (W. Germany)*** 67: 85-87.

5 1975 L.S. Sidhu, H.S. Sodhi and *D.P. Bhatnagar*. Anthropometric changes from adulthood to old age. ***Ind. J. Phy. Anth. and Hum. Genet***. 1 (2): 119-127.

6 1976 *D.P. Bhatnagar*. A study of ABO and Rh blood groups in congenital heart disease. *The Anthropologist* XXIII (1 & 2): 1-3.

7 1977 *D.P. Bhatnagar*, L.S. Sidhu and N.D. Aggarwal. Family studies for the mode of inheritance of arthrogyposis multiplex congenita. ***Z. Morph. Anthrop. (W.Germany)*** 68: 233-40.

8 1977 L.S. Sidhu,*D.P. Bhatnagar*, P. Malhotra and H.S. Sodhi. Association of finger ball dermatoglyphics with pulmonary tuberculosis. *Anthrop. Anz. (W.Germany)* 36 (1) : 36-42.

9 1977 *D.P. Bhatnagar*, L.S. Sidhu and N.D. Aggarwal. Genetics of congenital talipes equino varus-analysis of 139 pedigrees. *The Anthropologist* XXIV (1 & 2) : 1-13.

10 1978 L.S. Sidhu and *D.P. Bhatnagar*. Symphalangium- A pedigree analysis. ***Ind. J. Heredity*** 10(5) : 93-96.

11 1978 L.S. Sidhu, A. Sharma, P. Singal and *D.P. Bhatnagar*. A study of relationship between pulmonary tuberculosis and palmar dermatoglyphics traits. *Anthrop. Anz. (W.Germany)* 36(3) : 219-223.

12 1979 B. Bhutani and *D.P. Bhatnagar*. Blood groups in relation to fibromyoma uterus. ***The Clin. Rep.*** (1): 14-17.

13 1979 *D.P. Bhatnagar*, L.S. Sidhu and B.Bhutani. An immuno-haemaological study among pregnant women of Patiala (India). *Anthrop. Anz. (W.Germany)* 37(1) : 10-17

14 1979 *D.P. Bhatnagar* and B.Bhutani. Blood groups in relation to ovarian tumors. ***The clin. Rep***. III (8) : 277-279.

15 1980 *D.P. Bhatnagar* and B.Bhutani. Study of blood groups and rhesus isoimmunization in antenatal cases. *Anthrop. Anz. (W.Germany)* 38(2) : 148-153.

16 1980 *D.P. Bhatnagar* and H.S. Sodhi. Somatomeric comparison of normal and pulmonary tubercular patients. ***Ind. J. Phys. Anthrop. and Hum. Genet***. 6 (1) : 33-37.

17 1980 *D.P. Bhatnagar*. Some morphological measures in athletes, Volleyball and Kabaddi players in rural areas of Madhya Pradesh. ***J. Sports Med. (Italy)*** 20 (1) : 109-112.

18 1980 *D.P. Bhatnagar*. Tuberculosis and finger ball dermatoglyphics - a comparative study of normal and patient series among females. ***The Clin. Rep***. IV (1) : 31-38.

19 1980 L.S. Sidhu, R.K.Bansal, *D.P. Bhatnagar* and S.L. Bansal. Variation of colourvision in Punjabi children studied on Pickford Nicolson anamaloscope. ***Ind. J. Phys. Anthrop. and Hum. Genet***. 6 (2) : 131-135.

20 1981 L.S. Sidhu, P. Malhotra, P. Singal and *D.P. Bhatnagar*. Palmar dermatoglyphics and Diabetes Mellitus: A comparative study of normal and patient series among females. *Indian Anthropologist* 11 (1) : 57-64.

21 1981 *D.P. Bhatnagar*, L.S. Sidhu and P. Singal. Development of deciduous dentition in Punjabi infants and children. *Acta Med. Auxol.(Italy)* 13: 161-166.

22 1981 L.S. Sidhu, R. Grewal and *D.P. Bhatnagar*. A study of physical growth in breast fed and bottle fed male infants. ***Ind. J. Pediatrics.*** 48 : 75-79.

23 1982 L.S. Sidhu, *D.P. Bhatnagar* and A.P. Dubey. Secular trends in heights and weights of Punjabi boys. *Anthrop. Anz. (W.Germany)* 40(3) : 187-192.

24 1982 *D.P. Bhatnagar* and J.L. Bhanot. Blood volume in normal infants and children. *Human Biology- Recent Advances* Vol. I: 133-139.

25 1982 *D.P. Bhatnagar*, L.S. Sidhu, N.D. Aggarwal and V.B. Mathur. Comparative study of normal and CTEV foot with special reference to the diagnosis of this abnormality. *Human Biology- Recent Advances* Vol. I : 175-189.

26 1982 *D.P. Bhatnagar*, L.S. Sidhu, N.D. Aggarwal and V.S. Joshi. A new approach for the diagnosis of congenital talipes equino varus from foot measurements. *Indian Anthropologist* 12 (2): 151-154.

27 1983 *D.P. Bhatnagar*, R. Grewal and L.S. Sidhu. Development of milestones of behaviour in Punjabi infants and children. *Indian Anthropologist* 13 (1): 61-64.

28 1983 *D.P. Bhatnagar*, P. Singal, L.S. Sidhu and A.S. Puri. Association of finger ball dermatoglyphics with bronchial asthma. *Human Biology- Recent Advances* Vol. II: 41-48.

29 1983 P. Singal, *D.P. Bhatnagar* and L.S. Sidhu. Palmar dermatoglyphics and tuberculosis: a comparative study of normal and patient series among females. *Human Biology- Recent Advances* Vol. II: 165-171.

30 1983 R. Grewal and *D.P. Bhatnagar*. A comparative study of rural volleyballers of Assam and Madhya Pradesh. *Hung. Rev. Sports Med. (Hungary)* 24 (1): 23-27.

31 1983 K.L.Batish, S.S.Sidhu, S.Makhni, M.K.Batish and *D.P. Bhatnagar*. Fluorosis and finger ball dermatoglyphics - a comparative study. *Fluoride (USA)* 16(4): 198-208.

32 1984 *D.P. Bhatnagar*, S.P.Thapar and M.K.Batish. Identification of personal height from the somatometry of hand in Punjabis. *Forensic Science International (Denmark)* 24 (2): 137-141.

33 1984 *D.P. Bhatnagar* and R.Grewal. A comparative study of rural athletes of four states of India. *Brit. J. Sports Med. (UK)* 18 (1): 34-37.

34 1984 *D.P. Bhatnagar*, S.S. Sidhu, K.L. Batish and M.K. Batish. Ecological study of dermatoglyphics diversity in Fluorosis belt of Punjab (India). *Fluoride (USA)* 17 (3): 168-172.

35 1984 *D.P. Bhatnagar*, P. Singal, L.S. Sidhu and M.K. Batish. Anthropometric measurements of the full term Punjabi new borns. *Indian Anthropologists* 14 (2): 159-163.

36 1985 S.S. Sidhu, K.L. Batish and *D.P. Bhatnagar*. Epidemiological study of endemic fluorosis from village Khera of Punjab. *Fluoride (USA)* 18 (3): 149-156.

37 1985 *D.P. Bhatnagar*, P. Singal, L.S. Sidhu and J.L. Bhanot. Growth of weight, height, body surface area and their standards in Punjabi infants and children. *J. Ind. Anthrop. Soc*. 20 (2): 169-181.

38 1985 *D.P. Bhatnagar*, L.S. Sidhu, P. Singal and P. Chopra. Blood groups in asthma. *Biologica* 1 (1): 86-89.

39 1985 L.S. Sidhu, P. Singal, *D.P. Bhatnagar* and S. Jain. Sexual dimorphism- physique and body composition of adult Bhotias - a high altitudinal population. *Indian Anthropologist* 15 (2): 115-126.

40 1986 *D.P. Bhatnagar* and P. Singal. A comparative study of athletes of volleyball players from rural areas of Assam and Madhya Pradesh. In Modern Perspective in Physical Education and Sports Sciences, Harnam Publishers, New Delhi 117-123.

41 1986 *D.P. Bhatnagar*, A. Kumar and P. Singal (1986). Physiological maturity in relation to socio-economic status. *Biologica* 1 (2): 236-241.

42 1986 *D.P. Bhatnagar* and A. Kumar. The differences in eruption of permanent dentition among the individuals of two social groups of Punjabi origin. *Acta Medica Auxologica (Italy)* 18 (2): 129-134.

43 1987 P. Singal, L.S. Sidhu, *D.P. Bhatnagar*, H.S. Sodhi and A. Kumar. Criteria for determination of age through dental eruption for participation in sports. Sports Sciences - Health, Fitness and Performance. *IASSPE Publication* 93-100.

44 1987 *D.P. Bhatnagar*, A. Kumar and P. Singal. Menarcheal age in relation to socio-economic status. Sports Sciences - Health Fitness and Performance. *IASSPE Publication* 143-149.

45 1987 *D.P. Bhatnagar*, P. Singal and H.K. Grover. Somatometric variables and body components in relation to socio-economic status. *NIS Scientific Journal* 10 (3): 35-46.

46 1988 P. Singal, R. Mokha, *D.P. Bhatnagar* and L.S. Sidhu. Physique and body composition of female hockey players from Uttar Pradesh. *Trends in Sports Sciences* 139-147.

47 1988 H.S. Sodhi, R. Kumar, *D.P. Bhatnagar*, S.P. Singh and R. Mokha. Modern perspectives of kinanthropometry. *Trends in Sports Sciences* 107-120.

48 1988 R. Mokha, P. Singal, *D.P. Bhatnagar* and L.S. Sidhu. Intersportive differences in physique and body composition of female players from Uttar Pradesh. *NIS Scientific Journal* 11: 52-58.

49 1988 P. Singal, L.S. Sidhu and *D.P. Bhatnagar*. Estimated fat, bone mineral, total body water and cell solids in females of two communities of Punjab (India). *Anthrop. Anz. (W.Germany)* 46: 51-57.

50 1989 A. Kumar and *D.P. Bhatnagar*. Influence of socio-economic factors on dental age. *Modern Trends in Anthropology* Pp. 13-25.

51 1989 *D.P. Bhatnagar*, P. Singal and P.S. Bajaj (1989). Physical growth and body composition in two endogamous groups of Chamba. ***Ind. J. of Sport Sciences*** 1 (2): 23-28.

52 1990 *D.P. Bhatnagar*, P. Singal, G. Kaur and N. Khandelwal. Age changes in growth and body composition of Rajputs of Kulu Valley. ***Ind. J. of Sport Sciences*** 2 (1): 56-61.

53 1990 P. Singal, ***D.P. Bhatnagar*** and H. Kaur. Changes in somatotypes during 5 to 16 years in Rajput and Brahmin girls of Chamba Distt. (H.P.). ***Ind. J. Phys. Anthrop. and Hum. Genet***. 16: 49-62.

54 1991 L.S. Sidhu, ***D.P. Bhatnagar***, P. Singal, A.K. Khullar and J.L. Bhanot. Age changes in working capacity studied from Oxygen consumption and heart rate on bicycle ergometer. ***Ind. J. Sport Sc. and Phy. Edu.*** 3(1): 23-28.

55 1991 S.P. Pandove, L. Rama Kumar, *D.P. Bhatnagar* and S.R. Garg. Prediction of various body parameters from foot length in newborn. ***New Horizons in Hum. Biol***. 83-92.

56 1991 P. Singal, L.S. Sidhu, ***D.P. Bhatnagar*** and H.K. Garcha. Cephalo-facial measurements in adult Bhotias of Mana Valley- a high altitudinal population. ***New Horizons in Hum. Biol.*** 115-122.

57 1991 M.K. Batish, H. Singh, ***D.P. Bhatnagar*** and K.L. Batish. Attitudes towards various health care systems- an epidemiological study. ***New Horizons in Hum. Biol***. 213-221.

58 1991 A.Kumar and *D.P. Bhatnagar*. Mental age in Khatris of Punjabi origin. ***New Horizons in Hum. Biol***. 245-250.

59 1991 G.L. Khanna and *D.P. Bhatnagar*. Physiological profile of aerobic, anaerobic capacities and cardio-pulmonary responses in 8-18 years of children. ***Ind. J. Sport Sc. and Phy. Edu***. 3(2): 68-76.

60 1992 G.L.Khanna, *D.P. Bhatnagar* and D.N. Mathur. Prediction of aerobic, anaerobic capacity from maximal, submaximal and recovery cardio-pulmonary responses in children of 8 to 18 years. ***Ind. J. Sport Sc. and Phy. Edu***. 4 (1): 1-7.

61 1992 G.L. Khanna and *D.P. Bhatnagar*. Age changes in aerobic, anaerobic capacity and cardio-respiratory responses in Indian boys. ***Ind. J. Physio. and Applied Sc.*** 46 (2) : 89-100.

62 1993 P. Singal, ***D.P. Bhatnagar*** and S. Dhillon. Intersportive differences in anthropometric measurements and body composition of National level women. ***Ind. J. Sport Sc. and Phy. Edu.*** 5(2): 74-83.

63 1993 G.L. Khanna and *D.P. Bhatnagar*. Relationship of age, height and weight with physiological variables in children of 8-18 years. ***Ind. J. Sport Sc. and Phy. Edu.*** 5 (2): 60-68.

64 1994 P. Singal, *D.P. Bhatnagar*, Y.K. Maraul and S. Dhillon. Morphological profile and body composition in various sports of national level men. ***Ind. J. Sport Sc. and Phy. Edu***. 6 (1): 21-31.

65 1995 P. Singal, L.S. Sidhu, ***D.P. Bhatnagar*** and J. Kaur. Age at menopause and morphological profile of Bahawalpuria women. *Bulletin of the Department of Anthropology, Dibrugarh University* 23: 109-117.

66 1996 P. Singal, ***D.P. Bhatnagar*** and A. Kaur. Emergence and agenesis of third molar and its relationship with cephalo-facial measurements in Punjabi girls. ***J. Hum. Ecol***. 7(1): 51-54.

67 1996 ***D.P. Bhatnagar***, R. Mokha and S. Kaur. Foot arch and jumping ability in female basketball players- a radiological study. *Human Biology - Global Development*, USG Publishers, Ludhiana 255-259.

68 1997 N. Mehta, J. Virdi, ***D.P. Bhatnagar*** and H. Kaur. Transient alloalbuminaemia caused by antibiotic drugs. ***J. Hum. Ecol.*** 8 (2): 87-94.

69 1998 M.K. Batish, H. Lall, ***D.P. Bhatnagar***, P. Singal and A.P. Singh. $Glucose_6$ phosphate dehydrogenase deficiency in newborns. *Physical Anthropology and Human Genetics*. Ed. I.J.S. Jaswal, Asia Visions, Ludhiana Pp. 240-248.

70 1998 *D.P. Bhatnagar*. Growth and development of clubfoot children - a diagnostic and prognostic study. (In Punjabi). *Proc. 15th Punjabi Development Conference* held at Patiala Pp. 155-159.

71 1998 P. Singal, *D.P. Bhatnagar* and S. Kaur. Morphological profile of athletes and controls ranging in age from 10 to 18 years. ***Ind. J. Sport Sc. and Phy.Edu***. 10(1&2): 53-63.

72 1999 M.K. Batish, *D.P. Bhatnagar*, P. Singal and K.L. Batish. Electro-cardiographic changes in the first week of life-heart rate. Human Growth. Eds. Bhatnagar ***et al***. Pp. 28-32.

73 1999 *D.P. Bhatnagar*, S. Kaur and S.K. Sidhu. High altitude and growth: patterns of physical growth in Bhotia Rajputs of Mana Valley. Human Growth. Eds. Bhatnagar *et al*. Pp. 44-53.

74 1999 *D.P. Bhatnagar*, P. Singal and R.K. Purewal. Dental development and onset of menarche in Jat Sikh girls. *The Anthropologist* I (3): 209-212.

75 2000 *D.P. Bhatnagar*, P. Singal and G.K. Bains. Physiological maturity in Balmiki girls. Anthropology at the turn of Century. Eds. Vashisht *et al*. Pp. 165-172.

76 2000 *D.P. Bhatnagar*, P. Singal and G. Teka. Development of facial hair in Jat Sikh boys. *Advances in Human Biology at the Turn of Millennium*. Publication Bureau, Punjabi University, Patiala Pp. 32-37.

77 2000 H.K. Kang, *D.P. Bhatnagar* and M.K. Batish. Health care systems in Punjab - a comparative study. *Advances in Human Biology at the Turn of Millennium*. Publication Bureau, Punjabi University, Patiala Pp. 49-63.

78 2001 L.S. Sidhu, P. Singal, *D.P. Bhatnagar* and A. Kaur. A study of age changes in skin colour reflectance of Vokkaliga boys of Mysore. *The Anthropologist* 3(2): 105-109.

79 2001 *D.P. Bhatnagar*, P. Singal and S.P. Thapar. Anatomy of Malleus- A Human Ear Ossicle. *The Anthropologist* 3(2): 139-141.

80 2002 P. Singal, *D.P. Bhatnagar* and S.Kaur. Body fat and lean body mass- bone mineral, total body water and cell solids in athletes ranging in age from 10 to 18 years. *Ind. J. Sports Sc. and Phy. Edu*. 11: 1-14.

81 2003 *D.P. Bhatnagar*, P. Singal, S.K. Verma, A.K. Wangoo and T. Singal. A haematological study among the Vokkaligas of Mysore. *The Anthropologist* 5 (1): 45-48.

82 2003 H.K.Sethi, P. Singal, L.S. Sidhu and *D.P. Bhatnagar*. Body composition and blood pressure in working and non-working women with special reference to ageing. *Understanding People of India - Anthropological Insight.* Eds. Kalla and Bhattacharya Pp. 101-112.

83 2003 H. Kaur, *D.P. Bhatnagar* and P. Singal. Physical growth of Punjabi children ranging in age from 3 months to 3 years. *Understanding People of India - Anthropological Insight.* Eds. Kalla and Bhattacharya. Pp. 113-121.

84 2003 *D.P. Bhatnagar*, L.S. Sidhu and P. Singal. Some important statistical methods for the analysis of biological/anthropological data. *Understanding People of India - Anthropological Insight.* Eds. Kalla and Bhattacharya Pp. 122-124.

85 2003 P.P.Singh, M.Singh, *D.P. Bhatnagar*, S.S.Mastana and U.Gerdes. Role of inflammatory factors in coronary atherogenesis: an assessment of some indicators for future research. *Ind. J. Phys. Anthrop. and Hum. Genet.* 22 (2): 155-162.

86 2004 P. Singal, *D.P. Bhatnagar* and S. Kaur. Skeletal maturity in athletes and control : assessed by Tanner Whitehouse method (TW_2). *Ind. J. Sport Sc. and Phys. Edu*. 13 (1&2): 25-34.

87 2005 P.P. Singh and *D.P. Bhatnagar*. Apolipoprotein A-1 (Pstl) polymorphism in two populations of Punjab. *Ind. J. Phys. Anthrop. and Hum. Genet.* 24 (1): 1-5.

88 2005 M. Singh, P.P. Singh, *D.P. Bhatnagar* and H. Kaur. Estimation of immunoglobulin IgG in Haemophilics receiving factor replacement therapy. *Ind. J. Phys. Anthrop. and Hum. Genet.* 24 (1): 57-60.

89 2006 P. Singal, *D.P. Bhatnagar* and S. Kaur. An auxological study of morphological and sexual maturation in female athletes. *Ind. J. Sport Sc. and Phys. Edu*. 15 (1&2): 13-24.

90 2006 P. Singal, *D.P. Bhatnagar* and S. Kaur. Anthropometric profile and development of facial hair in male athletes. *J. Exercise Sc. and Physiotherapy*, 2: 52-58.

Books

1.	1987	*D.P. Bhatnagar*	*Lahu Ki Kahani* (Story of Blood) Submitted to Punjab Language Department
2.	1988	*D.P. Bhatnagar*	*Hamara Sarir*: (Our Body) Submitted to Punjab Language Department
3.	1989	*D.P. Bhatnagar*	*Pardushan* (Pollution) Submitted to Punjab Language Department
4.	1995	*D.P. Bhatnagar* and P. Singal	**Human Anatomy and Physiology.** Submitted to Pb. Univ. Text-Book Board, Chandigarh.
5.	1996	*D.P. Bhatnagar* and P. Singal	**Pollution and Human Health.** Submitted to Pb. Univ. Text-Book Board, Chandigarh
6.	1997	*D.P. Bhatnagar* and P. Singal	**Human Ecology.** Submitted to Pb. Univ. Text-Book Board, Chandigarh.
7.	2001	S.P. Singh, P. Singal and *D.P. Bhatnagar*	**Growth Standards 2001: Evaluation of Physical Growth of Punjabi Children.** Human Auxology Series No. 1, Dept. of Human Biology, Punjabi Univ., Patiala.
8.	2005	*D.P. Bhatnagar* and P. Singal	**Growth and Development of Children.** (In press)

Books Edited

1	1982	L.S. Sidhu, I.J.S. Bansal, L. Singh, *D.P. Bhatnagar*, S.K. Verma, J.L. Bhanot, D.K. Kansal, M.S. Sohal and P. Singhal.	**Human Biology - Recent Advances.** Today and Tomorrow Publishers, Delhi. Volume - I: Proceedings of International Symposium on Human Growth. Volume - II: Proceedings of International Symposium on Dermatoglyphics.
2	1990	H.S.Sodhi, *D.P.Bhatnagar*, P.Suriarajan and R.Mokha.	**Origins of Kinanthropometry.** NWGK Publication, Patiala.
3	1991	I.J.S.Bansal, L.S.Sidhu, L.Singh, *D.P.Bhatnagar*, P.Singhal, H.Kaur, P.Singal, S.P.Singh, S.Dhiman and S.Kaur.	**New Horizons in Human Biology.** Today and Tomorrow Publishers, Delhi.
4	1994	L.S.Sidhu, H.S.Sodhi and *D.P.Bhatnagar*,	**Planning for Development of Sports in India.** IASSPE Publication, Patiala.
5	1999	*D.P.Bhatnagar*, S.K.Verma and R.Mokha,	**Human Growth : A Multidisciplinary Approach,** ESPS Publication, Patiala
6	2000	P.Singhal, S.P.Singh, L.S.Sidhu, *D.P.Bhatnagar*, H.Kaur, S.M.S.Chahal, P.Singal, P.Mehta and S.Kaur.	**Advances in Human Biology at the turn of Millennium.** Publication Bureau, Punjabi University, Patiala.

Influence of Resistance Training on Anabolic Hormones in Pre-Pubertal and Pubertal Males

Tsolakis, Charilaos* and Bogdanis, Gregory C. **

*Department of Track & Field and **Department of Sports Medicine & Biology of Physical Activity, Faculty of Physical Education and Sports Science, University of Athens, Greece
Corresponding Author: Tsolakis Charilaos, Ph.D, 6 Kotsika str. 10434 Athens, Greece, Email: tsolakis@phed.uoa.gr

Abstract

This review focuses on the hormonal responses to resistance training in pre-pubertal and pubertal males with the aim to elucidate possible mechanisms that may be responsible for the increases in strength and power following systematic training in these age groups. Studies that have controlled for the confounding effects of growth and motor skill acquisition, have shown that resistance training results in significant increases in muscular strength even before puberty. Although the training induced muscle hypertrophy in pre-pubescents is possible, it is much less compared that of post-pubescents. On the other hand an equal or greater improvement in neuromuscular activation, motor skill and intrinsic muscular adaptations are reported in the pre-pubescents compared to the post-pubescents following resistance training programs. Resting serum testosterone concentration has been found to increase following 2-12 month resistance training programs and this is accompanied with an increase in muscle strength. Changes in strength and hormonal concentrations depend on the characteristics of the resistance training program, with the most important being exercise intensity and volume.

Key Words: Growth Hormone, Testosterone, Children

Introduction

Resistance training for children and adolescents has been a topic of great interest among scientists, physicians, coaches, young athletes and their parents. The research conducted in this area during the last two decades has provided valuable information on the responses of the young organism to this type of training and has advanced our understanding on mechanisms responsible for these adaptations (*Falk and Tenenbaum, 1996*). This review focuses on the hormonal responses to resistance training in pre-pubertal and pubertal males with the aim to elucidate possible mechanisms that may be responsible for the increases in strength and power following systematic training in these age groups.

Effectiveness of resistance training in pre-pubertal and pubertal males

The participation of boys in resistance training programs leads to a positive influence on their fitness that results in an increase in sport performance and offers protection from sports injuries (*Kraemer-Fleck, 1993*). Resistance training in young boys also improves quality of life and contributes to positive attitude toward wellness and exercise (*Shephard, 1984*). One of the most important characteristics of resistance exercise programs for children must be safety. Emphasis should be placed on proper technique and sessions should be supervised by a qualified instructor. Exercise intensity and interval between exercises should be chosen according to the maturation level of the young athlete, but maximal loading should be avoided (*Bases, 2004*).

Heavy resistance exercise in adults' results in significant adaptive responses, including increases in strength and power and muscle hypertrophy that, are dependent on the type, intensity of loading and volume of training (*Fleck and Kraemer, 1987*). It is well known that in adults, the increases in strength during the early phase of training are attributed mainly to neural factors, but as training proceeds, there is a gradually increased contribution of muscular hypertrophy to the increases in strength (*Moritani, 1992*). The effectiveness of resistance training in children seems to be dependent primarily on the provision of a sufficient training intensity and volume and to a lesser degree on training duration, following the principle of specificity. Strength increases ranging from 5 to 50% have been reported using isometric, isotonic and isokinetic training methods involving high intensity loads (*Kraemer et al., 1989, Sale, 1989*). As training progresses there is an interaction between neural factors and muscle hypertrophy. In pre-pubescent children, neural factors would predominate, but as the child reaches puberty the growth and maturation related hormones favor muscle hypertrophy (*Kraemer et al., 1989, Sale, 1989*). The optimal combination of training method, mode, intensity, volume and duration of training for maximal strength gain during preadolescence however, has yet to be determined.

Irrespective of the mechanism responsible, muscular strength gains have been evident across all maturity stages, including pre-pubescents (*Nielsen et al., 1980, Weltman et al., 1986, Blimkie et al., 1989, Ramsay et al., 1990, Hassan, 1991, Fukunaga et al., 1992, Faigenbaum et al., 1993, Ozmun et al., 1994*), pubescents and post pubescents individuals (*Pheifer-Francis, 1986, Sailors-Berg, 1987, Sale, 1989*). Studies that have controlled for the confounding effects of growth and motor skill acquisition, have shown that resistance training results in substantial and significant increases in strength before puberty beyond what would occur due to the normal growth (*Nielsen et al., 1980, Weltman et al., 1986, Sailors-Berg, 1987, Hassan, 1991, Fukunaga et al., 1992, Ozmun et al., 1994,*). The trainability of strength during the post-pubertal period is a less contentious issue. Significant strength gains in this age group have resulted from isometric training, dynamic or isotonic weight training, isokinetic and hydraulic resistance training and appear to be directly related to training frequency (*Blimkie & Bar-Or, 1996*).

The conclusions from the studies which examine the effectiveness of resistance training during preadolescence compared to training during adolescence and adulthood are still debatable (*Nielsen et al., 1980, Pfeifer and Francis, 1986, Sailors and Berg, 1987, Sale, 1989*). Studies often suffer from methodological shortcomings, such as absence of a control group, inappropriate training program and lack of statistical power to allow for sound conclusions (*Falk and Tenenbaum, 1996*). Nevertheless, most, but not all, studies indicate that when the relative training loads are moderate to high and the groups are formulated according to distinct maturity levels, it appears that pre-pubescents are probably less trainable in terms of absolute strength, but equally if more trainable in percentage improvements compared to adolescents and adults (*Hakkinen et al., 1989, Sailors and Berg, 1987, Sale, 1989, Fukunaga et al., 1992*). Although the training induced muscle hypertrophy in pre-pubescents is possible (*Mersh and Stoboy, 1989, Fukunaga et al., 1992*), it is much less compared that of post-pubescents. On the other hand an equal or greater improvement in neuromuscular activation, motor skill and intrinsic muscular adaptations are reported in the pre-pubescents compared to the post-pubescents following resistance training programs. (*Blimke and Bar-Or, 1996*)

Hormonal mechanisms influencing gains in muscular strength

The pubertal growth spurt is influenced by the release of important hormones such as Growth Hormone (GH), insulin-like growth factor I (IGF-I) and steroid sex hormones that induce increases in growth velocity, bone and muscle maturation, functional ability and several metabolic adaptations (*Rogol, 1994*). These changes may influence the development of physical capacity and performance during childhood and adolescence. Adrenarche (as defined by synthesis and secretion of androgens when the adrenal zona reticularis matures) is characterized by a progressive increase in the secretion of adrenal hormones. The gonadarche (as defined by activation of the testes and ovaries at puberty) follows 2 to 3 years after this first stage and is under the control of GH, IGF-I and steroid sex hormones (Lee, 1995). The release of these hormones is controlled by the pulsatile stimulation of a hypothalamic gonadotrophin – releasing factor. The processes that initiate the onset and progression of human puberty are not completely understood. The dual role of the recently discovered hormone leptin, i.e. as a regulator of fat mass and as a metabolic signal to the reproductive axis, suggests that leptin may be a permissive factor responsible for the onset of puberty (*Matzoros et al., 1997*).

Increased plasma levels of GH, testosterone, estradiol and progesterone have an anabolic effect on structural protein production. The synergistic action of GH and gonadal steroids promotes the pubertal growth spurt mainly in bones and muscles and this may contribute to metabolic and hormonal responses of children and adolescents during exercise. (*Boisseau and Delamarche, 2000*). Such mechanisms appear to be operational in response to a training stimulus provided by heavy resistance exercise and could theoretically influence the growth and remodeling process of various body tissues over the course of a resistance training program.

The endocrine system of the body adapt to the repeated stimulation of exercise training by: a) altering the intensity of the exercise stimulus necessary to increase or decrease hormone secretion, b) altering the tissue responsiveness to the hormone. This is done by increasing or decreasing the number of circulating proteins that bind the hormone and protect it from degradation but also render it biologically inactive, as well as changing the number of cellular hormone receptors or post receptor function, and c) working through neuroendocrine adaptations to alter basal and maximal hormone secretion (*Roemmich, 2005*). The endocrine environment can have a profound impact on the adaptation process of skeletal muscle to resistance exercise and it is well known that acute as well as long-term resistance training activates a wide variety of neuroendocrine mechanisms (*Kraemer, 1988, Hakkinen, 1989, Kraemer, 1992a*).

Hormonal variables have also been used as indicators of the magnitude of training stress during resistance exercise and other forms of training (*Adlecreutz et al., 1986, Hakkinen et al., 1987, Fry et al., 1993*). It has been noted that chronic hormonal adaptations have been correlated to changes in muscular strength and power for competitive Olympic style weight lifters (*Hakkinen et al., 1987, Fry et al., 2000*), as well as to fiber type alterations in previously untrained men (*Staron et al., 1994*) and consequently, the various hormonal mechanisms probably respond differentially in trained and untrained individuals (*Hakkinen, 1989*).

Role of Testosterone

Testosterone (T), the male sex hormone, is considered to be an anabolic hormone and contributes also to metabolic control (*Viru and Viru, 2005*). The "free: or biologically available T hypothesis, supports the idea that only the free hormone is transported to the target tissues, suggesting that the level of free androgen index (FAI) may be of importance for trainability (*Kraemer et al 1990*). FAI is the ratio of the concentration of T and the sex hormone binding globulin (SHBG), and thus the amount of active T is determined by SHBG concentration (*Remes et al, 1979*). SHBG may also act as a hormone itself and may have a distinct biological activity, as also suggested for other binding proteins (*Rosner, 1991*). The SHBG declines progressively during pubertal phases in healthy boys (*Anderson, 1974*).

Exercise can acutely increase or decrease circulating T, depending on the mode and the intensity of exercise (*Schmid et al., 1982*). Increases occur during and after relatively short, high intensity work such as resistance training or sprint events, while declines are associated with increasing duration endurance events especially marathon and ultra running events (*Kuoppasalmi et al., 1980, Schurmeyer et al., 1984*). In resistance training, the main role of T is the induction of synthesis of contractile proteins in involved muscles. Beside that, during acute resistance exercises, as well as during competition, T action seems to be essential for mobilizing performance capacity (*Viru and Viru, 2005*). Although there is no evidence that T influences the neural adaptations in resistance training, essential is the influence of high preconditioning T levels on central nervous structures. (*Kurz et al., 1986, Araki et al., 1991, Matsumoto, 1992*)

The initial report of *Fahey et al., (1976)* supports the possibility that resistance training may alter hypopituitary axis in younger males. However, studies on the responses of T to resistance training of young males have only recently appeared in the literature (*Kraemer et al., 1989*). The effect of the increase in T in growing individuals due to resistance training on growth and development remains to de studied.

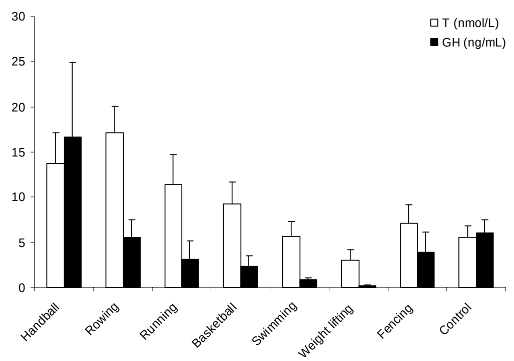

Figure 1. Resting testosterone (T) and growth hormone (GH) in pre-pubertal male athletes of different sports and in non-athletes (Control). Modified with permission from Tsolakis et al. 2003, Hormones: 2(2): 103-112

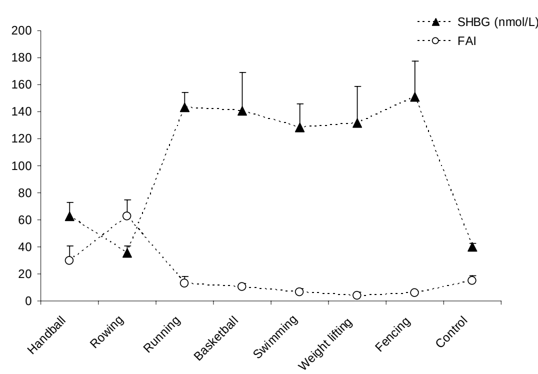

Figure 2. Sex hormone binding globulin (SHBG) and free androgen index (FAI) in pre-pubertal male athletes of different sports and in non-athletes (Control). Modified with permission from Tsolakis et al. 2003, Hormones: 2(2): 103-112

Role of Growth Hormone

Growth hormone (GH) has been linked to the promotion of anabolism in both muscle and connective tissue. Specifically, it enhances cellular amino acid uptake and protein synthesis in skeletal muscle, resulting in hypertrophy of both muscle fiber types (*Crisis et al., 1991*). The anabolic effects of GH result from direct and indirect interactions with androgens (*Jorgensen et al, 1996*), and thyroid hormone (*Weiss and Refetoff, 1996*) and are mediated via IGF-I (*Florini et al., 1996*) The complexity of pituitary production and release of GH and binding proteins is just beginning to be elucidated (*Nindl, 2003*). It appears that GH responses depend upon type, load and volume of exercise. This suggests that a threshold exist for intensity of exercise to elicit a significant response of the hypopituitary axis to resistance exercise (*Kraemer, 1992*). Activation of a relatively large muscle mass also appears to be a vital element of the exercise stimulus to elicit a significant GH response. Resistance exercise workouts that have short rest periods (1 min rest between sets and exercises, moderate-to-high intensities (load: 8-12 RM) and whole body workout protocols (8-10 exercises) results in the highest GH changes in the blood (*Kraemer et al., 1990, 1991, Hakkinen and Pakarinen, 1995, Roemmich and Rogol 1997, Hansen et al., 2001*). Surprisingly, no changes in the resting concentrations of GH have been observed in response to short periods of resistance training in young untrained men (*Kraemer et al., 1998, Kraemer et al., 2005, Hansen et al., 2001*) or even long term trained weight lifters (*Hakkinen et al., 1988, Ahtianen et al., 2003*) at various ages (*Kraemer et al., 1999, Mc Call et al., 1999, Hakkinen et al., 2000*). The response of GH to exercise in children seems to be related to the pubertal and maturity stage of the individual (*Bouix et al., 1994, Marin et al., 1994, Wirth and Gieck, 1994*). Most studies in children and adolescents report resting plasma GH levels (*Caccciari et al., 1990, Mero et al., 1990, Zakas et al., 1994, Tsolakis et al., 2003a,b, 2006*), while there is a scarcity of data for the GH responses to exercise (*Adiyaman et al., 2004; Eliakim et al., 2006*).

Influence of resistance training on T, GH and neuromuscular performance in pre-pubescent, pubescent and adolescent individuals

Since resistance training appears to increase strength in all ages, there appears to be some rationale for recommending resistance training as a means of improving sports performance even during preadolescence. There is insufficient evidence to state unequivocally that resistance training will have a positive effect on sports performance during preadolescence (*Blimkie, 1993*). Improvements in sport performance during preadolescence after different forms of resistance training have also been inferred from more indirect evidence, e.g. improvement in vertical jumping performance (*Mero et al., 1989, 1990a, b, Tsolakis et al., 2003a, b, 2006 in press*). However, even though there is a positive correlation between motor fitness and sports performance the results do not provide unequivocal evidence of a positive effect of resistance training on sports performance during preadolescence years.

The influence of various forms of sports training on the endocrine system has been studied mainly in adults involved in heavy training (*Kraemer and Rogol, 2005*). In fact there are very few data on the relationship between exercise and hormonal levels related to growth and maturation in sedentary pre-pubertal, pubertal and post-pubertal children (*Fahey et al., 1976, Zakas et al., 1993, Tsolakis et al., 2000, 2004*). On the other hand more data exist for athletes in the pre-pubertal (*Mero et al., 1989,1990,a,b, Cacciari et al., 1990, Dally et al.,1998, Tsolakis et al., 2006*) and post-pubertal period (*Fry et al., 1993 Steinacker et al., 1993, Kraemer et al., 1992c, Gorostiaga et al., 1999, 2003*).

Specifically T and FAI mean values have been reported to increase (*Mero et al., 1990, Zakas et al., 1994, Tsolakis et al., 2000, 2004, 2006*), or remain stable *Dally et al., (1998)* following two months to one year training. Some of these studies reported conflicting data on GH levels (*Mero et al., 1990a, b, Zakas et al., 1994, Tsolakis et al., 2006*). However most of these studies have suffered from methodological problems such as the use of small samples sizes that limit their external validity. The impact of acute exercise on the hypopituitary axis of youth has not been widely studied and there is not enough data to draw safe conclusions (*Kraemer et al., 1992b*).

Effects of short and long term resistance training

The effects of short term (2 months) resistance training on hormonal concentrations has been examined in two groups of untrained pre-pubertal and pubertal boys (*Tsolakis et al., 2000*). The mean post - training T concentration of the pre-pubertal group increased by 123%, whereas the respective increase in the pubertal group was 32% (*Tsolakis et al., 2000*). Another study published recently (*Tsolakis et al., 2004*), investigated the influence of two months of resistance training followed by two months of detraining on strength adaptations and selected hormones (T, SHBH) in sedentary pre-pubertal boys. Significant post training isometric strength gains (17.5%) and increases in T and FAI ($p<0.05$-0.001) were observed in the experimental group. Detraining resulted in a significant loss (9.5%, $p<0.001$) of isometric strength whereas the hormonal parameters remained unchanged. The resistance training-induced strength changes were not correlated with changes in the anabolic and androgenic activity. Similar results were observed after six weeks of heavy resistance training in the dynamic strength of upper extremity (23%) and leg extensors (12%) in male 14-16 year old handball players. Moreover a significant increase was observed in throwing velocity in the resistance training group. Muscle hypertrophy did not accompany the strength gains, suggesting specific neurological adaptations (*Gorostiaga et al., 1999*).

The addition of either high or mild intensity cycloergometer training to three month sessions whole body calisthenics significantly increased T and GH levels in pubertal and post-pubertal sedentary boys but not in the pre-pubertal group (*Zakas et al., 1994*). An intensive gymnastic training program (3 h per day) performed by preipubertal male gymnasts was not adequate to alter serum T concentrations over a 10 month period. A possible explanation for this result is that the gymnasts were well adapted to the training (*Daly et al., 1998*). On the other hand, eleven weeks of soccer training combined with a program of explosive strength training resulted in significant increases in vertical jumping performance (14%) and in resting total T concentrations (7.5%) without any significant correlations between changes in performance and T (*Gorostiaga et al., 2003*).

The mean serum testosterone concentration increased significantly after 1 year of specific training in four groups of pre-pubescent athletes (sprinters, tennis players, weight lifters and endurance runners), while GH remained unaltered. Additionally the experimental group increased speed and speed strength. Significant correlations were observed between the relative changes in testosterone, GH and the relative changes in speed. The increased anabolic activity had positive effects on physical performance and trainability at the early stages of puberty (*Mero et al., 1990*).

Influence of specific sports training on hormonal levels

There is a scarcity of data regarding the effects of specific sports training on hormonal levels in young athletes. *Mero et al., (1989),* compared the neuromuscular, metabolic and hormonal profiles of trained pre-pubescent tennis players and an untrained group. Drop jump height was significantly greater ($p<0.05$) in the tennis players than in the control boys. However, there were non significant differences between the group serum hormone levels (*Mero et al., 1990*). Plasma levels of T, SHBG and GH were not different between of junior weight lifters, endurance and sprint runners. Interestingly, T concentration was significantly correlated with jumping performance. It was suggested that the training background and the advanced biological maturation of the athletes affected their strength capacity (*Mero et al., 1990*).

Significant differences were observed in plasma levels of dehydroepiandrosterone sulphate (DHEA-S) and T between pre-pubescent and pubescent football players and untrained controls (*Cacciari et al., 1990*). Plasma levels of T were significantly lower in the pre-pubescent group of athletes and significantly higher in the pubescent group compared to those of the controls. The higher values in pubertal subjects were justified by their advanced maturation level compared to controls, while in pubertal subjects training may produce a decrease in plasma T as in adults (*Lauro et al., 1984, Hackney et al., 1988*).

Tsolakis et al., (2003b) demonstrated the effects of the specificity of training stimulus on the hormonal adaptations among pre-pubertal athletes of different sports. Figures 1 and 2 show the basal concentrations of T, GH, SHBG and FAI in 11-13 years old athletes of various sports (handball, rowing, running, basketball, swimming, weight-lifting and fencing), compared with a control group of untrained children. As can be seen, there are differences in hormonal concentrations between sports, probably because of differences in the content of training programs. The low T and GH in the weight lifting group was not expected, but may possibly be explained by their lower level of maturation compared to the other groups.

Hormonal indices of overtraining and overreaching in young athletes

As also observed in adult studies, the impact of very intense short duration in adolescent athletes of various sports result in significant hormonal changes, indicating a state of overreaching (*Fry et al., 1993, Steinacker et al., 1993, Gorostiaga et al., 1999*). Seven days of high volume resistance training sessions resulted in significant decreases in post exercise T levels in 28 junior elite weight lifters, indicating an impending overtraining syndrome (*Fry et al 1993*) since the high load of training may elicit an excessive endocrine demand in post-pubertal handball players (*Gorostiaga et al., 1999*). Significant increases in T and GH were reported after an acute weight lifting program in the most experienced athletes of the same study, suggesting that training experience in elite adolescent weightlifters is most influential on the hypopituitary-gonadal training adaptations (Kraemer et al., 1992c). T and free T significantly decreased by 20 and 22% ($p<0.05$) after 16 days of high volume intensive rowing training in adolescent rowers. When the training volume decreased by 24% and the intensity was more than double T and free T increased significantly by 23 and 34.5% ($p<0.05$) respectively (Steinacker et al., 1993).

Conclusions

The bulk of the available evidence would suggest that resistance training in children may result in an increase in hormones influencing anabolic activity and has a positive effect in physical performance and trainability even at the early stages of puberty. However, these changes are not always evident, probably due to the different characteristics of the resistance training programs across studies. It seems that there is an "intensity and volume threshold" of resistance training in order to have changes in hormonal concentrations that override the rapid growth process of puberty. Further longitudinal studies are needed to examine the influence of resistance training programs on the mechanisms that control growth and maturation.

References

Adiyaman, P., Ocal, G., Berberoglu, M., Evliyaoglu, O., Aycan, Z., Cetinkaya, E., Bulca,Y., Ersoz, G.and Akar, N. 2004. Alterations in serum growth hormone (GH)/GH dependent ternary complex components (IGF-I, IGFBP-3, ALS, IGF-I/IGFBP-3 molar ratio) and the influence of these alterations on growth pattern in female rhythmic gymnasts. *Journal of Pediatric Endocrinology and Metabolism,* **17(6):** 895-903.

Adlercreutz, H., Harkonen, M., Kuoppasalmi, K., Tikkanen, H., Remes, K., Dessypris, A., and Karvonen, J. 1986. Effect of training on plasma anabolic and catabolic steroid hormones and their response during physical exercise. *International Journal of Sports Medicine,* **7:** S27-S28.

Ahtiainen, J.P., Pakarinen, A., Kraemer, W.J., and Hakkinen, K. 2003. Muscle hypertrophy, hormonal adaptations and strength development during strength training in strength-trained and untrained men. *European Journal of Applied Physiology,* **89:** 555-563.

Anderson, D.C. 1974. Sex hormone binding globulin. Clinical Endocrinology, **3:** 69-96.

Araki, I., Harada, Y., and Kuno, M. 1991. Target-dependent hormonal control of neuron size in the rat spinal nucleus of the bulbocavernosus. *Journal of Neurosciences*, **11:** 3025-3033.

BASES. 2004. Position statement on guidelines for resistance exercise in young people. *Journal of Sports Sciences*, **22:** 383-390.

Blimikie , C.J.R., Ramsay, J., Sale, D., and Mac Dougall, D., and Smith, K. 1989. Effects of 10 weeks of resistance training on strength development on pre-pubertal boys. In: S. Oseid and K-H Carlsen (Eds), *Children and Exercise XIII,* 183-197.Champaign, IL: Human Kinetics.

Blimkie, C.J.R. (1993). Resistance training during preadolescence. *Sports Medicine*, 15(6): 389-407.

Blimkie, C.J.R. and Bar-Or, O. 1996. Trainability of Muscle Strength, Power and Endurance during Childhood. In: *The child and adolescent athlete*. O Bar-Or (ed) Blackwell Science, 113-129.

Boisseau, N., and Delamarche, P. 2000. Metabolic and Hormonal Responses to Exercise in children and Adolescents. *Sports Medicine*, **6:** 405-422.

Bouix, O., Brun, J.F., Fedou, C., Raynard, E., Lenoir, V., and Orsetti, A. 1994. Plasma beta-endorphin corticotrophin and growth hormone to exercise in pubertal and pre-pubertal children. *Hormone and Metabolic Research*, **26(4):** 195-199

Cacciari, E.L., Mazzanti, L., Tassinari, R., Bergamaschi, C., Magnani, F., Zappulla, G., Nanni, C., Cobianchi, T., Ghini, R., and Tani, G.1990. Effects of sport (football) on growth: Auxological, anthropometric and hormonal aspects. *European Journal of Applied Physiology,* **61:** 149-158.

Crist, D.M., Peake, G.T., Loftfield, R.B., Kramer, J.C., and Egan, P.A. 1991. Supplemental growth hormones alter body composition, muscle protein metabolism and serum lipids in fit adults: characterization of dose-dependent and response-recovery effects. *Mechanisms of Ageing and Development*, **58:** 191-205.

Dally, R.M., Rich, P.A., and Klein, R. 1988. Hormonal responses to physical training in high-level peripubertal male gymnasts. *European Journal of Applied Physiology*, **79:** 74-81.

Eliakim, A., Nemet, D., Zaldivar, F., McMurray, R.G., Culler, F.L., Galassetti, P.and Cooper, D.M. 2006. Reduced exercise-associated response of the GH-IGF-I axis and catecholamines in obese children and adolescents. *Journal of Applied Physiology*, **100(5):** 1630-7.

Fahey, T.D, Del Valle-Zuris, A., Ochisen, G., Tried, M., and Seymour, J. 1979. Pubertal stage differences in hormonal and hematological responses to maximal exercise in males. *Journal of Applied Physiology*. **46 (4):** 823-827.

Faigenbaum, A.D., Zaichkowsky, L.D., Wescott, W.L., Micheli, L., and Fehlandt, A.F. 1993. The effects of twice a week strength training program on children. *Paediatric Exercise Science*, **5:** 339-346.

Falk, B. and Tenenbaum, G. 1996. The effectiveness of resistance training in children: a meta analysis. *Sports Medicine*, **22:** 176-186.

Fleck, S.J. and Kraemer, W.J. 1987. *Designing resistance training programs*. Champaign, IL: Human Kinetics.

Florini, J.R., Ewton, D.Z., and Coolican, S.A. 1996. Growth hormone and the insulin-like growth factor system in myogenesis. *Endocrine Reviews*, **17(5):** 481-517.

Fry, A.C., Kraemer, W.J., Stone, M.H., Warren, B.J., Kearney, J.T., Fleck, S.J., and Weseman, C.A. 1993. Endocrine and performance responses to high volume training and amino acid supplementation in elite junior weight lifters. *International Journal of Sports Nutrition,* **3:** 306-322.

Fry, A.C., Kraemer, W.J., Stone, M.H., Koziris, L.P., Thrush, J.T., and Fleck, S.J. 2000. Relationships between serum testosterone, cortisol and weightlifting performance. *Journal of Strength and Conditioning Research*, **14(3):** 338-343.

Fukunaga, T., Funato, K., and Ikegawa, S. 1992. The effects of resistance training on muscle area and strength in pre-pubescent age. *The Annals of Physiological Anthropology,* **11:** 357-364.

Gillam, G.M. 1981. Effects of frequency of weight training on muscle strength enhancement. *Journal of Sports Medicine***, 21:** 432-436.

Gorostiaga, E.M., Izquierdo, M., Iturralde, P., Ruesta, M., and Ibanez, J. 1999. Effects of heavy resistance training on maximal and explosive force production, endurance and serum hormones in adolescent handball players. *European Journal of applied Physiology,* **80:** 485-490.

Gorostiaga, E.M., Izquierdo, M., Ruesta, M., Iribarren, J., Gonzalez-Badillo, J.J., and Ibanez, J. 2004. Strength training effects on physical performance and serum hormones in young soccer players. *European Journal of Applied Physiology*, **91:** 698-707.

Hacney, A.C., Sinning, W.E., and Bruot, B.C. 1988. Reproductive hormonal profiles of endurance-trained and untrained males. *Medicine and Science in sports and Exercise,* **20:** 60-65.

Hakkinen, K., Pakarinen, A., Allen, M., Kauhanen, H., and Komi, P.V. 1987. Relationships between training volume, physical performance capacity and serum hormone concentrations during prolonged training in elite weight lifters. *International Journal of Sports Medicine,* **8(Suppl):** 61-65.

Hakkinen, K. 1989. Neuromuscular and hormonal adaptations during strength and power training. *Journal of Sports Medicine and Physical Phitness*, **29:** 9-24.

Hakkinen, K., Mero, A., and Kauhanen, H. 1989. Specificity of endurance, sprint and strenght training on physical performance capacity in young athletes. *Journal of sports Medicine*, **29:** 27-35.

Hakkinen, K., and Pakarinen, A. 1995. Acute hormonal responses to heavy resistance exercise in men and women at different ages. *International Journal of Sports Medicine,* **16(8):** 507-513.

Hakkinen, K., Pakarinen, A., Allen, M., Kauhanen, H., and Komi, P.V. 1998. Neuromuscular and hormonal adaptations in athletes to strength training in 2 years. *Journal of Applied Physiology*, **65:** 2406-2412.

Hakkinen, K., Pakarinen, A., Kraemer, W.J., Newton, R.U., and Allen, M. 2000. Basal concentrations and acute response of serum hormones and strength development during heavy resistance training in middle-aged and elderly men and women. *Journals of Gerontology.* Series A, Biological Sciences and Medical Sciences, **55:** B95-B105.

Hansen, S., Kvorning, T., Kjaer, M., Sjogaard, G. 2001. The effect of short-term strength training on human skeletal muscle: the importance of physiologically elevated hormone levels. *Scandinavian Journal of sports Medicine*, **11:** 347-354.

Hassan , S.E.A. 1991. Die trainierbarkeit der maxinmalkraft bei 7-bis 13 jahrigen kindern. *Leistungssport,* **5:** 17-24.

Jorgensen, J.O.L., Vahl, N., Hansen, T.B., Fisher, S., Hagen, C., and Christiansen, J.S. 1996. Influence of growth hormone and androgens on body composition in adults. *Hormone Research,* **45:** 94-98.

Kraemer, W.J. 1988. Endocrine responses to resistance exercise. *Medicine Science in sports and Exercise,* 20 (suppl), S152-157.

Kraemer, W.J., Fry, A.C., Frykman, P.N., Conroy, B., and Hoffman, J. 1989 Resistance training and Youth. *Paediatric Exercise Science*. **1:** 336-350.

Kraemer, W.J., Marchitelli, L., Gordon, S.E., Harman, E., Dziados, J.E., Mello, R., Frykman, P., McCurry, D., and Fleck, S.J. 1990. Hormonal and growth factor responses to heavy resistance exercise protocols. *Journal of Applied Physiology,* **69:** 1442-1450.

Kraemer, W.J., Gordon, S.E., Fleck, S.J., Marchitelli, L.J., Mello, R., Dziados, J.E., Friendl, K., and Harman, E. 1991. Endogenous anabolic responses to heavy resistance exercise in males and females. *International Journal of Sports Medicine.* **12(2):** 228-235.

Kraemer, W.J. 1992a. Hormonal Mechanisms Related to the Expression of Muscular Strength and Power. In: *Strength and Power in Sport.* P.V. Komi, (ed). Blackwell Scientific Publications, 64-76.

Kraemer, W.J. 1992b. Endocrine responses and Adaptations to Strength Training In: *Strength and Power in Sport.* P.V. Komi, (ed). Blackwell Scientific Publications, 291-304.

Kraemer, W.J., Fry, A.C., Warren, B.J., Stone, M.H., Fleck, S.J., J.T. Kearney, J.T., Conroy, B.P., Maresh, C.M., Weseman, C.A., Triplett, N.T., and Gordon, S.E.,. 1992c. Acute hormonal responses in elite junior weightlifters. *International Journal of Sports Medicine*, **13 (2):** 103-109.

Kraemer, W.J. and Fleck, S.J. 1993. *Strength training for young athletes*. Champaign, IL. Human Kinetics

Kraemer, W.J., Staron, P.S., Hagerman, F.C., Hikida, R.S., Fry, A.C., Gordon, S.E., Nindl, B.C., Gothshalk, L.A., Volek, J.S., Marx, J.O., Newton, R.U., and Hakkinen, K. 1998. The effects of short-term resistance training on endocrine function in men and women. *European Journal of Applied Physiology*, **78:** 69-76.

Kraemer, W.J., Hakkinen, K., Newton, R.U., Nindl, B.C., Volek, J.S., McCormick, M., Gotsthalk, L.A., Gordon, S.E., Fleck, S.J., Campbell, W.W., Putukian, M., and Evans, W.J. 1999. Effects of heavy resistance training on hormonal response patterns in younger vs older men. *Journal of Applied Physiology,* **87:** 982-992.

Kraemer, W.J. and Rogol, A.D. (2005). *The Endocrine System in Sports and Exercise.* Blackwell Scientific Publications.

Kraemer, W.J., Nindl, B.C., and Gordon, S.E. (2005) Resistance Exercise: Acute and Chronic Changes in Growth Hormone Cncentrations. In: *The Endocrine System in Sports and Exercise.* Kraemer, W.J and A.D., Rogol (eds). Blackwell Scientific Publications, 110-121.

Kuoppasalmi, K., Naveri, H., Harkonen, M., and Adlerkreutz, H. 1980. Plasma cortisol, androstendione, testosterone, and luteinizing hormone in running exercise of different intensities. *Scandinavian Journal of Clinical and Laboratory Investigations*, **40:** 403-409.

Kurtz, E.M., Sengelaub, D.R., and Arnold, A.P. 1986. Androgens regulate the dendritic length of mammalian motoneurons in adulthood. *Science*, **232:** 395-398.

Lauro, P., N. Bergamo, N., R. Bertini, R., S. Dazzi, S., A. Dorigoni, A., G.B. Lanzingher, G.B., Merz, O., Sarti, F., Zanon, B., Passamani, P., Schlecther, P., and Furlanello, F. (1984). Variazioni di alcuni parametric ormonali in atleti della 'Marciaonga'. *Med Sport*, **37 :** 409-417.

Lee, P.A. 1995. Physiology of puberty. In Becker KL, ed. *Principles and practice of endocrinology and metabolism,* 2nd ed. Philadelphia: Lipincott: 822-830.

Mantzoros, C.S., Flier, J.S., and Rogol, A.D. (1997). A longitudinal assessment of hormonal and physical alterations during normal puberty in boys. V. Rising leptin levels may signal the onset of puberty. *Journal of Clinical Endocrinology and Metabolism,* **82:** 1066-1070.

Marin, G., Domene, H.M., Barnes, K.M., Blackwell, B.J., Cassorla, F.G., and Cutler,G.Bjr. 1994. The effects of estrogen priming and puberty on the growth hormone response to standardized treadmill exercise and arginine-insulin in normal girls and boys. *Journal of Clinical Endocrinology and Metabolism*, **79(2):** 537-541.

Matsumoto, A. 1992. Sex steroid induction of synaptic reorganisation in the adult *Neuroendocrine brain Reviews* **3:** 287-306.

McCall, G.E. Byrnes, W.C., Fleck, S.J. and Kraemer, W.J. 1999. Acute and chronic responses to resistance training designed to promote muscle hypertrophy. *Canadian Journal of Applied Physiology*. **24:** 96-107.

Mero, A., Jaakola, L. and Komi, P.V. 1989. Neuromuscular, metaolic and hormonal profiles of young tennis players and untrained boys. *Journal of Sports Sciences*, **7:** 95-100.

Mero, A., Kauhanen, H., Peltola, E., Vuorimaa, T. and Komi, P.V. 1990a Physiological performance capacity in different pre-pubescent athletic groups. *Journal of Sports Medicine and Physical Fitness,* **30:** 57-66

Mero A., Jaakola. L. and Komi, P.V. 1990b. Serum hormones and physical performance capacity in young boys athletes during a 1-year training period. *European Journal of Applied Physiology and Occupational Physiology*, **60:** 32-37.

Mersch, F. and Stoboy, H. 1989. Strength training and muscle hypertrophy in children. In S. Oseid-K-H. Karlsen, (eds) *Children and Execise XIII,* 165-183. Human Kinetics, Champaign IL.

Moritani, T. 1992. Time course of adaptations during strength and power training. In: *Strength and Power in Sport.* P.V. Komi, ed. Blakwell Scientific Publications, 266-278.

Moritani, T. 1993. Neuromuscular adaptations during the acquisition of muscle strength, power and motor tasks. *Journal of Biomechanics*, **26:** 95-107.

Nielsen, B., Nielsen, K., Behrendt-Hansen, M. and Asmusen, E. (1980). Training of functional muscular strength in girls 7-19 years old. In K.Berg and B.D. Eriksson (eds*) Children and Exercise IX*, 69-78. Human Kinetics, Champaign, IL.

Nindl, B.C., Kraemer, W.J., Marx, J.O., Tuckow, A.P. and Hymer, W.C. 2003. Growth hormone molecular heterogeneity and exercise. *Exercise and Sports Science Reviews,* **31(4):** 161-166.

Ozmun, J.C., Mikesky, A.E., and Surburg, P.R. 1994. Neuromuscular adaptations following pre-pubescent strength training. *Medicine Science in Sports and Exercise*, **26:** 510-514.

Pfeifer, R.D. and Francis, R.S. 1986. Effects of strength training on muscle development in pre-pubescent, pubescent and post pubescent males. *Physician and Sports Medicine,* **14:** 134-143.

Ramsay, J.A., Blimkie, C.J.R., Smith, K., Garner, S., Mac Dougal S.D. and Sale, D.G. 1990). Strength training effects in pre-pubescent boys. *Medicine and Science in Sports and Exercise,* **22:** 605-614.

Remes, K., Kuoppasalmi, K. and Adlekreutz, H.. 1979. Effect of long term physical training on plasma testosterone, androstendione, luteinizing hormone and sex hormone binding globulin capacity. *Scandinavian Journal of Clinical Investigation*, **39:** 743-749.

Roemmich, J.N. (2005. Growth, Maturation and Hormonal Changes During Puberty: Influence of Sport Training. In: *The Endocrine System in Sports and Exercise*. Kraemer, W.J and A.D., Rogol (eds). Blackwell Scientific Publications, 512-524.

Roemmich, J.N. and Rogol, A.D. 1997. Exercise and growth hormone: does one affects other? *Journal of Pediatrics*, **131(1pt2):** S75-S80.

Rogol, A.D. 1994. Growth at puberty: interaction of androgen and growth hormone. *Medicine and Science in Sports and Exercise*, **26:** 767 –770.

Rosner, W. 1991. Plasma steroid-binding proteins. *Endocrinology and Metabolism Clinics of North America,* **20(4):** 697-720.

Sailors, M. and Berg, K. 1987. Comparison of responses to weight training in pubescent boys and men. *Journal of Sports Medicine and Physical Fitness*, **27:** 30-37.

Sale, D.G. 1989. Strength training in children. In C.V. Gisolfi and D.R. Lamb (eds) *Perspectives in Exercise Science and Sports Medicine*, Vol. 2 Youth and Exercise and Sport, 165-222. Benchmark Press, Indianapolis..

Schmid, P., Push, H.H., Wolf, W., Pilger, E. and Pessenhofer, H. 1982. Serum FSH, LH, and testosterone in humans after physical exercise. *International Journal of Sports Medicine*, **3:** 84-89.

Schurmeyer, T., Wickings, E.J., Freischeim,C.W. and Nieschlag, E. (1983) Saliva and serum testosterone following oral testosterone undecanoate administration in normal and hypogonadal men. *Acta Endocrinologica*, **102:** 456-462.

Servedio, F.J., Bartels, R.L., Hamlin, R.L., Teske, D., Shafer, T. and Servedio, A. 1985. The effects of weight training using Olympic style lifts on various physiological variables in pre-pubescent boys. *Medicine and Science in sports and Exercise,* 17: 288.

Shephard, R.J. 1984. Physical activity and child health. *Sports Medicine*, **1:** 205-233.

Siegel, J.A., Camaione, D.N. and Manfredi, T.G. (1989) The effects of upper body resistance training on pre-pubescent children. *Paediatric Exercise Science*, **1:** 145-154.

Staron, R.S., Karapondo, D.L., Kraemer, W.J., Fry, A.C., Gordon, S.E., Falkel, J.E., Hagerman,F.C. and Hikida, R.S. 1994. Skeletal muscle adaptation during the early phase of heavy resistance training in men and women**.** *Journal of Applied Physiology*, **76:** 1247-1255.

Steinacker, J.M., Laske, R., Hetzel, W.D., Lormes, W., Liu, Y. and Stauch, M. 1993. Metabolic and Hormonal Reactions During Training in Junior Oarsmen. *International Journal of Sports Medicine*, **14(Suppl),** S24-S28.

Tsolakis, C., Messinins, D., Stergioulas, A. and Dessypris A. 2000. Hormonal responses after strenght training and detraining in pre-pubertal and pubertal boys. *Journal of Strength and Conditioning Research*, **14(4):** 399-404.

Tsolakis, C., Vagenas, G. and Dessypris, A. 2003a. Leptin, Testosterone, GH, body composition and neuromuscular performance in pre-pubescent athletes and untrained boys. *Journal of Strength and Conditioning Research*, **17:** 40-46.

Tsolakis C, Xekouki, P., Kaloupsis, S., Karras, D., Messinis, D., Vagenas, G. and Dessypris, A. 2003b. The influence of exercise on growth hormone and testosterone in pre-pubertal and early pubertal boys. *Hormones,* **2(2):** 13-112.

Tsolakis, C., Vagenas, G. and Dessypris, A. 2004. Strength adaptations and hormonal responses to resistance training and detraining in preadolescent males. *Journal of Strength and Conditioning Research.* **18(3):** 625-629.

Tsolakis, C., Bogdanis, G.C., Vagenas, G. and Dessypris, A. 2006. Influence of a 12-month conditioning program on physical growth, serum hormones and neuromuscular performance of peripubertal male fencers. *Journal of Strength and Conditioning Research* (in press).

Viru, A. and Viru, M. 2005. Resistance Exercise and Testosterone. In: *The Endocrine System in Sports and Exercise.* Kraemer, W.J and A.D., Rogol (eds). Blackwell Scientific Publications, 319-338.

Viru, A.A. 1985. *Hormones in Muscular Activity.* I. Hormonal Enseble in Exercise. CRC Press, Boca Raton, FL: 87.

Weiss, R.E. and Refetoff, S. 1996. Effect of thyroid hormone on growth: lessons from the syndrome of resistance to thyroid hormone. *Endocrinology and Metabolism Clinics of North America,* **25(3):** 719-730.

Weltman, A., Janney, C., Rians, C.B., Strand, K., Berg, B., Tippitt, S., Wise, J., Cahill, B. and Katch, F. 1986. The effects of hydraulic resistance strength training in pre-pubertal males. *Medicine and Science in Sports and Exercise*, 18: 629-638.

Wirth, V.J. and Gieck, J. 1994. Growth hormone: Myths and misconceptions. *Journal of sports Rehabilitation,* **5(3):** 244-250.

Zakas, A., Mandroukas, K., Karamouzis, M. and Panagiotopoulou, G. 1994. Physical training, growth hormone, and testosterone levels and blood pressure in pre-pubertal, pubertal and adolescent boys. *Scandinavian Journal of Medicine and Science in Sports.* **4:** 113-118.

Is There a Positive Relationship between Physical Fitness and Physical Activity in Children? - A Brief Review

Monyeki, M. A.* and Kemper, H.C.G.**
*Lecturer in Human Movement Science in the School of Biokinetics, Recreation and Sport Science, North-West University (Potchefstroom Campus), Potchefstroom, Republic of South Africa.
**Emeritus professor, Senior researcher, EMGO Institute, Faculty of Medicine, VU University Medical Center, Amsterdam, Netherlands.

Abstract

Physical activity is regarded as an important component of a healthy lifestyle. It is a well-known notion that physical activity is strongly related with physical fitness in adults (Blair et al., 1989; Anderson & Haraldsdottir, 1995; Young & Steinhardt, 1993). The aim of this review is to investigate as whether this notion will exist for the Ellisras rural children and children from other studies. Eight out of 11 found published studies which investigated the relationships between physical activity and physical fitness in children were included in the review. The included observational studies met the criteria used in the selection covering physical fitness and physical activity in children between the age from 5 to 14 years old. An overview of Ellisras Longitudinal Study and other 7 eligible studies shared common findings of either few or low and moderate relationship between physical activity and physical fitness and especially with endurance performance does exist. The observed results therefore warrant further investigation on this relationship over a period of time from different cultural contexts.

Key Words: Physical Fitness, Physical Activity, Children, Comparative Review, Health, Chronic Diseases

Introduction

Physical fitness and physical activity of children are issues of current interest among public health and sport sciences professionals. Studies show that an early sign of chronic disease and risk factors for chronic disease like elevated cholesterol and hypertension which may be considered normal at the middle-age population can also be found in young children (*National Institutes of Health, 1996; US Department of Health and Human Services, 1996, World Health Organisation, 2002*). An alarming situation is that current generation of children and youth are often characterized as either physically unfit or physically inactive, or both (*Malina, 1997*). Therefore, the consequences of low aerobic fitness and low levels of physical activity found to be associated with chronic disease risk factors in children (*Davies et al., 1995; Deheeger et al., 1997; Kemper, 2004*).

Physical activity in the physiological terms refers to "…bodily movement produced by skeletal muscles and resulting in energy expenditure (*Bouchard et al., 1990*). Therefore, physical activity may be carried out in different forms or context such as free movement, play, formal exercise, dance, physical education, sport, work, and probably others. Physical fitness in children is classified into twofold context: motor and health-related fitness. The motor fitness includes components of skilled movements, i.e. agility, balance, coordination, power, speed, strength and muscular endurance that enable the individual to perform a great variety of physical activities. Health-related fitness is oriented towards health status and is operationalised in terms of cardiorespiratory function, abdominal and low back musculoskeletal function, and fatness (Malina, 1997). According to the findings by *Malina (1997)* is that in many developed countries, emphasis on the fitness of children and youth has shifted from a primary motor focus to health-related focus over the past 15-20 years. The shift in emphasis to health-related for children and youth is based on either one or both of the following premises related largely to adult health concerns: (1) regular physical activity during childhood and youth may function to prevent or impede the development of several adult diseases which include physical inactivity in a complex, multi-factoral etiology: degenerative diseases of the heart and blood vessels, musculoskeletal disorders of the lower back, obesity and related complications; and (2) habits of regular physical activity during childhood and youth may directly and favorably influence physical activity habits in adulthoods and in turn have beneficial effect on the fitness and health status of adults *(Malina, 1997).*

It is been suggested that physical activity and physical fitness are strongly related (*Livingstone, 1994*). Comparative review studies on this relationship are limited, particularly in South Africa. The aim of this review is therefore, to investigate as whether this relationship will exist for the Ellisras rural children when compared with children from other studies. This review study will be presented by discussing the benefits that can be achieved by participating in physical activity and physical fitness, inclusion criteria and discussion of findings from literature on the relationship between physical fitness and physical activity in children, and recommendations.

Physical Activity and Physical Fitness Benefits to Health

Inactivity has been linked to the development of chronic diseases (*Westernerp, 1999; Grund et al., 2001*). While physical activity is been considered as a modifiable factor for preventing and reducing mortality from many chronic diseases of lifestyle (*National Institutes of Health, 1996; US Department of Health and Human Services, 1996; Bauman & Owen,1999*). In addition it is been suggested that people who are regularly active are more advantaged than the sedentary one's with regard to development of chronic diseases (*Powell, 1997*). Regular physical activity is linked to enhanced health and to reduced risk for all-cause mortality and the development of many chronic diseases (*US Department of Health and Human Services, 1996*). Furthermore, participation in physical activity provides people with substantial physical, social and mental health gains and well-being throughout the entire lifespan (*Gallahue & Ozmun, 1995*).

Physical fitness is the maintenance of basic body functions to get through day-to-day activities around the work place and the house. Cardiorespiratory endurance, or the body capacity to use oxygen efficiently, is often considered the most important health-related component of physical fitness (*Malina, 1997*). Research findings suggested that cardiorespiratory activity can reduce the risk or alleviate the symptoms of cardiovascular disease, obesity, hypertension, high blood cholesterol, and diabetes (*Blair et al., 1989; Pate et al., 1995; National Institutes of Health, 1996; US Department of Health and Human Services, 1996; Williams, 2001*).

Is There A Relationship Between Physcial Fitness And Physical Activity In Ellisras Children And Children From Other Studies?

In answering the research question raised in this review a literature search was performed with the aid of computer through Medline, PUBMED search performed on 18 April 2006, using physical fitness and physical activity as key words. Further, studies included were restricted to those studies which deal with children (i.e. covering the age range from 5 to 14 years) on the relationship between physical fitness and physical activity. The included studies were mostly on cross-sectional design. Eight out of 11 found published studies which were relevant and were included in the review (Table 1). The excluded studies were based on the associations between nutrition or growth, fatness and physical fitness and physical activity or vice versa, or children older than the one included in the selection criteria. Furthermore, some investigating the role of physical activity in obesity/overweight.

Table 1. An overview information of observational studies on physical fitness and physical activity in children

Country	Reference	Number. of subjects studied by gender	Age range (years)
Ellisras (South Africa)	*Monyeki et al. 2005*	212 (112 boys; 100 girls)	7-14
Senegal	*Benefice, 1993;* *Benefice, 1998*	40 (20 boys; 20 girls); 140 (66 boys ; 74 girls)	10 &13; 8.5-13.5
Mozambique	*Prista et al., 1997*	593 (277 boys; 316 girls)	8-14
Taiwan	*Haung and Malina, 2002*	282 (138 boys; 144 girls)	12-14
Estonia	Oja & Jürimäe, 1998	294 (161 boys; 133 girls)	6
Kiel (Germany)	*Grund et al. (2000)*	88 (49 boys; 39 girls)	5-11
Bangor, North Wales	*Rowlands et al., 1999*	34 (17 boys; 17 girls)	8-10

In contrary to what was postulated by *Livingstone (1994)* that it is obvious that activity and fitness are strongly related the reviewed studies showed few relationships (Table 1). **In South Africa**, the cross-sectional findings in 212 boys and girls aged 7-14 year old from the Ellisras Longitudinal Study (*Monyeki et al., 2000*) showed few significant relationships between physical activity and sit-ups, shuttle run and 1600m run in girls, but none in boys (Monyeki et al., 2005).Further, in **Senegal** *Benefice (1992; 1998)* reported low relationships between estimated activity and motor fitness variables. In addition Benefice's study showed gender differences in the relationship between cardiorespiratory fitness and activity in girls, but not in boys.Furthermore, similar results were also found in a study that was done in **Mozambique**, where it was reported that total physical activity was significantly associated with cardiorespiratory endurance run (*Prista et al., 1997*).In **Taiwane** youth 12-14 years of age, estimated energy expenditure in moderate-to-vigorous physical activity was significantly related to the one-mile run and sit-and-reach, but was not related to sit-ups and the sum of skinfolds. After controlling for age, sex, socio-economic status and area of resident, though not significant, were low, 0.12 to 0.19, and the amount of variance accounted for was <5% (*Haung and Malina, 2002*).**Estonian children**, few significant relationships between fitness and activity were observed after the correction for age, height and weight (*Oja & Jürimäe, 1998*). Such relationships were found between activity, plate tapping, flamingo balance, standing broad jump, bent arm hang, handgrip, endurance shuttle run for boys and girls separately.

In **Kiel (Germany),** a study by *Grund et al. (2000)* which investigated the relationships between physical activity, physical fitness, muscle strength and nutritional state in 88 children 5- to 11-year-old revealed no association between energy expenditure and activity with aerobic fitness.

In **Bangor, North Wales**, *Rowlands and colleagues (1999)* in their study which investigated the relationship between habitual daily activity and levels of body fatness and aerobic fitness in 8- to 10-year-old children. In their study significant relationship between aerobic fitness (endurance run on a treadmill) and activity (Tritrac and pedometer) was found.

Implications and the Wayforward

The outcomes of this review study were in contrast with observed strong relationship found in adults' studies on the relationship between physical fitness and physical activity. This may however be a major concern for public health and human movement science professionals, and therefore appeal for further investigation in the relationship between physical fitness and physical activity over a period of time. Criticism made by *Malina (1997)* are that the physical education profession should start to shift emphasis on sport skills and do much on health-related physical fitness such as cardiorespiratory fitness, muscle and power strength. The stated criticism may seem to be relevant for the findings in this review. Moreover, many involved in public health or the health promotion field hold that cardiorespiratory endurance and fitness should be the objective of physical education at all grade levels, particularly in the context of the goals of the Healthy People 2000 (*U.S. Public Health Service, 1990*).

Todate, few studies have examined the relationship between activity and fitness particularly in developing countries like South Africa. Therefore, more studies from different cultural background including Ellisras Longitudinal Study with the emphasis on longitudinal design are needed to confirm or refute the discrepant findings regarding physical fitness and physical activity in children. In addition to activity questionnaire, there is also a need to employ some sophisticated methods of assessing physical activity in children in order to draw a clear conclusion on (1) the relationship between physical fitness and physical activity in children and (2) to unravel the causality of this relationship with randomized control trials with physical activity as the independent and physical fitness as the dependent variable.

References

Anderson, L.B. and Haraldsdottir, J. 1998. Preliminary evidence for activity-fatness relationship in Portuguese adolescents. *Journal of Sports Science*, **16:**31-32.

Araùjo, T., Matsudo, S., Andrade, D., Matsudo, V., Andrade, R., Rocha, A., Andraede, E. and Rocha, J. 1997. Physical fitness and physical activity levels of school children. In J. Welsman, N. Armstrong and B. Kirby. Children and Exercise XIX vol. II, XIXth International Symposium of Pediatric Work Physiology, Exerter, Washington Singer Press, 16-21 September, 91-95.

Bauman, A. and Owen, N. 1999. Physical activity of adult Australians: epidemiological evidence and potential strategies for health gain. *Journal of Science in Medicine of Sport,* **2:** 30-41.

Benefice, E. 1992. Physical activity and anthropometric and functional characteristics of mildly malnourished Senegalese children. *Annals of Tropical Paediatric,* **12:** 55-66.

Benefice, E. 1998. Physical fitness and body composition in relation to physical activity in prepubescent Senegalese children. *American Journal of Human Biology,* **10:** 385-396.

Blair, S.N., Kohl, H.W., Paffenbarger, R.S., Clarke, D.G., Cooper, K.H. and Gibbons, L.W. 1989. Physical fitness and all-cause mortality: a prospective study of healthy men and women. *Journal of American Medical Association,* **262:** 2395-401.

Davies, P.S.W., Gregory, J. and White, A. 1995. Physical activity and body fatness in pres-school children. *International Journal of Obesity,* **19:**6-10.

Deheeger, M., Rolland-Cachera, M.F. and Fontvieille, A.M. 1997. Physical activity and body composition in 10 year old French children: linkages with nutritional intake? *International Journal of Obesity,* **21:** 372-9.

Gallahue, D.L. and Ozmun, J.C. 1997. Understanding Motor Development. Infants, Children, Adolescents, Adults. Boston: McGraw-hill.

Grund, A., Dilba, B., Forberger, K. and Krause, H. 2000. Relationships between physical activity, physical fitness, muscle strength and nutritional state in 5- to 11-year-old children. *European Journal of Applied Physiology,* **82:** 425-438.

Grund, A., Krause, H., Siewers, M., Rieckert M. and Müller, MJ. 2001. Is TV viewing an index of physical activity and fitness in overweight and normal weight children? *Public Health Nutrition,* **4(6):** 1245-1251.

Haung, Y.C. and Malina, R.M. 2002. Physical activity and health-related fitness in Taiwanese Adolescents, *Journal of Physiological Anthropology,* **21(1):** 11-19.

Kemper, H.C.G. 2004. My e-motions Elsevier Gezondheidszorg, Maarssen, pp7-36.

Malina, R.M. 1995. Physical activity and fitness of children and youth: Questions and implications. *Medical Exercise Nutrition and Health,* **4:**123-135.

Malina, R.M. 1997. Activity and fitness of youth: Are they related? Do they track? Exercise and Fitness-Benefits and Risks. *Children & Exercise XVIII*. Edited by K Frosberg, O Lammert, H St. Hansen and C J.R. Blimkie. Odenese University Press, pp161-169.

Monyeki, M.A., Koppes, L.L.J., Kemper, H.C.G., Monyeki, K.D., Toriola, A.L., Pienaar, A.E. and Twisk, J.W.R. 2005. Relationship between physical activity and physical fitness of Ellisras rural primary school children of South Africa, *Journal of Physical Education and Recreation (Hong Kong),* **11(2):** 54-60.

Monyeki, K.D., Cameron, N. and Getz, B. 2000. The Growth and Nutritional status of rural South African children aged 3-10 years old: The Ellisras Growth Study. *American Journal of Human Biology,* **12:** 42-49.

National Institutes of Health. 1996. NIH consensus development panel on physical activity and cardiovascular health. *Journal of American Medical Association,* **276:**241-246.

Oja, L. and Jürimäe, T. 1998. Relationships between physical activity, motor ability, and anthropometric variables in 6-year-old Estonian children. *Medicine and Sport Science*. Basel, Karger, **43:**68-78.

Pate, R.R., Pratt, M., Blair, S.N., et al. 1995. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sport Medicine. *Journal of the American Medical Association,* **273:**402-7.

Powell, K. 1997. Population attribute risk of physical inactivity. In: Leon A, ed. *Physical activity and cardiovascular health.* A national consensus. Champaign, Illinois: Human Kinetics, 40-7.

Prista, A., Marques, A.T. and Maia, J.A.R. 1997. Relationship between physical activity, socioeconomic status and physical fitness of 8-15-year-old youth from Mozambique. *American Journal of Human Biology,* **9:** 449-457.

Rowlands, A.V., Eston, R.G. and Ingledew, D.K. 1999. Relationship between activity levels, aerobic fitness and body fat in 8- to 10-yr-old children. *Journal of Applied Physiology*, **84(4):** 1428-1435.

Sallis, J.F., McKenzie, T.L. and Alcaraz, J.E.1993. Habitual physical activity and health-related physical fitness in fourth-grade children. *American Journal of Disease in Children,* **147:** 890-896.

US Department of Health and Human Services. 1996. Physical activity and health: a report of the Surgeon General. Atlanta, GA: US Department of Health and Human Services, CDC, National Center for Chronic Disease Prevention and Health Promotion.

Westernerp, K.R. 1999. Obesity and physical activity. *Internal Journal of Obesity,* **23(3):** 59-64.

World Health Organisation. 2002. World Health Report 2002: reducing risk-promoting health life. Geneva, Switzerland, p1-248. www.who.int/whr/en.

Young, D.R. and Steinhardt, M.A. 1993. The importance of physical fitness versus physical activity for coronary artery disease risk factors: a cross-sectional analysis. *Research Quarterly for Exercise and Sport*, **64:** 377-384

Cardiorespiratory Training during Childhood and Adolescence

Armstrong*, N., Barrett, L.A. and Welsman,*** J.R.**
*Deputy Vice-Chancellor, Children's Health and Exercise Research Centre (CHERC), University of Exeter, Exeter, EX1 2LU, United Kingdom. Email: N.Armstrong@exeter.ac.uk
**Research Fellow in the CHERC University of Exeter, Exeter, EX1 2LU, United Kingdom.
Email: Laura.A.Barrett@exeter.ac.uk
***Reader in Paediatric Exercise Physiology and Deputy Director of the CHERC. University of Exeter, Exeter, EX1 2LU, United Kingdom. Email : J.R.Welsman@exeter.ac.uk

Abstract

Increasing numbers of young people are participating in sports competitions (Sport England, 2003) and use training programmes to improve their cardiorespiratory (or aerobic) fitness as indicated by peak oxygen uptake (peak VO_2). This paper reviews the scientific bases of training programmes in young people and presents recommendations for training programmes appropriate for enhancing the peak VO_2 of children and adolescents from the age of 8-18 years. From the studies reviewed, 3 to 4 sessions per week, of 40 to 60 minutes duration, at an intensity of 85 to 90% of maximum heart rate, over a period of at least 12 weeks appears to be the minimum volume of exercise required to induce improvements in peak VO_2. Both children and adolescents are capable of increasing their peak VO2 through appropriate exercise training and there is no evidence to suggest that there is a sex difference in responses.

Key Words: Age, Exercise Prescription, Maturation, Peak Oxygen Uptake, Sex

Introduction

The origins of this paper lie in an invitation to participate in the International Olympic Committee Medical Commission consensus statement meeting on "training the elite child athlete" in November 2005. At the end of the conference the expert committee agreed a consensus statement *(International Olympic Committee's Medical Commission, 2005)*. This consensus document provides, in addition to specific training recommendations, information on the principles of training for child athletes and issues related to overtraining. The intention of the document was to improve the health and safety of the elite child athlete through the promotion of safe training principles and increase awareness of these principles amongst the athlete's support team.

An increasing number of young people are now participating in sports competitions. In a survey conducted by Sport England in 2002, 61% of young people were found to take part in sports competitions in or out of school (Sport England, 2003). This represented a rise in participation rates of three percent above those reported in a survey conducted in 1999 and eight percent above those reported in 1994 *(Sport England, 2003)*. In order to improve their performances and chances of success in these competitions young people participate in many different training programmes. Unlike recommendations designed for adults, many of these training programmes are not based on strong scientific evidence.

Exercise prescriptions for improving adults' cardiorespiratory (or aerobic) fitness are well established *(American College of Sports Medicine, 1998)* and some authorities have recommended their application to young people *(Rowland, 1985; American College of Sports Medicine, 1988).* However children and adolescents are not mini adults and as they grow and mature their physiological responses to physical activity and exercise develop as they progress to adulthood (for review see *Armstrong, 2006)*. Consequently, their responses to exercise training may also differ from those of adults.

Despite considerable research into children's and adolescents' responses to exercise training this area still warrants further investigation as small sample sizes and short-duration training programmes limit the extent to which the results of these studies may be generalised. Comparisons of young endurance athletes with non-training controls indicate expected aerobic training effects including increased maximal cardiac output, elevated blood and plasma volume and increased haemoglobin levels. During submaximal exercise reductions in heart rate with concomitant increases in stroke volume have been documented and there is evidence that trained young people exhibit larger myocardial mass and heart volume *(Armstrong and Welsman, 1997)*. Whether or not lung function is enhanced with endurance training in young people remains equivocal with some, but not all, studies indicating higher pulmonary capillarization and pulmonary diffusing capacity in trained individuals. Data on blood lactate responses to maximal and submaximal exercise are also inconclusive with some studies reporting improvements with training but methodological differences hamper comparisons between studies *(Armstrong and Welsman, 1997)*.

Currently however, there are inadequate data to explore evidence-based, dose-response relationships between exercise training and cardiorespiratory outcome measures other than peak VO_2. This paper will therefore review studies that have investigated the effects of structured exercise training on peak VO_2. It is important to note that completion of an exercise training programme to optimise peak VO_2 does not necessarily translate into improved performance in endurance events. Successful performance requires a combination of elements such as speed, strength, flexibility and agility that combine to influence performance.

This paper reviews the scientific bases of exercise training in young people and presents training recommendations for enhancing cardiorespiratory (or aerobic) fitness as reflected by peak VO_2 for children and adolescents within the age range 8 to 18 years.

Method of Review

Relevant studies for review were located through computer searches of Medline, Sport Discus and personal databases, supplemented with an extensive search of bibliographies of accessed publications. Studies were only included in the analysis if they satisfied the following criteria.

- Published in the peer-review literature
- Participants were normal healthy young people
- Included both an experimental and a control group
- Provided a clear training prescription in terms of frequency, duration, intensity and programme length
- Participants were aged 8 years or above as the validity of directly determined peak VO_2 data from younger children is less secure *(Armstrong and Welsman 1997)*

Eighteen studies met the criteria and they are summarised in Tables 1 and 2. Table 1 describes studies of participants aged 8-10 years and Table 2 describes studies of participants aged 11-18 years.

The Effect of Age and Maturation on Responses to Training

It has been hypothesized that a maturational threshold exists whereby prepubescent children are unable to elicit physiological changes in response to training *(Gilliam and Freedson, 1980).* It has been proposed by *Katch (1983)* that there is a critical period in a child's life, a "trigger point", below which the effects of training will be minimal, or will not occur. It is believed that this trigger point is influenced by the modulating effects of hormones that initiate puberty and influence functional development and subsequent organic adaptations *(Katch, 1983).*

One study that supports this hypothesis followed a group of seven Japanese boys from the age of 9.7 – 15.8 years and determined their peak VO_2 annually *(Kobayashi et al., 1978).* The boys trained for 1 – 1.5 h per day, 4 or 5 times a week and engaged in various school based activities including endurance running, football and swimming. Peak VO_2 increased slowly in the boys until 1 year prior to peak height velocity after which peak VO_2 was found to increase above the normal increase attributable to age and growth (i.e. a greater increase was seen in the training group than in the control group). A major limitation of this study, however, was that measurements of peak VO_2 for the control group were not started until after the age of peak height velocity. Indirect supporting evidence for the "trigger point" hypothesis is provided by a study conducted by *Mirwald and colleagues (1981)* who measured peak VO_2 twice yearly in 25 boys from 7 – 17 years of age. From the beginning of the study peak VO_2 was found to be higher in the "active" boys compared with the "inactive" boys but this difference only reached statistical significance at peak height velocity.

In contrast with the findings of these studies, in an often cited report *Weber and colleagues (1976),* studied twelve pairs of identical twin boys where one twin trained and the other acted as his control. There were four sets of twins at each of 10, 13 and 16 years and the training twins followed the same 10-week programme. Percentage changes in the peak VO_2 of the trained boys were 23.5%, 14.2% and 20.5% at ages 10, 13 and 16 years respectively suggesting that the pre and post-pubertal periods were more amenable to training than circumpuberty. In a similar study, *Danis and colleagues (2003)* studied nine pairs of identical twin boys where one twin trained and the other acted as his control. An influence of training in the prepubertal but not in the pubertal twins was found. The findings of these two studies are in conflict with the view that more mature young people are more likely to improve aerobic fitness following training than those who have yet to reach puberty *(Katch, 1983).*

To address this issue, studies meeting the criteria for inclusion in this review were categorised into participants of either 8-10 years of age (Table 1) or 11-18 years of age (Table 2). Analysis of the studies in Tables 1 and 2 reveals that 6 of the 11 studies (55%) in Table 1 (participants <11 years) and 4 of the 7 studies (57%) in Table 2 (participants ≥ 11 years) reported significant increases in peak VO_2 with training. The average increase in mass-related peak VO_2 in studies in Table 1 was 6.5% (compared with an average control group change of – 0.4%) and in Table 2, 5.5% (control group 0.14%).

These figures represent a very crude overview of studies including different training programmes but they are in accord with the changes reported in reviews by Payne and Morrow (1993) and Le Mura and colleagues (1999).

Table 1. Exercise training and peak VO_2: studies with participants under 11 years of age

Study	Participants: Experimental (E)	Participants: Control (C)	Training protocol	Group	Peak VO_2 ($L.min^{-1}$) Pre	Post	Change(%)	Peak VO_2 ($mL.kg^{-1}\cdot min^{-1}$) Pre	Post	Change(%)
Lussier & Buskirk (1977)†	n = 16, 11 B, 5 G, 10.3 y	n = 10, 9 B, 1 G, 10.5 y	**Frequency:** 4 days/wk; **Intensity:** 92% max HR; **Duration:** 45 min; **Length:** 12 wks; **Type:** Continuous running & games	E	1.76	1.96	11.4	55.6	59.4	6.8 *
				C	1.83	1.96	7.1	53.1	53.9	1.5
Gilliam & Freedson (1980)	n = 11, B & G, 8.5 y	n = 12, B & G, 8.5 y	**Frequency:** 4 days/wk; **Intensity:** HR at 165 beats·min^{-1}; **Duration:** 14 - 21 min; **Length:** 12 wks; **Type:** Enhanced PE programme	E	1.29	1.34	3.9	43.4	42.9	-1.2 NS
				C	1.34	1.40	4.5	40.5	40.9	1.0
Becker & Vaccaro (1983)	n = 11 B, 9.6 y	n = 11 B, 10.0 y	**Frequency:** 3 days/wk; **Intensity:** 50% of the way between AT and peak VO_2; **Duration:** 40 min; **Length:** 8 wks; **Type:** Continuous cycling	E	–	–	–	39.0	47.0	20.5 NS
				C	–	–	–	41.7	44.0	5.5
Savage *et al.* (1986)†	2 groups: E_1 n = 12 B, 8.0 y; E_2 n = 8 B, 8.5 y	n = 10 B, 9.0 y	**Frequency:** 3 days/wk; **Intensity:** E_1 85% maxHR, E_2 68% maxHR; **Duration:** 2.4 - 4.8 km; **Length:** 10 wks; **Type:** interval running	E_1	–	–	–	55.9	58.5	4.7 *
				E_2	–	–	–	52.2	54.6	4.6 NS
				C	–	–	–	57.0	55.7	-2.3
Mc Manus *et al.* (1997)†	2 groups: E_1 n = 12 G, 9.3 y; E_2 n = 11 G, 9.8 y	n = 7 G, 9.6 y	**Frequency:** 3 days/wk; **Intensity:** E_1 80-85% maxHR, E_2 max sprints; **Duration:** E_1 20 min, E_2 8 - 16 min; **Length:** 8 wks; **Type:** E_1 continuous cycling, E_2 interval running	E_1	1.30	1.43	10.0	45.4	48.7	7.3 *
				E_2	1.54	1.67	8.4	48.3	50.3	4.1 *
				C	1.49	1.46	-2.0	44.9	43.8	-2.4
Welsman *et al.* (1997)†	2 groups: E_1 n = 18 G, 10.1 y; E_2 n = 17 G, 10.2 y	n = 16 G, 10.2 y	**Frequency:** 3 days/wk; **Intensity:** E_1 80% maxHR, E_2 75 - 80% max HR; **Duration:** E_1 20 min, E_2 20-25 min, E_2 8 - 16 min; **Length:** 8 wks; **Type:** E_1 continuous cycling, E_2 aerobics & circuit training	E_1	1.76	1.79	1.7	51.8	52.2	0.7 NS
				E_2	1.58	1.61	1.9	47.0	47.8	1.7 NS
				C	1.72	1.72	0.0	46.2	45.9	-0.6

B, boys; G, girls; AT, anaerobic threshold; HR, heart rate; † maturity assessed; * indicates significantly different from pretraining value at $P < 0.05$; NS indicates not significantly different from pretraining value at $P < 0.05$.

Table 1. (Continued) Exercise training and peak VO_2: studies with participants under 11 years of age

Study	Participants: Experimenta (E)l	Participants: Control (C)	Training protocol		Peak VO_2 ($L.min^{-1}$) Pre	Post	Change(%)	Peak VO_2 ($mL.kg^{-1}·min^{-1}$) Pre	Post	Change(%)
Tolfrey *et al.* (1998) †	*n* = 12 B,	*n* = 10 B,	**Frequency** 3 days/wk **Intensity** 80% max HR **Duration** 30 min, **Length** 12 wks **Type** Continuous cycling	EB	1.60	1.66	3.8	46.6	47.2	1.3 NS
	10.6 y	10.3 y		EG	1.36	1.54	13.2	39.3	42.4	7.9 NS
	n = 14 G,	*n* = 9 G,		CB	1.62	1.65	1.9	50.7	50.3	-0.1
	10.6 y	10.5 y		CG	1.52	1.52	0.0	44.7	43.0	-3.8
Williams *et al.* (2000) †	2 groups E_1 *n* = 13 B,	*n* = 14 B,	**Frequency** 3 **days/wk** **Intensity** E_1 80 - 85% max HR [1] **,** E_2 max sprints **Duration** E_1 20 min, E_2 6 - 8 min **Length** 8 **wks** **Type** E_1 continuous cycling, E_2 interval running	E_1	1.80	1.93	7.2	54.7	57.5	5.1 NS
	10.1 y	10.1 y		E_2	1.84	1.91	3.8	54.8	56.2	2.6 NS
	E_2 *n* = 12 B,									
	10.1 y			C	1.92	1.97	2.6	56.4	56.7	0.5
Mandigout *et al.* (2001) †	*n* = 18 B,	*n* = 28 B,	**Frequency** 3 **days/wk** **Intensity** **Boys:** 75 -80% max HR continuous , Girls: 90% max HR interval **Duration** Boys-15 - 20 min continuous, Girls-60 - 90 min interval **Length** 13 **wks** **Type** Boys-Continuous, Girls-Interval running aerobic activities	EB	1.70	1.84	8.2	47.2	49.2	4.2 *
	10.7 y	10.5 y		EG	1.30	1.57	20.7	38.6	41.9	8.5 *
	n = 17 G,	*n* = 22 G,		CB	1.60	1.70	6.2	46.1	45.5	-1.3
	10.5 y	10.5 y		CG	1.40	1.50	7.4	39.6	39.5	0.2
Baquet *et al.* (2002) †	*n* = 13 B	*n* = 10 B,	**Frequency** 2 **days/wk** **Intensity** 80 - 95% max HR **Duration:** 30 min, **Length** 7 **wks** **Type** interval running	E	1.54	1.68	9.1	43.9	47.5	8.2 *
	n = 20 G	9.0 y								
	9.5 y			C	1.62	1.62	0.0	46.2	45.3	-1.9
	8.5 y									
Obert *et al.* (2003)	*n* = 9 B,	*n* = 9 B,	**Frequency** 3 **days/wk** **Intensity** **Boys**-80% max HR continuous, **Girls**- 90% max HR interval **Duration** 60 min **Length** 13 **wks** **Type** Boys- continuous running, Girls-interval running	EB	_	_	_	44.1	50.9	15.4 *
	10.5 y	10.7 y		EG	_	_	_	40.9	44.2	8.1 *
	n = 10 G,	*n* = 7 G,		CB	_	_	_	51.5	50.3	-2.3
	10.4 y	10.7 y		CG	_	_	_	42.4	42.6	0.5

B, boys; G, girls; AT, anaerobic threshold; HR, heart rate; † maturity assessed; * indicates significantly different from pretraining value at $P < 0.05$; NS indicates not significantly different from pretraining value at $P < 0.05$.

There is therefore no evidence to indicate a greater effect of training on the peak VO_2 of those 11 years and above than those under 11 years of age. Similarly, of the eight studies which verified the prepubertal status of participants, five (63%) showed a significant increase in peak VO_2 and three reported no significant change. Therefore, despite suggestions of a "maturation threshold" *(Gilliam and Freedson, 1980)* or a "critical or trigger point" *(Katch, 1983)* underpinning trainability, the influence of age and maturation on increasing the peak VO_2 of 8-18 year-olds through training remains to be proven.

The Effect of Sex on Responses to Training

The majority of exercise training studies have recruited boys as participants and others have combined the data of boys and girls during analysis. Consequently, it is difficult to draw any conclusions about the effect of sex on responses to training from the studies presented in this review. Those which have compared the responses of boys and girls have concluded that the increase in peak VO_2 is of the same order in both sexes once initial peak VO_2 values have been taken into account *(Rowland, 1985; Tolfrey et al., 1998; Mandigout et al., 2001)*. Very few studies have addressed the issue of sex differences in response to training and further research is necessary.

Table 2. Exercise training and peak VO_2: studies with participants 11 years of age and above

Study	Participants: Experimenta (E)l	Participants: Control (C)	Training protocol		Peak VO_2 ($L.min^{-1}$) Pre	Post	Change(%)	Peak VO_2 ($mL.kg^{-1}\cdot min^{-1}$) Pre	Post	Change(%)
Massicotte & Macnab(1974)	3 groups *n* = 9 B in each 12.5 y	*n* = 9 B 12.5 y	**Frequency:** 3 **days/wk** **Intensity:** E_1 HR at 170 - 180 beats·min^{-1} E_2 HR at 150 - 160 beats·min^{-1} E_3 HR at 130 - 140 beats·min^{-1} **Duration:** 12 min, **Length:** 6 **wks** **Type:** Continuous cycling	E_1	2.00	2.30	15.0	46.7	51.8	10.8 *
				E_2	1.80	1.90	5.6	47.4	48.0	1.3 NS
				E_3	1.70	1.80	5.9	46.6	48.2	3.4 NS
				C	2.00	1.90	-5.0	45.7	44.2	-3.3
Stewart & Gutin (1976)	*n* = 13 B 10 - 12 y	*n* = 11 B, 10 - 12 y	**Frequency:** 4 **days/wk** **Intensity:** 90% of max HR **Duration:** 25 min, **Length:** 8 **wks** **Type:** interval running	E	_	_	_	49.8	49.5	-0.6 NS
				C	_	_	_	48.4	49.2	1.7
Burkett *et al.* (1985)	*n* = 10 G 15.6 y	*n* = 9 G, 15.6 y	**Frequency:** 5 **days/wk** **Intensity:** 70% of max HR continuous 90% of max HR interval **Duration:** started at 9.7 km·wk^{-1} up to32.2 km·wk, **Length:** 20 **wks** **Type:** continuous & interval running	E	_	_	_	45.1	49.4	9.3 *
				C	_	_	_	43.2	43.2	0.0
Mahon & Vaccaro (1989)	*n* = 8 B 12.4 y	*n* = 8 B, 12.3 y	**Frequency:** 4 **days/wk** **Intensity**70 - 80% max HR continuous 90 - 100% peak VO2, 135% HR at VT interval **Duration:** 20 - 30 min continuous 100 - 800 m (from 1.5 - 2.5 km) interval **Length:** 8 **wks** **Type:** Continuous & interval running	E	1.87	2.04	9.1	45.9	49.4	7.6 *
				C	1.77	1.84	4.0	45.4	45.9	1.1
Rowland & Boyajian (1995) †	*n* = 13 B, *n* = 24 G, 10.9 - 12.8 y	*n* = 13 B, *n* = 24 G, 10.9 - 12.8 y	**Frequency:** 3 **days/wk** **Intensity:** HR at 153 - 184 beats·min^{-1} **Duration:** 20 - 30 min **Length:** 12 **wks** **Type:** Aerobic circuit training distance running/walking games, basketball	E	2.02	2.24	10.9	44.7	47.6	6.5 *
				C	1.96	2.02	0.1	44.3	44.7	0.9
Rowland *et al.* (1996) †	*n* = 11 B, *n* = 20 G, 11.8 y	*n* = 11 B, *n* = 20 G, 11.8 y	**Frequency:** 3 **days/wk** **Intensity:** 87.5% max HR **Duration:** 30 min **Length:** 13 **wks** **Type:** aerobic dance, step aerobics, distance running, circuit activities	EB	2.15	2.29	6.5	45.4	48.2	6.1 NS
				EG	1.81	1.97	8.8	43.9	46.1	5.0 NS
				CB	2.08	2.15	3.4	45.3	45.4	0.2
				CG	1.46	1.81	24.0	43.7	43.9	0.4
Stoedefalke *et al.* (2000) †	*n* = 20 G 13.6 y	*n* = 18 G, 13.7 y	**Frequency** : 3 **days/wk** **Intensity:** : 75 - 85% max HR **Duration:** : 20 min **Length:** : 20 **wks** **Type** : treadmill running, cycle & rowing ergometry, stair stepping, aerobic dance	E	2.25	2.32	3.1 NS	_	_	_
				C	2.39	2.45	2.5	_	_	_

B, boys; G, girls; VT, ventilatory threshold; HR, heart rate; † maturity assessed; * indicates significantly different from pretraining value at $P < 0.05$; NS indicates not significantly different from pretraining value at $P < 0.05$.

Exercise prescription

Training programmes to improve cardiorespiratory fitness depend upon mode, frequency, duration and intensity of exercise and programme length. Each of these elements is discussed in the following sections and the studies summarised in Tables 1 and 2 were examined in detail in order to develop appropriate training guidelines.

Mode

A variety of exercise modes have been used in training studies undertaken with young people. Studies involving continuous exercise *(Massicotte and Macnab, 1974; Lussier and Buskirk, 1977; McManus et al., 1997)*, interval training *(Savage et al., 1986; McManus et al., 1997; Baquet et al., 2002)* and a mix of the two *(Burkett et al., 1985; Mahon and Vaccaro, 1989; Mandigout, et al., 2001; Obert et al., 2003)* have resulted in significant increases in peak VO_2. Similarly, both cycling and running training have produced increases in peak VO_2. It can be concluded that, exercise using large muscle groups, regardless of mode, has the potential to increase peak VO_2. However, studies incorporating both interval and continuous exercise appear to have been the most successful, possibly because the variation retained the participants' interest and attention and facilitated sessions of longer duration. Resistance exercise has also been observed to significantly increase peak VO_2 in two studies following 4 *(Docherty et al., 1987)* and 14 *(Weltman et al., 1986)* weeks of training.

Frequency and Duration

With two exceptions the frequency of training in all studies was 3 to 4 sessions per week. In a study performed by *Burkett and colleagues (1985)* 5 sessions per week were employed and only 2 sessions per week in a study conducted by *Baquet and colleagues (2002)*. Both of these studies demonstrated significant increases in peak VO_2 (i.e. 9.3% and 8.2% respectively).

The duration of sessions varied from 12 to 90 min with most studies in the range 20 to 40 min per session. Interestingly, the study employing a session duration of 12 min reported a significant increase in peak VO_2 only in the group training at high intensity *(Massicotte and Macnab, 1974)*. This indicates the potential importance of training volume (interaction between intensity and duration). In general, training sessions of 40 to 60 min have been the most successful in increasing peak VO_2.

Intensity

The intensity of exercise appears to be crucial and of the 9 studies which have used a training stimulus of 85% to 90% of maximum heart rate (HR max), 7 induced significant increases in peak VO_2. Two studies have specifically addressed training intensity. Savage and colleagues (1986) reported a significant increase in peak VO_2 in boys who trained at 85% of HR max but no increase in peak VO_2 in boys who trained at 70% of HR max. Similarly, Massicotte and Macnab (1974) compared boys who trained for 12 min, 3 times per week for 6 weeks at 66 to 72%, 75 to 80% or 88 to 93% of HR max. Only the group who trained at the highest intensity significantly improved peak VO_2. It is important to note that in both these studies the training groups were not matched for total exercise volume. The duration and frequency of the exercise sessions and the length of the training period were identical for each group. This would result in the boys in the higher intensity exercise groups expending more energy than those in the lower intensity exercise groups and consequently experiencing a greater exercise volume.

Programme Length

The length of training programmes ranged from 6 to 20 weeks but no clear inferences of length of programme on increase in peak VO_2 can be drawn from the available data. For example, *Stoedefalke and colleagues (2000)* trained postmenarcheal girls for 20 weeks without inducing an increase in peak VO_2 whereas *Massicotte and Macnab (1974)* demonstrated a 10.8% increase in peak VO_2 in boys after only 6 weeks of training.

A study conducted by *Obert and colleagues (1996)* is worthy of note because of the high frequency (10 per week) and long duration (60 to 90 min) of sessions and the programme length (52 weeks). The study is, however, limited by the small sample size (5 girls in the experimental group). To maintain consistency between training and assessment mode the pre-test and post-test assessments were carried out using a swim bench ergometer. This limits the ability to compare the results of this study with those that determined peak VO_2 using treadmill or cycle ergometer protocols. Nonetheless, the 29% increase in mass-related peak VO_2 seen as a result of training in the girls who participated in this study is striking. This study highlights the potential importance of long-term, specific training programmes. Given the inconsistency of significant improvements in peak VO_2 identified in studies lasting 7-8 weeks and the failure of some 12-week programmes to enhance peak VO_2 it seems prudent to recommend minimum programme duration of 12 weeks.

Conclusion

Current evidence does not support the view that prepubescent children cannot respond to exercise training. Detailed review of the literature suggests that if exercise volume is sufficient young people's peak VO_2 can be enhanced with training with typical increases of 6%. Few studies have examined sex differences in the trainability of young peoples' peak VO_2 but the available data do not indicate this to be a factor. From careful scrutiny of the studies summarised in Tables 1 and 2 appropriate guidelines for exercise training to improve young peoples' peak VO_2 were developed and are outlined in Table 3. These guidelines are recommended to improve cardiorespiratory (or aerobic) fitness as reflected by peak VO_2. Additional training would be necessary to improve other elements important for success in endurance performance.

Table 3. Exercise Prescription

Mode	Mixture of continuous exercise and interval training using large muscle groups
Frequency	Minimum 3 to 4 sessions per week
Duration	40 to 60 minutes
Intensity	85 to 90% of maximum heart rate
Programme length	Minimum length of 12 weeks

References

American College of Sports Medicine 1988. Physical Fitness in Children and Youth : An Opinion Statement. *Medicine and Science in Sports and Exercise* **20:** 422-423.

American College of Sports Medicine 1998. The recommended quantity and quality of exercise for development and maintaining cardiorespiratory and muscular fitness and flexibility in health adults. *Medicine and Science in Sports and Exercise* **30:** 975-991.

Armstrong, N., Ed. 2006. Paediatric exercise physiology. Edinburgh, Churchill Livingstone.

Armstrong, N. and Welsman, J. 1997. *Young people and physical activity*. Oxford, Oxford University Press.

Baquet, G., Berthoin, S., Dupont, G., Blondel, N., Fabre , C. and Praagh, E. van. 2002. Effects of high intensity intermittent training on peak VO_2 in prepubertal children. *International Journal of Sports Medicine* **23:** 439-44.

Burkett, L. N., Fernhall, B.and Walters, S. C. 1985. Physiologic Effects of Distance Running Training on Teenage Females. *Research Quarterly for Exercise and Sport* **56:** 215-220.

Danis, A., Y. Kyriazis and Klissouras, V.2003. The Effect of Training in Male Prepubertal and Pubertal Monozygotic Twins. *European Journal of Applied Physiology* **89:** 309-318.

Docherty, D., H. A. Wenger and M. L. Collis 1987. The Effects of Resistance Training on Aerobic and Anaerobic Power in Young Boys. *Medicine and Science in Sports and Exercise* **19:** 389-392.

Gilliam, T. B. and Freedson, P. S.1980. Effects of a 12 Week School Physical Fitness Program on Peak VO_2, Body Composition and Blood Lipids in 7 to 9 Year Old Children. *International Journal of Sports Medicine* **1:** 73-78.

International Olympic Committee's Medical Commission 2005. IOC Consensus Statement on Training the Elite Child Athlete. **2005**.

Katch, V. L. 1983. Physical Conditioning of Children. *Journal of Adolescence Health Care* **3:** 241-246.

Kobayashi, K., Kitamura, K., Miura, M., Sodeyama, H. , Murase, Y. and Miyashita, M.1978. Aerobic Power as Related to Body Growth and Training in Japanese Boys: a Longitudinal Study. *Journal of Applied Physiology* **44:** 666-672.

LeMura, L. M., Dullivard, S. P. von and Carlonas, R. 1999. Can exercise training improve maximal aerobic power (VO_2 max) in children: a meta-analytic review. *Journal of Exercise Physiology online* **2:** 1-14.

Lussier, L. and Buskirk, E. R. 1977. Effects of an Endurance Training Regimen on Assessment of Work Capacity in Prepubertal Children. *Annals New York Academy of Sciences* **30:** 734-747.

Mahon, A. D. and Vaccaro, P.1989. Ventilatory Threshold and VO_2 max Changes in Children Following Endurance Training. *Medicine and Science in Sports and Exercise* **21:** 425-431.

Mandigout, S., Lecoq, A. M., Courteix, D., Guenon, P. and Obert, P. 2001. Effect of Gender in Response to an Aerobic Training Programme in Prepubertal Children. *Acta Paediatrica* **90:** 9-15.

Massicotte, D. R. and Macnab, R. B. J.1974. Cardiorespiratory adaptations to training at specified intensities in children. *Medicine and Science in Sports* **6:** 242-246.

McManus, A. M., Armstrong, N.and Williams, C. A. 1997. Effect of Training on The Aerobic Power and Anaerobic Performance of Prepubertal Girls. *Acta Paediatrica* **86:** 456-459.

Mirwald, R. L., D. A. Bailey, Cameron, N. and Rasmussen, R. L. 1981. Longitudinal Comparison of Aerobic Power in Active and Inactive Boys Aged 7.0 to 17.0 Years. *Annals of Human Biology* **8:** 405-414.

Obert, P., Courteix, D., Lecoq, A. M.and Guenon, P. 1996. Effect of long-term intense swimming training on the upper body peak oxygen uptake of prepubertal girls. *European Journal of Applied Physiology* **73:** 136-143.

Obert, P., Mandigout, S., Nottin, S., Vinet, A., N'Guyen L. D. and Lecoq, A. M. 2003. Cardiovascular Responses to Endurance Training in Children : Effect of Gender. *European Journal of Clinical Investigation* **33:** 199-208.

Payne, G. V. and Morrow, J. R. 1993. Exercise and VO_2 max in children: A meta-analysis. *Research Quarterly for Exercise and Sport* **64:** 305-313.

Rowland, T. W. 1985. Aerobic response to endurance training in prepubescent children: a critical analysis. *Medicine and Science in Sports and Exercise* **17:** 493-7.

Savage, M. P., Petratis, M. M., Thomson, W. H., Berg, K., Smith, J. L.and Sady, S.P. 1986. Exercise training effects on serum lipids of prepubescent boys and adult men. *Medicine and Science in Sports and Exercise* **18:** 197-204.

Sport England 2003. *Young people and sport in England. Trends in participation 1994 - 2002*. London, Sport England.

Stoedefalke, K., Armstrong, N., Kirby, B. J. and Welsman , J. R. 2000. Effect of Training on Peak Oxygen Uptake and Blood Lipids in 13 to 14 - Year Old Girls. *Acta Paediatrica* **89:** 1290-1294.

Tolfrey, K., Campbell, I. G.and Batterham, A. M.1998. Aerobic Trainability of Prepubertal Boys and Girls. *Pediatric Exercise Science* **10:** 248-263.

Weber, G., Kartodihardjo, W. and Klissouras, V. 1976. Growth and Physical Training with Reference to Heredity. *Journal of Applied Physiology* **40:** 211-215.

Weltman, A., Janney, C., Rians, C. B., Strand, K., Berg, B., Tippett S., Wise, J., Cahill B. R.and Katch, F. I.1986. The Effects of Hydraulic Resistance Strength Training in Pre-pubertal Males. *Medicine and Science in Sports and Exercise* **18:** 629-638.

Parent-Offspring Correlations in Body Measurements, Physique and Physiological Variables among Santhals of West Bengal

Ghosh, Sudipta and Malik, S.L.
Department of Anthropology, University of Delhi, Delhi-110007

Abstract

Intrafamilial resemblances in different morpho-physiological variables were examined among Santhals, a tribal population from West Bengal. Data were collected on 400 families that included 400 fathers, 400 mothers, 292 sons and 170 daughters. The parent-offspring and mid-parent-offspring correlation coefficients reveal that the degree of resemblance varies considerably from one measurement to another. Relationship between the parental and the filial generation is stronger in the transverse and longitudinal measurements, followed by head and face measurements and the weakest in the circumferential and bulk measurements.

Key Words: Body Measurements, Somatotype, Santhals, Parent-Offspring Correlations, Familial Resemblance,Tribe

Introduction

Morpho-physiological features are the product of continuous and complex interaction of biological or indigenous and environmental or exogenous factors. Biological factors influencing these characteristics, among other, are heredity or genetics, age and sex of an individual. Exogenous factors, on the other hand, include both environmental and socio-cultural factors such as nutrition, altitude, climate, socio-economic status, religious practices, cultural activities and mode of subsistence.

It is now well established that both environmental and genetic factors contribute to the patterns of growth and development of different body measurements (*Devi and Reddi, 1983*). Therefore, all the anthropometric traits are the result of the influence of either genetic or environmental factors, or combinations of both (*Susanne, 1975*). The influence of genetic and environmental factors in anthropometric traits indicates varying degree of hereditary control over their phenotypic expression (*Singh, 1992*). In terms of phenotypic resemblances of relatives, correlations among parent-offspring probably provide the best estimates of the genetic resemblance of parent and children in human populations (*Mueller, 1976*). The parent–offspring and mid-parent–offspring correlation coefficients indicate that to what extent genetic determination varies from one measurement to another (*Susanne, 1975*). Correlations among first degree relatives, i.e. parent–offspring and sib–sib pairs with respect to body size are affected by assortative mating and common household environment (*Malik and Singh, 1996*). In a panmictic population, for polygenic traits, correlation coefficient for mid-parent–offspring and parent–offspring would occur 0.71 and 0.50 respectively, though the observed correlation coefficient are mostly lower than the expected values both for mid-parent– offspring and parent– offspring (*Susanne, 1975*).

Further, it is useful and imperative to study the familial resemblance of a trait under different environmental conditions and in different ethnic groups, as heritability and familial resemblance is a property not only of a trait but is also a function of the population (*Falconer, 1960*). Gene frequencies and environmental causes of variation may differ among populations and cause fluctuations in parent-offspring correlation of a particular trait.

The question of the genetic contribution to anthropometric measurements is frequently raised. Several investigators have reported that human variations in different anthropometric measurements are closely associated with the differences in their nutritional status. However, there are less number of studies examining the role of genetics and environment on anthropometric measurements in different regions, especially in Indian tribal populations. Internationally, there have been investigations on intrafamilial correlations involving parents and their children for morpho-physiological parameters in a variety of populations representing different genetic and environmental backgrounds (*Susanne, 1975; Rao et al., 1975; Mueller, 1976; Russell, 1976; Roberts et al., 1978; Bouchard et al., 1980; Sanchez-Andres and Mesa, 1994; Katzmarzyk et al., 2000; Rebato et al., 2000; Perusse et al., 2000; Burke et al., 2001; Safer et al., 2001; Koziel, 2001; Coady et al., 2002; Hunt et al., 2002; Skaric-Juric, 2003; Salces et al., 2003 and 2004*).

It is ideal to conduct Anthropological research on a homogenous population where hereditary aspects of a trait can be examined with less error and contamination. Like any tribal population, Santhals of West Bengal are close knit homogenous population, prerequisite for familial study, where tribe endogamy and clan exogamy are strictly followed during marriages. Keeping these objectives in mind, a study was carried out to investigate intrafamilial resemblance of consanguineal relatives, i.e. parent–offspring to study the relative effect of heredity and environment on various morpho-physiological traits among the Santhals of West Bengal. In order to meet the aim of the present study, a number of anthropometric measurements, somatotype components and physiological parameters have been taken into considerations.

Materials and Methods

The Sample: Cross-sectional sample of 400 Santhal families, consisting of 1262 individuals, were surveyed from 18 villages of Ranibandh block of Bankura district of West Bengal. The selection of the district, block and the villages was based on Multi-stage random cluster sampling. Unit of the study was a family having ever married women, her husband and at least one of their adult children. In the present study, an ever-married woman from each selected family has been henceforth referred as ‘Mother’, her husband as ‘Father’, their sons as ‘Son’ and their daughters as ‘Daughter’. Parent-Offspring (PO) resemblances in morpho-physiological variables of Santhals were examined for four familial correlations [Father-Son (FS), Father-Daughter (FD), Mother-Son (MS) and Mother-Daughter (MD)]. Similarly, in Mid-Parent-Offspring (MPO), familial correlations for Mid-Parent-Son (MPS) and Mid-Parent-Daughter (MPD) were estimated simultaneously. If available, in a family data on both son and daughter, but not on two sons or two daughters were collected. In case of multiple adult children in a family simple random sampling was used to select: (i) one son, (ii) one daughter or (iii) one son and one daughter, as the case may be. The subjects comprised 400 Fathers, aged 40-87 years (mean age 57.5 years); 400 Mothers, aged 35-83 years (mean age 48.6 years); 292 Sons, aged 18-63 years (mean age 26.3 years) and 170 Daughters, aged 18-50 years (mean age 24.5 years).

Nearly 85 percent of such families that met the requirement were covered from these 18 villages. Anthropometric and physiological measurements were taken on each subject. Date of birth of subjects was recorded by asking them. In case of doubt it was verified by other sources. Decimal age of each subject was calculated by subtracting the date of birth of the subject from the date of data collection, using the decimal age calendar (*Tanner et al., 1969*). All the subjects between 25.500 and 26.500 years were classified in the age group 26 years, whereas those falling between 48.500 and 49.500 were included in the age group of 49 years and so on.

The Place: West Bengal, with an area of 88,752 km^2, is the most densely populated state in the country (904 persons living per km^2) having a total population of 80,221,171 (*Census, 2001*). Bankura district is one of the districts of the state of West Bengal with a total land area of 6,882 km^2. The district is situated at the latitude of $23^0 12^/$ and the longitude of $87^0 6^/$. Located in the western part of the state, Bankura is situated on the northern bank of the river Dhaleshwari (Dhalkisor). The district is bordered by Bardhaman in its north, Puruliya in its west, Hugli in its east and Midnapur in its south. Bankura is a district with high percentage of tribal population. Cultivation is the main source of income. The total population of Bankura is 31, 91,822, as per *2001 census*, constitute 4 percent of the state's population. The total number of Schedule tribe population is 3, 29,080 out of which 16, 5843 are males and 16, 3237 are females. Schedule caste (31.4%) and schedule tribe (10.3%) constitute 41.7 percent of the district population that is higher than the state's contribution (29.2%). The district has a population density of 464 persons per km^2, which is lower compared to 904 of the state. Percentage of the urban population is the lowest (7.37%) as compared to the other districts of the state. Sex ratio of 953 is the highest, as compared to the other districts of West Bengal and it is slightly higher than that of the state average of 951 as well as national figures (*Census, 2001*). According to 2001 census, literacy in Bankura is 77.21% among males and 49.80% among females.

Ranibandh block is one of the 22 Community Development Blocks of district Bankura. The total land area of the block is 428 km^2 with a population density (244 per km^2), the lowest as compared to the other blocks. The total population of the block is 1,08,591. The sex ratio of Ranibandh (964 females per 1000 males) is the highest as compared to the other blocks and is also higher than that of the district, as well as the state average. The total number of tribal population of this block is 49,321 out of these 24,912 are males and 24,409 are females. 55,550 of the total population (including both tribal and non-tribal) are literates in this block, out of which 36,238 are males and 19,312 are females (*Census, 2001*). The tribal populations inhibiting in Ranibandh block are Santhal, Sardar, Munda and Bumij. Of these, Santhals are the highest in number. The area is undulating, relatively hard and is reddish lateritic in nature. Ranibandh is predominantly a Santhal region and some of the villages are exclusively occupied by them. The block has 208 villages that are governed by 8 Gram Panchayats, namely, 1) Puddi, 2) Ambikanagar, 3) Rajakata, 4) Rudra, 5) Haludkanali, 6) Ranibandh, 7) Barikul, and 8) Raotora.

The Population: Santhals are the third largest tribal community in India after the Gonds and the Bhils. The Santhal inhabit in a wide area of West Bengal, Bihar, and Orissa. Their main concentration is in Bihar, mainly in the Santhal Paragana. In West Bengal, they are mainly distributed in the district of Malda, Birbhum, Bankura, Midnapur and 24th Paragana.Their habitational places are generally covered with the forest and the hills. These are intercepted by numerous streams and springs. In some parts, there are ranges of low hills, while in others, the conical shaped hills rise abruptly from the undulating plains. Most part of the countryside is covered with the Sal forest that contributes to the well being of the dwellers. The area in the plain is characterized with the lateritic reddish soil having scanty water supply.

The Santhals belong to the Proto-Australoid, according to Guha (*Guha, 1944*), who considered that they arrived in India soon after the Negritos. Santhals are the largest tribe to retain an aboriginal language, known as *Santali,* belonging to Austro-Asiatic, sub-family of the Austric family. This language is closely related to Mundari as well as Ho, Korku, Savara and Gadaba languages spoken by nearby inhabiting smaller tribes (*Culshaw, 1949*). The Santhals have been living in southern and western part of the West Bengal for at least five hundred years. It has been found that few of the Santhal villages in Bankura district are over three hundred years old.

The primary occupation of the Santhals is agriculture, while food gathering and hunting are their important subsidiary occupations. In addition, animal husbandry also contributes marginally to their livelihood. Both men and women take part in agricultural activities, with a division of labor on the basis of gender. Women are tabooed from ploughing the field. Otherwise, both the genders take equal part in transplanting, deweeding, reaping, thrashing, winnowing, and husking. Santhals are expert hunters who hunt a variety of animals that are available in their surrounding forests. Fishing is additional economic activity of the Santhals. They fish in river, ponds and other water- logged areas with the help of nets, traps, bow and arrows. They also do fishing with the help of poisonous plants. Between the harvest and the spring festival, a period, which corresponds with the cold weather, most of the villagers of the Bankura district, migrate to the east, for work in the harvest fields of the Ganges delta.

The community life of the Santhals hovers around their village. The houses are built on either side of the village street, which is wide enough to cross two bullock carts at a time. This kind of settlement is known as linear type settlement pattern. Every house has its main door's opening on to the village street, but the entrance of each hut or room never faces the street, instead it faces the small courtyard of the house. The huts are generally two-sloped gable shaped, though four-sloped huts are also not very rare.

The staple food of the Santhals is boiled rice, locally known as *daka*. They usually take meals thrice a day. In the morning they take breakfast, known as *basiam*. It consists of a small quantity of cold rice or rice gruel, prepared with the evening meal of the previous day and is kept for the morning. In the morning they eat that with salt. For lunch and dinner they have hot boiled rice with vegetable curry (*utu*). When available their vegetable diet is supplemented with fish and meat.

Since Santhals live in a patrilineal society, every male of their society has to undergo an initiation rite through the *Cacho chhatiar* ceremony by which he becomes an effective member of the society and enjoys the rights, duties and privileges of a full-fledged member (*Mukherjee, 1962*). Marriage is not permissible for those who do not performs this rite, and those who die without observing this ceremony will be buried instead of cremated after their death. In a Santhal society a political unit, named *Panchayat*, maintain law and order in the society. It governs by a number of officials. The village headman or *Manjhi* is the man of greatest consequence in the community. The post of the village headman is hereditary; the eldest son of the headman becomes the next headman. There is often a deputy headman, the *Paranik*, who works as an adviser. Another important position in the political organization is the post of the *Jogmanjhi*, who is a kind of "censor of morals", according to *Culshaw* (*1948*). He is the guardian of the morals of the young men in the village, and his wife gives moral lessons to the young women. *Naeke*, the village priest, is entrusted with the duties of worshiping the village deities. The humblest of the village officials is the *Godet*, the messenger of the headman. When a child is born or a villager dies, it is the *Godet* who carries the news to all the houses.

The Santhals are divided into 12 exogamous totemic clans, locally known as *Paris*. These are: 1) *Hansda*, 2) *Marndi*, 3) *Soren*, 4) *Hembrom*, 5) *Tudu*, 6) *Kisku*, 7) *Murmu*, 8) *Baske*, 9) *Besra*, 10) *Pauria*, 11) *Chore* and 12) *Bedea* (*Datta-Majumdar, 1956*). *Pauria*, *Chore* and *Bedea* clans are on the verge of extinction and not even a single member of these three clans was found during the present study. The clans are strictly exogamous in nature and there are no intra-clan marriages. Generally members of a clan may marry person of another clan, with two exceptions. The first exception prohibits marriage between a *Marndi* and a *Kisku* and the second prohibits the marriage of a *Tudu* and a *Besra*, both because of the quarrel between these clans. In marriage system, monogamous marriage is the most prevalent one among Santhals, though polygynous marriage is also found in some cases. There are seven accepted forms of marriages or *Bapla* namely, *Kring Bahu Bapla*, *Ghardi Jawae Bapla*, *Itut Bapla*, *Sanga Bapla*, *Kiring Jawae Bapla, Tunki Dipil Bapla* and *Nirbolok Bapla*.

The supreme deity in Santhal religion is termed as *Maran Buru*, who is believed to be the giver of life, rain, crops and all other necessaries. *Maran Buru* is also referred to as *Thakur*. *Cando, Sin Cando, Cando Bonga and Sin Bonga*, all of which stands primarily for Sun God, often refer to as the synonyms of *Maran Buru*.

Measurements: Following anthropometric measurements were taken by using standard methods (*Martin and Saller, 1957; Tanner et al., 1969*). These measurements are; 1) Height vertex, 2) Sitting height vertex, 3) Total upper extremity length, 4) Total upper arm length, 5) Total fore arm length, 6) Hand length, 7) Total lower extremity length and 8) Head cum neck segment, 9) Body Weight, 10) Biacromial breadth, 11) Bicristal breadth, 12) Head circumference, 13) Mid upper arm circumference, 14) Mid calf circumference, 15) Head length, 16) Head breadth, 17) Nasal height, 18) Nasal breadth, 19) Bizygomatic breadth, 20) Bigonial breadth and 21) Total facial height.

In addition, physiological parameters like, I) Blood pressure (both Systolic and Diastolic), II) Heart rate, III) Pulse rate and IV) Handgrip strength were collected from each subject.

Further, somatotype was rated by using Heath and Carter's anthropometric method (*Carter, 1980*). Somatotype components were determined using the equations of Heath and Carter (*Heath and Carter, 1967*) as follows:

Endomorphy (relative fatness) was calculated from the sum of the triceps, subscapular and suprailiac skinfolds and was adjusted for stature.

$$\text{Endomorphy} = -0.7182 + 0.1415\,(X) - 0.00068\,(X)^2 + 0.0000014\,(X)^3$$

Where, X is the sum of skinfolds at triceps, subscapular and suprailiac.

In the next step, Endomorphy was corrected with Height, using the following equation:

Height corrected Endomorphy = Endomorphy * 170.18 / Height.

Mesomorphy (relative musculo-skeletal development) was derived from the humerus and femur breadths and from flexed arm and calf girths corrected for the corresponding skinfold thickness (triceps or medial calf).

Mesomorphy = (0.858* Bicondylar humerus + 0.601*Bicondylar femur + 0.188 *Corrected mid upper arm circumference + 0.161*Corrected mid calf circumference) – (Height * 0.131) + 4.50

Where,

Corrected Mid upper arm circumference = Mid upper arm circumference (cm) – Skinfold at triceps (mm) / 10 and

Corrected calf circumference = Calf circumference (cm) – Skinfold at calf (mm) / 10.

Ectomorphy (relative linearity) was based on a height-weight ratio.

$$HWR = \frac{Height}{\sqrt[3]{Weight}}$$

When, HWR > 40.75, then

Ectomorphy = HWR*0.732 – 28.58

When HWR < 40.75 > 38.25, then

Ectomorphy = HWR*0.463 – 17.63

When HWR ≤ 38.25, then

Ectomorphy = 0.1

Statistical Analysis

In statistical analysis, mean, standard error and coefficient of variation were estimated in Fathers (400), Mothers (400), Sons (292) and Daughters (170) for above mentioned anthropometric measurements, somatotype components and physiological variables by using computerized statistical softwares, viz. SPSS and MS Excel. Additionally, partial correlations were calculated for above-mentioned morpho-physiological variables in four familial pairs of parent and offspring, e.g., Father-Son (FS), Mother-Son (MS), Father-Daughter (FD) and Mother-Daughter (MD). Furthermore, mid-parent-offspring partial correlations were calculated for the same measurements. T-test was anticipated to examine the significance of four pairs of parent-offspring as well as mid-parent-offspring correlations for these measurements. Finally, Z-test was estimated to analyze the significance of the difference between mid-parent-son and mid-parent-daughter correlations for different morpho-physiological variables and somatotype components.

Results and Discussion

Results of present study of Parent-Offspring resemblances in morpho-physiological variables among Santhals of West Bengal are presented in three categories, viz. Body measurements, Body physique and Physiological variables.

Body Measurements: In Santhals, Son and Daughter are markedly taller and heavier with longer extremities, bigger bone widths and circumferences than Father and Mother respectively (Table 1). On the other hand, Father and Mother show higher mean values in most of the head and face measurements, like Head length, Nasal height, Nasal breadth, Bigonial breath and Total facial height, than Son and Daughter respectively. Among these four groups of Santhals, i.e. Father, Mother, Son and Daughter, Son have greater mean values in most of the body measurements, except for segmental measurements of upper extremity and head and face measurements, where Father show marginally higher values. Sex differences are evident in this population, as Father and Son have relatively higher mean values than Mother and Daughter in all the body measurements, except for Bicristal breadth, which is comparatively greater in Mother.

Table 1. Descriptive statistics of Body measurements of Father, Mother, Son and Daughter

Body Measurements	Father (400)			Mother (400)			Son (292)			Daughter (170)		
	Mean	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*
Height vertex, cm	159.84	3.94	0.32	148.94	3.82	0.29	162.88	3.87	0.37	150.79	3.96	0.46
Sitting height vertex, cm	79.29	4.86	0.19	73.71	4.82	0.18	81.10	4.61	0.22	74.51	4.31	0.25
Total upper extremity length, cm	74.39	5.12	0.01	67.17	4.88	0.16	74.37	5.30	0.23	67.58	9.78	0.50
Total upper arm length, cm	30.20	7.95	0.12	26.76	7.44	0.10	30.26	8.03	0.14	27.15	8.33	0.17
Total fore arm length, cm	26.16	6.28	0.08	23.92	6.66	0.08	26.11	6.58	0.10	24.13	8.59	0.16
Hand length, cm	18.03	9.77	0.09	16.49	9.02	0.07	18.00	8.05	0.09	16.29	11.84	0.15
Total lower extremity length, cm	91.70	4.69	0.22	88.16	4.16	0.18	92.29	5.24	0.28	88.32	4.78	0.32
Head cum neck segment, cm	28.72	9.04	0.13	27.67	8.72	0.12	30.32	7.65	0.14	28.22	10.96	0.24
Body weight, kg	47.15	14.29	0.34	41.38	16.05	0.33	51.94	12.01	0.37	42.86	13.65	0.45
Biacromial breadth, cm	37.96	6.42	0.12	35.14	6.69	0.12	39.45	6.43	0.15	35.87	6.08	0.17
Bicristal breadth, cm	27.09	6.96	0.09	29.97	7.25	0.10	27.55	7.04	0.11	26.49	6.37	0.13
Head circumference, cm	54.87	3.20	0.09	54.20	2.95	0.08	55.55	2.80	0.09	54.25	2.59	0.11
Mid upper arm circumference, cm	23.72	9.55	0.11	23.39	10.36	0.12	25.01	7.16	0.11	23.43	8.36	0.15
Mid calf circumference, cm	29.25	8.43	0.12	28.84	8.36	0.12	31.66	6.79	0.13	29.54	7.53	0.17
Head length, cm	19.26	4.44	0.04	18.46	3.77	0.04	19.20	4.14	0.05	18.37	3.68	0.05
Head breadth, cm	14.13	4.05	0.03	14.01	3.99	0.03	14.28	4.27	0.04	14.12	3.74	0.04
Nasal height, cm	4.79	9.20	0.02	4.38	9.87	0.02	4.65	9.99	0.03	4.27	7.61	0.03
Nasal breadth, cm	3.82	10.29	0.02	3.48	8.87	0.02	3.78	7.51	0.02	3.47	9.28	0.03
Bizygomatic breadth, cm	13.73	4.34	0.03	13.25	4.34	0.03	13.82	4.24	0.03	13.28	4.56	0.05
Bigonial breadth, cm	10.82	5.80	0.03	10.15	6.51	0.03	10.80	6.27	0.04	10.09	6.50	0.05
Total facial height, cm	11.30	5.82	0.03	10.39	6.74	0.04	11.03	6.30	0.04	10.32	6.36	0.05

Variability in body measurements, as evident from coefficient of variation, is the highest in Body weight as compared to other body measurements, more so in parental generation than in filial generation (Table 1). This is perhaps because of the fact that Body weight can be influenced by numerous environmental factors. It varies with changes in nutritional status, socio-economic status, occupation, etc. medium variability is observed in Hand length, Head cum neck segment and mid upper arm circumference. Nasal shape has high variability in this population, as both Nasal height and Nasal breadth have large coefficient of variations. Head shape, on the other hand, exhibits low variability in Santhal Father, Mother, Son and Daughter, as manifested from coefficient of variation of Head circumference, Head length and Head breadth. Similar low variability is observed in Stature.

Thus, both Son and Daughter have affinity with their Father and Mother. Sex differences are apparent in almost all the body measurements. For example, Santhal Father and Son are taller, heavier with broader shoulder, greater circumferences and bigger head and face in comparison with Mother and Daughter. As a consequence, Sons resemble their Father while Daughters resemble their Mother in terms of different body measurements. Considerably higher mean values of different body measurements among Son and Daughter, than their Father and Mother respectively indicate a positive secular trend. This observation of secular trend is further strengthened by the fact that the parents have not yet reached senescence, as mean ages of Father and Mother are 57.5 and 48.6 years respectively. These observations are in agreement with the study made by previous investigators who observed secular trend in filial generation in various body measurements (*Susanne, 1975 and 1977; Kaur and Singh, 1981; Malik and Singh, 1996; Roy and Singh, 1992; Ulijaszek, 2001; Ali et al., 2000; Krawczynski et al., 2003; Malina et al., 2004; Carrascosa et al., 2004; and Simsek, 2005*).

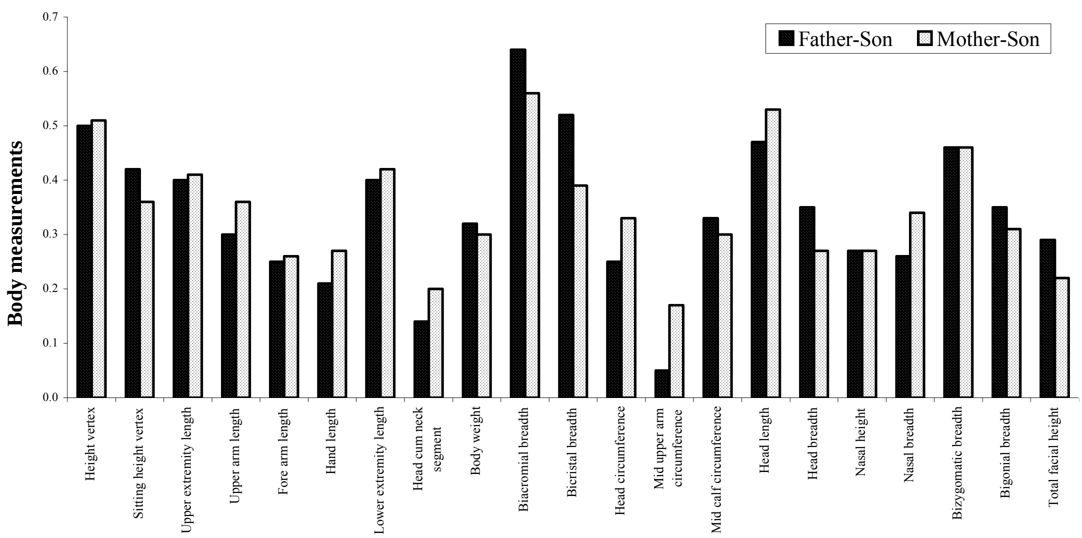

Figure 1. Parent-Son (PS) correlations in Body measurements

Examination of intra-familial correlations in body measurements suggests that both Son and Daughter have the highest correlation in Biacromial breadth with their parents, as compared to other body measurements. This is followed by Stature and Total upper extremity length (Table 2 and 3). On the other hand, the lowest correlation is observed in Mid upper arm circumference in Mother-Son (MS), Father-Son (FS) and Father-Daughter (FD) but not in Mother-Daughter (MD), where the lowest correlation is noticed in Body weight.

Table 2. Parent-Son (PS) correlation coefficient (r) for Body measurements

Body Measurements	Father–Son (FS)		Mother-Son (MS)	
	(r)	*T - test*	*(r)*	*T - test*
Height vertex, cm	.50	9.75*	.51	9.96*
Sitting height vertex, cm	.42	7.95*	.36	6.51*
Total upper extremity length, cm	.40	7.37*	.41	7.57*
Total upper arm length, cm	.30	5.32*	.36	6.47*
Total fore arm length, cm	.25	4.42*	.26	4.62*
Hand length, cm	.21	3.68*	.27	4.81*
Total lower extremity length, cm	.40	7.34*	.42	7.88*
Head cum neck segment, cm	.14	2.34*	.20	3.53*
Body weight, kg	.32	5.73*	.30	5.28*
Biacromial breadth, cm	.64	14.34*	.56	11.63*
Bicristal breadth, cm	.52	10.23*	.39	7.26*
Head circumference, cm	.25	4.32*	.33	5.99*
Mid upper arm circumference, cm	.05	0.78	.17	2.96*
Mid calf circumference, cm	.33	5.93*	.30	5.30*
Head length, cm	.47	9.02*	.53	10.50*
Head breadth, cm	.35	6.45*	.27	4.81*
Nasal height, cm	.27	4.72*	.27	4.78*
Nasal breadth, cm	.26	4.62*	.34	6.22*
Bizygomatic breadth, cm	.46	8.70*	.46	8.82*
Bigonial breadth, cm	.35	6.38*	.31	5.53*
Total facial height, cm	.29	5.20*	.22	3.79*

* Significant at 5% probability level, N = 292, d.f. = 290

In general, Body weight shows a trend of paternal influence, as both Son and Daughter have greater resemblance with Father in Body weight than with Mother (Figure 1 and 2). In transverse measurements, generally sons have relatively greater degree of paternal affinity, whereas Daughters have equivalent degree of resemblance with both Mother and Father.

Table 3. Parent-Daughter (PD) correlation coefficient (r) for Body measurements

Body Measurements	Father–Daughter (FD)		Mother-Daughter (MD)	
	(r)	*T - test*	*(r)*	*T - test*
Height vertex, cm	.48	7.00*	.48	7.15*
Sitting height vertex, cm	.32	4.41*	.37	5.08*
Total upper extremity length, cm	.49	7.31*	.47	6.96*
Total upper arm length, cm	.23	3.11*	.30	4.17*
Total fore arm length, cm	.35	4.81*	.21	2.80*
Hand length, cm	.31	4.29*	.31	4.24*
Total lower extremity length, cm	.33	4.56*	.35	4.89*
Head cum neck segment, cm	.18	2.37*	.27	3.66*
Body weight, kg	.21	2.81*	.08	1.08
Biacromial breadth, cm	.52	7.91*	.52	7.93*
Bicristal breadth, cm	.35	4.78*	.35	4.89*
Head circumference, cm	.43	6.17*	.20	2.67*
Mid upper arm circumference, cm	.07	0.88	.14	1.85
Mid calf circumference, cm	.11	1.42	.26	3.52*
Head length, cm	.49	7.23*	.39	5.52*
Head breadth, cm	.17	2.24*	.48	7.13*
Nasal height, cm	.26	3.42*	.30	4.12*
Nasal breadth, cm	.29	3.99*	.35	4.87*
Bizygomatic breadth, cm	.44	6.39*	.28	3.75*
Bigonial breadth, cm	.27	3.61*	.27	3.56*
Total facial height, cm	.23	3.05*	.34	4.75*

* Significant at 5% probability level, N = 170, d.f. = 168

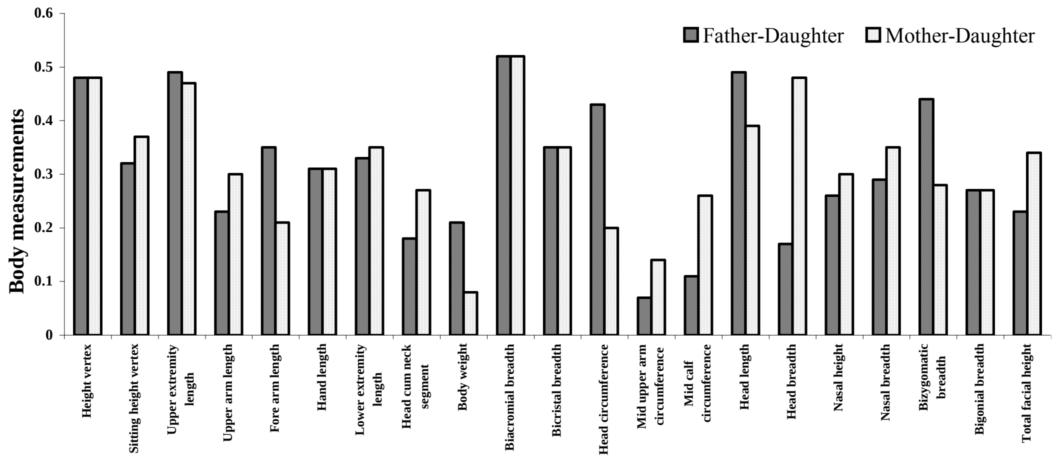

Figure 2. Parent-Daughter (PD) correlations in Body measurements

Overall, Parent–Offspring (PO) correlations are reasonably higher in transverse, longitudinal and segmental measurements, followed by head and face measurements and they are the least in circumferential and bulk measurements. In body measurements, both Son and Daughter exhibit greater correlations with Mother than Father. It suggests a strong pre-natal and post-natal resemblance between mothers and children, which continues even when they grow up, irrespective of the sex. However, both Son and Daughter have similar degree of resemblance with their parents in some body measurements. For example, with both Father and Mother,

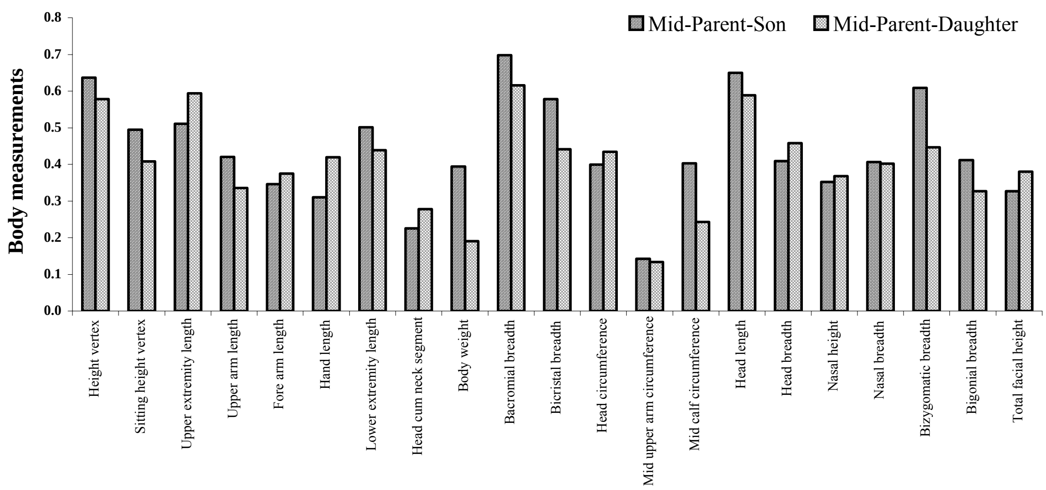

Figure 3. Mid-Parent-Offspring (MPO) correlations in Body measurements

Daughter have similar degree of affinity in Stature, Biacromial breadth, Bicristal breadth, Hand length and Bigonial breadth; while Son have similar degree of resemblance in Nasal height and Bizygomatic breadth. Comparison between the like-sex (FS and MD) and unlike-sex (MS and FD) pairs reveals that the differences are only marginal. This observation is similar to the one observed by *Mueller* (*1976*). Son have statistically significant correlations in all the body measurements with both Father and Mother, except for the correlation in mid upper arm circumference with Father. Daughter, on the other hand, have statistically significant correlations with both Father and Mother in all body measurements, except Mid upper arm circumference with both the parents and Body weight with Mother.

Mid-Parent-Offspring (MPO) correlations in body measurements of Santhals are represented in the Table 4 along with graphical illustration (Figure 3). MPO correlations have the same direction and variability as the PO correlations, but they are consistently higher.

Like PO correlation, both Mid-Parent-Son (MPS) and Mid-Parent-Daughter (MPD) show the highest correlation in Biacromial breadth, followed by Stature, Total upper extremity length, Bicristal breadth and Total lower extremity length. On the other hand, the lowest correlation is observed in Mid upper arm circumference in both MPS and MPD. As a consequence, in line with the observations recorded in Single-Parent-Offspring, higher Mid-Parent-Offspring correlation is observed in transverse measurement, followed by longitudinal, segmental and head and face measurements; the least is in soft tissue related measurements like circumferential and bulk measurements. Even in head and face measurements, measurements like Head length and Bizygomatic breadth precede other head and face measurements in both MPS and MPD. Correlations in both MPS and MPD are statistically significant in all the body measurements, except for Mid upper arm circumference in MPD. As compared to Daughter, Son exhibit greater degree of resemblance with their parents in most of the body measurements (Figure 3). However, the differences between the MPS and MPD correlations, as estimated from Z-test, are statistically non-significant in all the body measurements, except Body weight and Bizygomatic breadth (Table 4).

Table 4. Mid-Parent-Offspring (MPO) correlation coefficient (r) for Body measurements

Body Measurements	Mid-Parent–Son (MPS) [N_1]		Mid-parent–Daughter (MPD) [N_2]		*Z - test*
	(r_1)	*T - test*	*(r_2)*	*T - test*	
Height vertex, cm	.64	14.07*	.58	9.18*	0.96
Sitting height vertex, cm	.49	9.68*	.41	5.79*	1.11
Total upper extremity length, cm	.51	10.12*	.59	9.57*	1.23
Total upper arm length, cm	.42	7.88*	.34	4.61*	1.02
Total fore arm length, cm	.34	6.28*	.38	5.24*	0.34
Hand length, cm	.31	5.55*	.42	5.98*	1.30
Total lower extremity length, cm	.50	9.86*	.44	6.32*	0.83
Head cum neck segment, cm	.23	3.93*	.28	3.75*	0.58
Body weight, kg	.39	7.30*	.19	2.51*	2.31*
Biacromial breadth, cm	.70	16.60*	.62	10.13*	1.49
Bicristal breadth, cm	.58	12.06*	.44	6.37*	1.91
Head circumference, cm	.40	7.41*	.43	6.24*	0.44
Mid upper arm circumference, cm	.14	2.44*	.13	1.75	0.08
Mid calf circumference, cm	.40	7.50*	.24	3.24*	1.84
Head length, cm	.65	14.57*	.59	9.45*	1.02
Head breadth, cm	.41	7.63*	.46	6.68*	0.62
Nasal height, cm	.35	6.40*	.37	5.13*	0.19
Nasal breadth, cm	.41	7.57*	.40	5.69*	0.05
Bizygomatic breadth, cm	.61	13.08*	.45	6.46*	2.34*
Bigonial breadth, cm	.41	7.68*	.33	4.49*	1.00
Total facial height, cm	.33	5.89*	.38	5.33*	0.62

*Significant at 5% probability level, N_1 = 292, N_2 = 170

Thus, both Son and Daughter have similar degree of resemblance with mid-parent. In body measurements, both PO and MPO correlations exhibit values as high as the theoretical values, as proposed by *Susanne* (*1975*), especially in transverse and longitudinal measurements, more so in Son. He suggested that the observed correlation coefficients are mostly lower than the expected values, both for MPO and PO.

Body Physique: Among the three somatotype components of body physique, Mesomorphic component is dominant among Santhal Father, Mother, Son and Daughter (Table 5). Maternal effect is apparent in Mesomorphy, as both Son and Daughter resemble more with their Mother than their Father. In Endomorphy and Ectomorphy, sex differences are clearly evident. For example, in females (Mother and Daughter) these two components are co-dominant, whereas in males (Father and Son) Ectomorphy dominates over Endomorphy.

Table 5. Descriptive statistics of Somatotype components of Father, Mother, Son and Daughter

Somatotype Components	Father (400)			Mother (400)			Son (292)			Daughter (170)		
	Mean	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*
Endomorphy	1.98	49.22	0.05	3.16	48.73	0.08	2.04	43.47	0.05	3.18	40.41	0.10
Mesomorphy	4.81	25.86	0.06	5.43	24.26	0.07	5.33	19.59	0.06	5.31	22.77	0.09
Ectomorphy	3.98	34.42	0.08	3.17	49.50	0.08	3.50	33.91	0.07	3.15	45.32	0.11

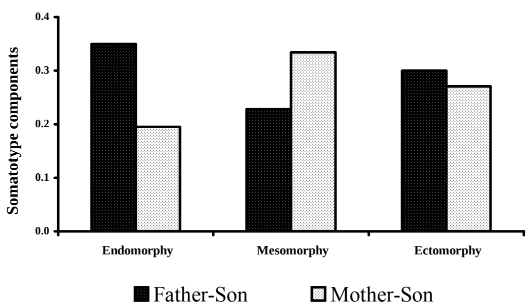

Figure 4. Parent – Son (PS) correlations in Somatotype components

Among somatotype components, Mesomorphic component shows greater homogeneity in this population, as evident from coefficient of variation, more so in filial generation than in parental generation. Among Santhals, gender has a role to play in the variations of Endomorphic and Ectomorphic components. For example, in males (Father and Son) comparatively greater dispersion is observed in Endomorphic component than in Ectomorphic component, whereas, in females (Mother and Daughter) similar magnitude of heterogeneity is noticed in both Endomorphic and Ectomorphic components.

Table 6. Parent-Son (PS) correlation coefficient (r) for Somatotype components

Somatotype Components	Father–Son (FS)		Mother-Son (MS)	
	(r)	*T- test*	*(r)*	*T- test*
Endomorphy	.35	6.36*	.20	3.39*
Mesomorphy	.23	3.99*	.33	6.03*
Ectomorphy	.30	5.36*	.27	4.79*

* Significant at 5% probability level, N = 292, d.f. = 290

In body physique, Son and Daughter have the highest correlation with Father in Endomorphic and Ectomorphic components respectively. The lowest correlation coefficient, on the other hand, is observed with Mother in Endomorphic component for both Son and Daughter. Both MS and MD pairs, have the highest correlation coefficient in Mesomorphic component as compared to other somatotype components

(Table 6 and 7). In somatotype, a hint of paternal influence is evident, as both Son and Daughter have greater degree of resemblance with Father than with Mother in all the three components, except for Mesomorphic component in Son (Figure 4 and 5).

Table 7. Parent-Daughter (PD) correlation coefficient (r) for Somatotype components

Somatotype Components	Father–Daughter (FD)		Mother-Daughter (MD)	
	(r)	*T- test*	*(r)*	*T- test*
Endomorphy	.28	3.74*	.06	.83
Mesomorphy	.28	3.74*	.26	3.52*
Ectomorphy	.30	4.14*	.24	3.16*

* Significant at 5% probability level, N = 170, d.f. = 168

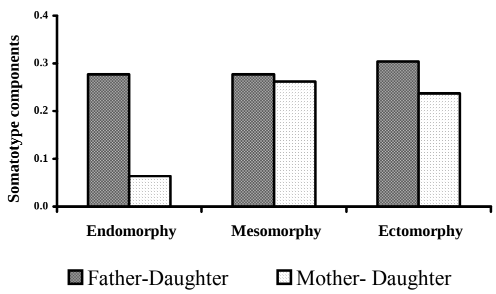

Figure 5. Parent – Daughter (PD) correlations in Somatotype components

Both Son and Daughter have statistically significant correlation coefficients with Father and Mother in all the three somatotype components, with the exception of the correlation between Mother and Daughter in Endomorphy.

MPO correlations in body physique of the Santhals are presented in Table 8 and Figure 6. The highest correlation coefficient is observed in MPS in Ectomorphic component, whereas the lowest correlation is noted in MPD in Endomorphic component. Both Son and Daughter have relatively greater resemblance in Ectomorphic and Mesomorphic components, followed by Endomorphic component with their Parent.

Table 8. Mid-Parent-Offspring (MPO) correlation coefficient (r) for Somatotype components

Somatotype Components	Mid-parent–Son (MPS) [N_1]		Mid-parent–Daughter (MPD) [N_2]		*Z - test*
	(r_1)	*T- test*	*(r_2)*	*T- test*	
Endomorphy	.33	5.85*	.18	2.40*	1.58
Mesomorphy	.37	6.87*	.34	4.67*	0.41
Ectomorphy	.38	6.95*	.34	4.66*	0.47

* Significant at 5% probability level, N_1 = 292, N_2 = 170

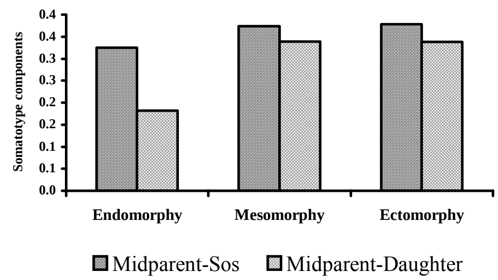

Figure 6. Mid-Parent –Offspring (MPO) correlations in Somatotype components

Among Santhals, both Son and Daughter have statistically significant correlation coefficients with Mid-Parent in all the three somatotype components. In general, Son reflect higher degree of resemblance with Mid-Parent as compared to Daughter in body physique (Figure 6), but, the difference is statistically non-significant at 5% probability level (Table 8).

Physiological Variables: Descriptive statistics of physiological variables of Santhal Father, Mother, Son and Daughter are represented in Table 9. Muscular strength, as estimated from Handgrip strength, is greater in Son and Daughter than Father and Mother respectively. On the other hand, Blood pressures, both Systolic and Diastolic, are relatively higher in Father and Mother as compared to Son and Daughter respectively.

Table 9. Descriptive statistics of Physiological variables of Father, Mother, Son and Daughter

Physiological Variables	Father (400)			Mother (400)			Son (292)			Daughter (170)		
	Mean	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*
Grip strength, kg	28.2	25.6	7.2	21.5	24.6	5.3	38.6	15.2	5.9	25.7	20.1	5.2
Systolic blood pressure, mm Hg	126.0	10.4	0.7	122.8	9.7	0.6	124.5	6.9	0.5	120.6	7.7	0.7
Diastolic blood pressure, mm Hg	82.1	10.9	0.5	81.6	11.1	0.5	81.1	11.1	0.5	78.8	10.6	0.6
Heart rate, per min	77.2	14.8	0.6	79.7	12.9	0.5	74.8	15.6	0.7	82.1	12.6	0.8
Pulse rate, per min	77.1	15.0	0.6	79.3	12.4	0.5	75.6	15.0	0.7	82.2	13.0	0.8

Sex differences are evident in Heart rate and Pulse rate, as Mother and Daughter have greater Heart rate and Pulse rate than the rates in Father and Son. The dispersion in Handgrip strength, as evident from coefficient of variation, is the highest amongst physiological variables. This heterogeneity in Handgrip strength is more apparent in parental generation than in filial generation. Systolic blood pressure, on the other hand, shows the minimum variation in Father, Mother, Son and Daughter. Gender differences are evident in Heart and Pulse rates, as these variables show greater dispersion in males (Father and Son) than in females (Mother and Daughter).

Table 10. Parent-Son (PS) correlation coefficient (r) for Physiological variables

Physiological Variables	Father–Son (FS)		Mother-Son (MS)	
	(r)	*T- test*	*(r)*	*T- test*
Grip strength, kg	.15	2.57*	.32	5.81*
Systolic blood pressure, mm Hg	.07	1.23	.08	1.37
Diastolic blood pressure, mm Hg	.15	2.50*	.11	1.90
Heart rate/ mint.	.12	2.13*	.23	4.02*
Pulse rate/ mint.	.13	2.18*	.23	4.10*

* Significant at 5% probability level, N = 292, d.f. = 290

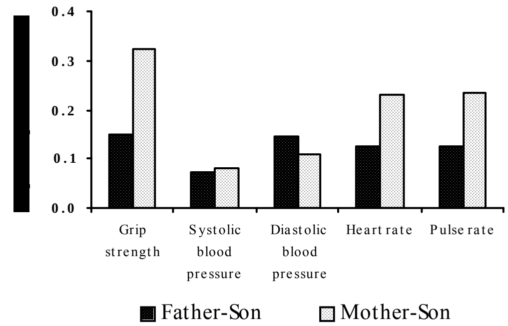

Figure 7. Parent – Son (PS) correlations in Physiological variables

Table 11. Parent-Daughter (PD) correlation coefficient (r) for Physiological variables

Physiological Variables	Father–Daughter (FD)		Mother-Daughter (MD)	
	(r)	*T- test*	*(r)*	T- test
Grip strength, kg	.29	3.85*	.34	4.72*
Systolic blood pressure, mm Hg	.16	2.05*	.27	3.68*
Diastolic blood pressure, mm Hg	.17	2.24*	.27	3.61*
Heart rate/ mint.	.25	3.40*	.09	1.20
Pulse rate/ mint.	.28	3.72*	.18	2.33*

* Significant at 5% probability level, N = 170, d.f. = 168

In physiological variables, Handgrip strength has the highest correlation coefficient in all the four familial correlations, i.e. FS, MS, FD and MD (Table 10 and 11). The lowest correlation, on the other hand, is observed in Systolic blood pressure in FS, MS and

FD, whereas it is noted in Heart rate in MD. Overall, maternal influence is apparent in physiological variables of Santhals, as both Son and Daughter have greater degree of resemblance with Mother as compared to their affinity with Father (Figure 7 and 8).

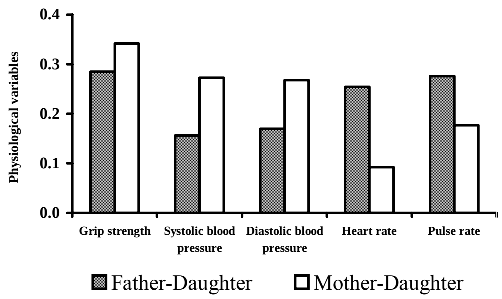

Figure 8. Parent – Daughter (PD) correlations in Physiological variables

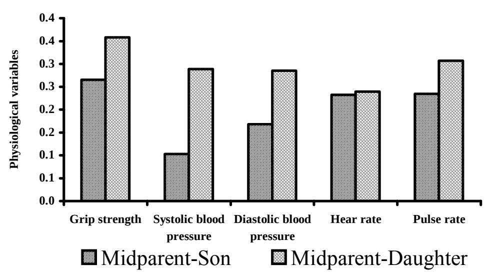

Figure 9. Mid-Parent – Offspring (MPO) correlations in Physiological variables

In general as compared to Son, Daughter has greater association with both Father and Mother in physiological parameters. Sons have statistically significant correlations with Father and Mother in all physiological variables, except Systolic blood pressure with Father and both Systolic and Diastolic blood pressure with Mother (Table 10). Daughter, on the other hand, have statistically significant correlations in all physiological parameters with both Father and Mother, except for Heart rate with Mother (Table 11).

Table 12. Mid-Parent-Offspring (MPO) correlation coefficient (r) for Physiological variables

Physiological Variables	Mid-parent–Son (MPS) [N_1]		Mid-parent–Daughter (MPD) [N_2]		*Z - test*
	(r_1)	*T- test*	*(r_2)*	*T- test*	
Grip strength, kg	.27	4.68*	.36	4.98*	1.06
Systolic BP, mm Hg	.10	1.76	.29	3.91*	2.00*
Diastolic BP, mm Hg	.17	2.90*	.29	3.85*	1.27
Heart rate/ mint.	.23	4.06*	.24	3.19*	0.08
Pulse rate/ mint.	.23	4.10*	.31	4.18*	0.81

* Significant at 5% probability level, $N_1 = 292$, $N_2 = 170$

MPO correlations of the Santhals in physiological variables are shown in Table 12 and Figure 9. Similar to the finding in PO correlations, the highest correlation is observed in Handgrip strength in both MPS and MPD. The lowest correlation, on the other hand, is noticed in Systolic blood pressure for MPS and in Heart rate for MPD (Table 12). Daughter have statistically significant correlations with Mid-Parent in all physiological variables, whereas, Son show statistically significant correlation in physiological variables, except Systolic blood pressure. As compared to Son, Daughter resembles more with their parents in all physiological parameters (Figure 9). However the difference, between the correlations of MPS and MPD is statistically non-significant, except systolic blood pressure.

From the above results it is clear that both PO and MPO correlations differ in various anthropological measurements. Correlations are generally the highest for transverse, longitudinal and other skeletal measurements, followed by head and face measurements and soft tissue related measurements like circumferential and bulk measurements. Calf girth shows higher PO correlation than arm girth. This finding is in agreement with earlier observations made on growing children (*Mueller, 1976*) and adults (*Susanne, 1975; Kaur and Singh, 1981; Malik and Singh, 1996; Devi and Reddi, 1983; Roy and Singh, 1992 and Sanchez-Andres, 1994*). Overall, both Father and Mother have nearly equivalent and important contributions in building up the morphological structure of the children. However, a trend of maternal effect is observed among Santhals, where, Mother have greater resemblance with Son and Daughter, as also noticed by Susanne and his co-authors (*Susanne et al., 2003*). Intrafamilial resemblance in somatotype components, especially in MPO correlations is statistically significant at 5% probability level. Son resemble more with their Mother than their Father in Mesomorphy. This observation is in accordance with the study made by *Sanchez-Andres* (*1995*). Father reflect greater resemblance in Endomorphy with their Son and in Ectomorphy with their Daughter. Therefore, by and large the results are in consistent with the notion that genes have influencing effect on human physique (*Katzmarzyk, 2000*). Significant intrafamilial resemblance is also observed in various physiological functions. However, familial resemblance of Systolic and Diastolic blood pressures differs. The degree of resemblance is higher in Diastolic blood pressure than Systolic blood pressure, which suggests that the Diastolic blood pressure has more pronounced genetic component as compared to Systolic blood pressure. This is in agreement with earlier investigations (*Skaric-Juric, 2003; Andre et al., 1986 and Hutchinson, 1987*). Grip strength has a maternal effect in its correlation, as both Son and Daughter resemble more with their Mother than their Father in Handgrip strength. Heart and Pulse rates suggest that gender does not play any role in genetic determination of these two variables, as Son resemble more with Mother than Father, while Daughter have greater degree of affinity with Father. In general, both Son and Daughter resemble their parents in all the morphological and physiological measurements. Even measurements with a large contribution of common family environment or residual environmental effects, like Blood pressure, have significant intrafamilial resemblance in this population. Hence, Santhals of West Bengal are a close knit and homogenous population with discernible positive secular trend and apparent familial affinity in morpho-physiological parameters.

Acknowledgement: We gratefully acknowledge the financial assistance rendered by the Ministry of Tribal Affairs, Govt. of India, for this investigation.

References

Ali, M.A., Uetake, T. and Ohtsuki, F. 2000. Secular changes in relative leg length in post-war Japan. *Am J Hum Biol,* **12 (3)**: 405-416.

Andre, J.L., Deschamps, J.P. and Gueguen, R. 1986. Familial resemblance of blood pressure and body weight. *Clin Exp Hypertens. A,* **8(4-5)**: 661-667.

Bouchard, C., Demirjian, A. and Malina, R.M. 1980. Heritability estimates of somatotype components based upon familial data. *Hum Hered,* **30(2)**: 112-118.

Burke, V., Beilin, L.J. and Dunbar, D. 2001. Family lifestyle and parental body mass index as predictors of body mass index in Australian children: a longitudinal study. *Int J Obes Relat Metab Disord,* **25(2)**: 147-157.

Carrascosa, A., Yeste, D., Copil, A. and Gussinye, M. 2004. Secular growth changes. Weight, height and body mass index values in infant, children, adolescent and young adults from Barcelona population. *Med Clin (Barc),* **123(12)**:445-51.

Carter, J.E.L. 1980. *The Heath and Carter Somatotype Method.* 3rd edition. San Diego State University Syllabus Service, San Diego.

Census of India. 2001. West Bengal. www. censusindia.com.

Coady, S.A., Jaquish, C.E., Fabsitz, R.R., Larson, M.G., Cupples, A. and Meyers, R.H. 2002. Genetic variability of adult body mass index: a longitudinal assessment in Framingham families. *Obesity Research,* **10**: 675-681.

Culshaw, W.J. 1949. *Tribal Heritage: A study of the Santhals.* Lutterworth Press, London.

Datta-Majumdar, N. 1956. *The santal: Study in culture change.* Govt, of India press.

Devi, M.R. and Reddi, G.G. 1983. Heritability of body measurements among the Jalari population in Visakhapatnam. *Ann Hum Biol,* **10(5)**: 483-485.

Falconer, D.F. 1960. *Introduction to Quantitative Genetics.* Ronald Press. New York.

Guha, B.S. 1944. *Racial elements in the populations.* Oxford University Press, Oxford.

Heath, B.H. and Carter, J.E.L. 1967. A modified somatotype method. *Am J Phys Anthropol,* **27:** 57-74.

Hunt, M.S., Katzmarzyk, P.T., Perusse, L., Rice, T., Rao, D.C. and Bouchard, C. 2002. Familial resemblance of 7-year changes in body mass and adiposity. *Obes Res,* **10(6)**: 507-517.

Hutchinson, J. and Byard, P.J. 1987. Family resemblance for anthropometric and blood pressure measurements in Black Caribs and Creoles from St. Vincent Island. *Am J Phys Anthropol,* **73(1)**: 33-39.

Katzmarzyk, P.T., Malina, R.M., Perusse, L., Rice, T., Province, M.A., Rao, D.C. and Bouchard, C. 2000. Familial resemblance for physique: heritabilities for somatotype components. *Ann Hum Biol,* **27(5)**: 467-477.

Kaur, D.P. and Singh, R. 1981. Parent-adult offspring correlations and heritability of body measurements in a rural Indian population. *Ann Hum Biol,* **8(4)**: 333-339.

Koziel. S. 2001. Relationships among tempo of maturation, Midparent height and growth in height of adolescent boys and girls. *Am J Hum Biol,* **13**(1): 15-22.

Krawczynski, M., Walkowiak, J. and Krzyzaniak. A. 2003. Secular changes in body height and weight in children and adolescents in Poznan, Poland, between 1880 and 2000. *Acta Paediatr,* **92(3)**: 277-282.

Malik, P. and Singh, R. 1996. Filial transmission of body measurements. *Hum Biol,* 83-84.

Malina, R.M., Pena Reyes, M.E., Tan, S.K., Buschang, P.H., Little, B.B. and Koziel, S. 2004. Secular change in height, sitting height and leg length in rural Oaxaca, southern Mexico: 1968-2000. *Ann Hum Biol,* **31(6)**:615-33.

Martin, R. And Saller, K. 1957. *Lehrbuch der Anthropooigie*. Gustav Fischer Verlag, Stuttgart.

Mueller, W.H. 1976. Parent-child correlations for stature and weight among school aged children: a review of 24 studies. *Hum Biol,* **48(2)**: 379-397.

Mukherjee, C.L. 1962. *The Santhals.* Calcutta: A. Mukherjee and Co. Pvt. Ltd.

Narain, P. 1988. Quantitative inheritance. In: *Statistical methods in human population genetics*. Ed: Malhotra, K.C. Indian Institute of Bio-social Research and Development. Indian Statistical Institute. Indian Society of Human genetics. 311-332.

Perusse, L., Rice, T., Province, M.A., Gagnon, J., Leon, A.S., Skinner, J.S., Wilmore, J.H., Rao, D.C. and Bouchard, C. 2000. Familial aggregation of amount and distribution of subcutaneous fat and their responses to exercise training in the HERITAGE family study. *Obesity Research***, 8**: 140-150.

Rao, D.C., Maclean, C.J., Morton, N.E. and Yee, S. 1975. Analysis of family resemblance. 5. Height and weight in Northeastern Brazil. *Am J Hum Genet,* **27**: 509-520.

Rebato, E., Salces, I., Rosique, J., San Martin, L. and Susanne, C. 2000. Analysis of sibling resemblance in anthropometric somatotype components. *Ann Hum Biol,* **27(2)**: 149-161.

Roberts, D.F., Billewicz, W.Z. and McGregor, I.A. 1978. Heritability of stature in a West African population. *Ann Hum Genet,* **42(1)**:15-24.

Roy, G. and Singh, R. 1992. Parent-adult offspring correlations of anthropometric measurements in an urban Indian population. *J Hum Ecol,* **3**(2): 125-132.

Russell, M. 1976. Parent-child and sibling-sibling correlations of height and weight in a rural Guatemalan population of preschool children. *Hum Biol,* **48 (3)**:501-515.

Safer, D.L., Agras, W.S., Bryson, S. and Hammer, L.D. 2001. Early body mass index and other anthropometric relationship between parents and children. *Int J Obes Relat Metab Disord,* **25(10)**: 1532-1536.

Salces, I., Rebato, E. and Susanne, C. 2004. Genetic and environmental sources on familial transmission in Biscayan families. III. The dynamometric strength. *Homo,* **54(3)**: 275-288.

Salces, I., Rebato, E., Slachmuylder, J.L., Vercauteren, M., Rosique, J. and Susanne, C. 2003. genetic and environmental sources on familial transmission in Basque families. II. Stature, weight and body mass index. *Ann Hum Biol,* **30(2)**: 176-190.

Sanchez-Andres, A. and Mesa, M.S. 1994. Heritabilities of morphological and body composition characteristics in a Spanish population. *Anthropol Anz,* **52**: 341-349.

Sanchez-Andres, A. 1995. Genetic and environmental influences on somatotype components: Family study in a Spanish population. *Hum Biol,* **67**: 727-738.

Simsek, F., Ulukol, B. and Gulnar, S.B. 2005. The secular trends in height and weight of Turkish school children during 1993-2003. *Child Care Health Dev,* **31(4)**:441-447.

Skaric-Juric, T. 2003. Path analysis of familial resemblance in blood pressure in Middle Dalmatia, Croatia. *Coll Anthropol,* **27(1)**: 229-237.

Susanne, C., Salces, I., Rebato, E., Slachmuylder, J.L., Vercauteren, M. And Rosique, J. 2003. Genetic and environmental sources on familial transmission in Basque families. II. Stature, weight and body mass index. *Ann Hum Biol,* **30 (2)**: 176-190.

Susanne, C. 1975. Genetic and environmental influences on morphological characteristics. *Ann Hum Biol,* **2(3)**: 279-287.

Susanne, C. 1977. Individuals age changes of the morphological characteristics. *Journal of Human Evolution,* **6**:181-189.

Tanner, J.M., Hiernaux, J. And Jarnan, S. 1969. Growth and physique studies. In: *Human Biology- A guide to field Methods. IBP Hand book no, 9.* Ed. J.S.Weiner and J.A.Lourie. Blackwell Scientific Publication, Oxford. 315-340.

Ulijaszek, S.J. 2001. Socio-economic status, body size and physical activity of adults on Rarotonga, the Cook Island. *Ann Hum Biol,* **28**: 554-563.

Cardiorespiratory Fitness in College Students of Uttar Pradesh, India

Bandyopadhyay, A.* and Bandyopadhyay, P.**

*School of Health Sciences (PPSK), Universiti Sains Malaysia, Health Campus, 16150 Kubang Kerian, Kelantan, Malaysia. E-mail : bamit74@india.com

** Institute of Dental Sciences, Pilibhit By Pass Road, Bareilly : 243006, UP, India, E-mail : pamit78@india.com

Abstract

Present study was undertaken to (i) evaluate VO_2max among college students of Uttar Pradesh, (ii) compare the data with other reports and (iii) compute prediction norms for VO_2max. Seventy five Male and seventy five female college students of 19 – 24 years having middle class socioeconomic background were recruited by random sampling from Institute of Dental Sciences, Bareilly, Uttar Pradesh, India. VO_2max was determined by Queen's College step test (QCT). Physical parameters were significantly correlated (P < 0.001) with VO_2max in both the sexes and they were (except age) significantly higher among males. Followings are the prediction norms for VO_2max from body height which showed maximum value of correlation coefficients.

Males : VO_2max (L/min) = 0.17 x body height (cm) – 26.439 [r = 0.91, SEE = 0.028]

Females: VO_2max (L/min) = 0.14 x body height (cm) – 20.549 [r = 0.86, SEE = 0.051]

The results indicated better cardiorespiratory fitness among males than female college students of Uttar Pradesh, India, because of higher values of all the physical parameters in males.

Key Words: VO_2max, QCT, Sedentary, Indians, Norms

Introduction

Maximum oxygen uptake or VO_2max has been internationally accepted as the best parameter to evaluate cardiorespiratory fitness. Direct measurement of cardiorespiratory fitness in terms of VO_2max is restricted within the well equipped laboratory because of its exhausting and difficult experimental protocol *(Fox, 1973)*. Among various indirect protocols *(Fox, 1973; Das and Bhattacharya, 1995; Kline et al., 1987; Siconolfi et al., 1982; Mcardle et al., 1972)* the Queen's College step test or QCT is the simplest one and has already been established as the best indirect method to evaluate cardiorespiratory fitness in young Indian individuals *(Chatterjee et al., 2006)*.

There is dearth of data on VO_2max among sedentary college students of Uttar Pradesh, India. The present study was therefore conducted to:

(i) Evaluate VO_2max in college students of Uttar Pradesh, India.
(ii) Compare the data with reports from India and abroad, and
(iii) Compute prediction norms for VO_2max in the studied population.

Materials and Methods

Selection of Participants

Male (N=75) and female (N=75) healthy sedentary students from the middle class socioeconomic background, having age range of 19 to 24 years were recruited for the study on the basis of random sampling from the Institute of Dental Sciences, Bareilly, Uttar Pradesh, India. The experimental protocol was fully explained to participants to allay their apprehension and ensure maximum co-operation. They had a light breakfast 2–3 hours before the test and refrained from any energetic physical activity for that period. The participants had no history of any major disease and did not follow any physical conditioning program, apart from some recreational sports. All the participants were non-smokers. Necessary permission was taken from the ethical committee to conduct the study.

Age of each participant was calculated from the date of birth as recorded in their school certificate. Body height and body mass were measured with standard instrument with an accuracy of ± 0.5 cm in case of body height and ± 0.25 kg in case of body mass. The body surface area was calculated from the equation of *DuBois and DuBois (1916)* which is as follows:

$$\text{BSA (m}^2) = (\text{Body Height})^{0.725} \times (\text{Body Mass})^{0.425} \times 0.007184$$

Evaluation of VO_2max by QCT

The step test was performed on a stool of 16.25 inches (41.3 cm) height for a total duration of 3 minutes at the rate of 24 cycles per minute, which was set by a metronome. After completion of the exercise, the subject was asked to remain standing and the carotid pulse rate was measured from 5–20 seconds of the recovery period. This 15 second pulse rate was converted into beats per minute and the following equations were used to predict the maximum oxygen uptake capacity (*Chatterjee et al., 2004; Chatterjee et al., 2005*):

In Males:

$$VO_2max \text{ (ml/kg/min)} = 55.23 - (0.09 \times \text{pulse rate in beats/min})$$

In Females:

$$VO_2max \text{ (ml/kg/min)} = 54.12 - (0.13 \times \text{pulse rate in beats/min})$$

The whole experiment was performed at a laboratory temperature varying from 27–29°C and with the relative humidity ranging between 75% and 83%.

Statistical Analysis

Student's t test, Pearson's product moment correlation and linear regression statistics were used for statistical treatment of the data.

Results

Means and standard errors of age, body height, body mass, BSA and VO_2max of the male and female participants are presented in table 1. Though age did not show any inter-group variation, but the values of all other parameters are significantly higher among males than the female students.

Table 1. Physical parameters and cardiorespiratory fitness (VO2max) of male and female sedentary university students.

Category	Age (Years)	Body Height (cm)	Body Mass (kg)	VO_2max ml/kg/min	VO_2max L/min
Male (N = 75)	21.6 ± 0.2	169.5 ± 0.5	56.7 ± 0.2	41.9± 1.6	2.376± 0.09
Female (N = 75)	22.9 ± 0.6	160.3 ± 0.6*	52.9 ± 0.8*	35.8± 1.2*	1.893± 0.10*

NS = Not significant, * = P < 0.001

Table 2. Correlation coefficients (r) of VO_2max with different physical parameters in male and female college students of Uttar Pradesh, India.

	Category	Age (Yrs)	Body Height (cm)	Body Mass (kg)	BSA (m^2)
VO_2max (L/min)	*Males*	0.62	0.91	0.82	0.85
	Females	0.58	0.86	0.72	0.76

In all the cases P < 0.001

Table 2 shows the correlation coefficients of VO_2max with different physical parameters. All the physical parameters are significantly (P<0.001) correlated with VO_2max in both the sexes. VO_2max exhibited maximum correlation with body height in both the sexes and therefore it was considered as the best independent parameter among all the physical parameters to compute the regression equation for VO_2max. These regression norms are shown in figure 1.

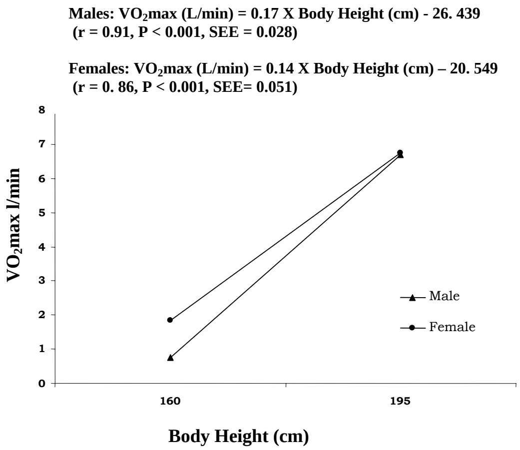

Figure 1. Relationship between VO_2max and body height in male & female college students

Discussion

The males have higher value of VO_2max than their female counterparts as also reported in previous studies from the country and abroad *(Fox, 1973; Das and Bhattacharya, 1995; Kline et al., 1987; Mcardle et al., 1972).* But the values of VO_2max obtained in both sexes is comparatively low indicating that the studied population have lower aerobic capacity and poor physical fitness in respect to Caucasians, Kurds, Yemenites, Europeans, Africans, Japanese, young population of Denmark and Americans *(Wyndham et al. 1963; Davies et al. 1972; Kitagawa et al. 1977; Okura and Tanaka 2001; Wassmer and Mookerjee 2002; Uth et al. 2004).* The VO_2max of active subjects reported by *Sengupta et al. (1974), Das (1968), Banerjee et al. (1974), Walter and Nancy (1983)* was much higher than that of the present study. On the other hand the cardiorespiratory fitness obtained in the present population is comparatively higher than male smokers and non-smokers of Kolkata *(Chatterjee et al., 1987),* female non-smokers of Kolkata *(Chatterjee and Chakraborty 1986)* and university boys and girls of Kolkata *(Chatterjee et al., 2004; Chatterjee et al., 2005).*

The physical parameters showed significant correlation with VO_2max as also reported in previous studies *(Kitagawa et al., 1977; Banerjee et al., 1974; Chatterjee et al., 1987; Chatterjee and Chakraborty 1986; Watanabe et al., 1994).* This might be the probable cause for having significantly greater VO_2max among males as they in turn showed significantly higher values of physical parameters (except age) than their female counterparts. In the present population, maximum correlation of VO_2max was obtained with body height in both the sexes and therefore body height was considered as the best parameter to compute the prediction norm for VO_2max among the young college students of Uttar Pradesh, India (Fig 1).

Conclusions

The present investigation depicted that the young college students of Uttar Pradesh, India have normal cardiorespiratory fitness which is well correlated with physical parameters with males having superiority than their female counterparts. Prediction norm for VO_2max computed in both the sexes from body height will help for diagnosis, follow up and treatment of any kind of cardiorespiratory trouble in the studied population.

References

Banerjee, P.K., Chatterjee, S., Chatterjee, P. and Maitra, S.R. 1974. Aerobic capacity of Bengalee young men trained and untrained. *Indian Journal of Physiology & Allied Sciences,* **28:** 91-99.

Chatterjee, S. and Chakraborty, B. 1986. Comparative study of VO_2max by three different ergometries in untrained college women. Japanese *Journal of Physiology,* **36:** 151–162.

Chatterjee, S., Chatterjee, P. and Bandyopadhyay, A. 2005. Validity of Queen's College Step Test for estimation Maximum oxygen uptake in Young

Indian Women. *Indian Journal of Medical Research,* **121:** 32-35.

Chatterjee, S., Chatterjee, P., Mukherjee, P.S. and Bandyopadhyay, A. 2004. Validity of Queen's College step test to use with young Indian men. *British Journal of Sports Medicine,* **38:** 289-291.

Chatterjee, S., Dey, S.K. and Nag, S.K. 1987. Maximum oxygen uptake capacity of smokers of different age groups. *Japanese Journal of Physiology,* **37:** 837-850.

Das, S.K., and Bhattacharya, G. 1995. A comparison of cardiorespiratory fitness in non-athletes and athletes of eastern India. *Indian Journal of Physiology & Allied Science,* **49:** 16–23.

Das, SK. 1968. The maximum aerobic capacity of Gorkha soldiers. *Indian Journal of Medical Research*, **56:** 1054-1062.

Davies, C.T.M., Barnes, C., Fox, RH.., Ojikutu, R.O., Samueloff, A.S. 1972. Ethnic differences in physical work capacity. *Journal of Applied Physiology,* **33:** 726-732.

DuBois, D. and DuBois, E.F. 1916. Clinical Calorimetry: A formula to estimate approximate surface area if height and weight be known**.** *Archives of International Medicine,* **17:** 863-871.

Fox, E.L. 1973. A simple accurate technique for predicting maximal aerobic power. *Journal of Applied Physiology,* **35:** 914-916.

Kitagawa, K., Miyashita, M., Yamamoto, K. 1977. Maximal oxygen uptake, body composition and running performance in young Japanese adults of both sexes. *Japanese Journal of Physical Education,* **21:** 335-340.

Kline, G.M., Porcari, J.P. and Hintermeister, R. 1987. Estimation of VO_2max from one mile track walk, gender, age and body weight. *Medical Science of Sports & Exercise,* **19:** 253–259.

McArdle, W.D., Katch, F.I. and Pechar, G.S. 1972. Reliability and interrelationships between maximal oxygen intake, physical work capacity and step test scores in college women. *Medical Science of Sports & Exercise,* **4:** 182–186.

Okura, T. and Tanaka, K. 2001. A unique method fro predicting cardirespiratory fitness using rating of perceived exertion. *Journal of Physiological Anthropology and Applied Human Sciences,* **20:** 255-261.

Sengupta, J., Srinivasulu, N., Sampath, K.I. and Malhotra, MS. 1974. Influence of age on maximal O_2 uptake and maximal heart rate of Indians during work. *Indian Journal of Medical Research,* **62:** 1228.

Siconolfi, S.F., Cullinane, E.M. and Careton, R.A. 1982. Assessing VO_2max in epidemiologic studies: modification of the Astrand-Rhyming test. *Medical Science of Sports & Exercise,* **14:** 335–338.

Uth, N., Sorensen, H., Overgaard, K. and Pedersen, K.P. Estimation of VO_2max from the ratio between HR_{max} and HR_{rest} – the heart rate ratio method. *European Journal of Applied Physiology,* **91:** 111-115.

Walter, S. and Nancy, N.R. 1983. Maximum oxygen uptake in young Indian asymptomatic smokers and non-smokers. *Indian Journal Medical Research,* **77:** 133-143.

Wassmer, D.J. and Mookerjee, S. 2002. A descriptive profile of elite US women's collegiate field hockey players. *Journal of Medicine Sports and Phys Fitness,* **42:** 165-171.

Watanabe, K., Nakadomo, F. and Maeda, K. 1994. Relationship between body composition and cardiorespiratory fitness in Japanese junior high school boys and girls. *Annals of Physiological Anthropology,* **13:** 167-174.

Wyndham, C.H., Straydom, N.B., Morrison, J.F., Peter J, Williams, C.G., Bredell, C.A.G. *et al* 1963..Difference between ethnic group in physical working capacity. *Journal of Applied Physiology,* **18:** 361-366.

Impact of Neurotoxicants on the Physical Development of Children

Chaudhary, S, Jaswal, I.J.S. & Jaswal, S.
Department of Human Development, Punjab Agricultural University, Ludhiana, Punjab

Abstract

The present study was undertaken to assess the impact of neurotoxicants on the physical development of children aged 6-7 years in two eco-settings of Ludhiana city of the Punjab State in India. The locality around industrial area was termed as neurotoxicant polluted setting (NPS) and the locality away from the industrial area was termed as neurotoxicant free setting (NFS). The sample comprised of 240 children aged 6-7 years (belonging to low socio-economic status, born and brought up in the specified setting and not of migrant family), randomly taken from the Government schools located in the two settings. Out of these 240 children, 120 each were drawn purposively from the two eco-settings. Standard instruments (anthropometer, weighing balance and fiberglass measuring tape) and procedures were used for anthropometric assessment. The results showed children of NPS to be better in weight whereas those of NFS were better on height. They were almost similar with respect to their head circumference.

Key Words: Environmental Pollution, Lead Poisoning, Health, Anthropometry, Weight, Height

Introduction

Children are partly the products of the environment both material and non-material, consequently any change in it is likely to affect them. Concern is being expressed to the increase in environmental pollution that is releasing potentially dangerous chemicals or toxicants in the air the children breathe, water they drink and land they live on. Of the various toxicants, childhood lead poisoning is now recognized as the number one preventable global environmental disease of children. Lead poisoning affects children's health and development, especially in densely populated urban and industrial cities. Even a low-to-moderate level of lead poisoning results in neuromotor problems (Sciarillo & Alexender, 1991). In the presence of underlying iron deficiency, the absorption of lead from various sources increases (Wasserman et al., 1994), thus aggravating the toxic effects of lead. Besides lead, other neurotoxicants like copper, selenium, arsenic etc. also affect the development of children. In addition, if the child is from low socio-economic status, neurotoxicants have an even more damaging effect on him/her as his immediate home environment is already deficit because of poverty.

Ludhiana, the industrial capital of Punjab in India, has a large share of industrial pollutants and effluents from industries such as hosiery, textile, spare parts, cycles, dyeing, sewing machines, auto parts, chemicals and vegetable hydrogenated fats. The impact of neurotoxicants on the physical development of children of the city was studied.

Materials and Methods

The study is based on a sample of 240 children aged 6-7 years, randomly drawn from the Government schools located in the two eco-settings of the Ludhiana district of the Punjab State in India. Neurotoxicant polluted eco-setting (NPS) was adjoining the industrial area and neurotoxicant free eco-setting (NFS) was about 15-20 km from the industrial area. The drinking water samples' qualitative analysis in terms of heavy metal content is presented in Table 1 for the two settings.

Out of 240 children, 120 children each were drawn purposively from these two eco-settings. Further, the children included in the sample from the two eco-settings satisfied the following criteria for their inclusion: -

(a) belonging to the low socio-economic status
(b) should be attending the school
(c) should not be of a migrant family
should have minimum six years residence in the specified area.

Table 1. Toxicants found in the drinking water samples

Toxicants (mg/litre)	Maximum permissible limits	Neurotoxicant Polluted Setting (NPS)	Neurotoxicant Free Setting (NFS)
Lead	0.1	0.38	0.1
Arsenic	0.05	0.37	0.1
Cadmium	0.005	0.85	0.0008
Copper	0.05	0.26	0.009

Standard instruments (anthropometer, weighing machine and fiber glass measuring tape) and procedures were used to measure the height (cm.), weight (kg.) and head circumference (cm.) of the subjects (Weiner & Laurie, 1969). The anthropometric measurements were taken in the morning and individuals wore minimal clothing during examination. Height was appreciated to the nearest 0.1 cm. with the subject in standing position, bare foot and with the head held in the Frankfurt-Horizontal plane. A gentle pressure was applied on the mastoid process during measurement. On the other hand, weight was measured to the nearest 0.1 kg. Similarly, head circumference was measured from glabella to glabella through occiput to the nearest 0.1 cm. Sahil's haemoglobinometer was used to test their haemoglobin level.

Data was analyzed by applying appropriate statistical methods such as arithmetic mean, standard deviation, percentages, co-efficient of variation and Z-test. Both 0.05 and 0.01 level of 'p' were considered for ascertaining the significance of results.

Results

Table 2. Haemoglobin (Hb) level of respondents of two Eco-settings

Eco-settings/Sex	Range	Various grades of Hb-level (NIN- 1986)			
		Non Anaemic (>12g/dl.)	Mild anaemic (> 10-11.9 g/ dl.)	Moderate anaemic (> 8-9.9g/dl.)	Severe anaemic (> 7.9g/ dl.)
Neurotoxicant Free					
Boys					
Girls	9-12	7(11.67)	35(58.33)	18(30)	-
Combined	8-12	3(5)	33(55)	19(31.67)	5(8.33)
		10(8.33)	68(56.67)	37(30.83)	5(4.17)
Neurotoxicant Polluted					
Boys					
Girls	7-12	3(5)	24(40)	27(45)	6(10)
Combined	6-12	2(3.33)	28(46.67)	21(35)	9(15)
		5(4.17)	52(43.33)	48(40)	15(2.5)

The respondents in both the eco-settings were almost similar in their socio-personal aspects. The respondents in both the eco-settings were also similar in that both these eco-settings housed respondents who were in majority anaemic, though the respondents of NPS were more anaemic than the respondents of NFS (Table-2), indicating their greater susceptibility to neurotoxicants. Respondents of NPS also showed greater variability in their Hb level to the extent that if some children had Hb level of 10 or 11g/100 ml., then there were also children who had Hb level as low as 6 or 7g/ml.

It is evident from Table 3 that the boys of NFS of both the age groups i.e. 6 and 7 years were comparatively taller (mean height 110.8 cm. at 6 and 115.7 cms. at 7 years) than their counterparts in NPS with mean height of 108.0 cm. at 6 years and 112.4 cm. at 7 years. Also the difference in height at the age group of 7 years was found to be significant ($p<0.05$); the difference was in favour of the NFS group (Table 4). However, the head circumference of the boys of both the eco-settings were almost similar. Further it was observed that the boys of NPS at both the age-levels weighed more than their counterparts in NFS; differences favouring NPS and being significant both at 6 years ($p<0.05$) and at 7 years ($p<0.01$) (Table 4).

.

Table 3. Physical development of respondents from two Eco-settings

Age (years)	Neurotoxicant Free				Neurotoxicant Polluted			
	N	Height (cm) Mean (SD)	Weight (kg) Mean (SD)	Head circm. (cm) Mean (SD)	N	Height (cm) Mean (SD)	Weight (kg) Mean (SD)	Head circm. (cm) Mean (SD)
BOYS								
6	25	110.8 (6.8)	14.3 (3.0)	50.8 (1.7)	22	108.0 (4.6)	16.1 (1.7)	50.6 (1.4)
7	35	115.7 (7.4)	15.5 (3.0)	50.9 (1.2)	38	112.4 (5.4)	18.5 (1.9)	50.9 (1.0)
GIRLS								
6	16	106.4 (6.3)	12.4 (2.2)	49.6 (1.1)	25	106.3 (4.0)	15.2 (2.3)	49.4 (1.1)
7	44	114.7 (6.0)	15.1 (2.3)	49.9 (1.4)	35	110.8 (6.0)	17.4 (2.0)	49.7 (1.3)

Table 4. Comparison in physical development from two Eco-settings.

Age (years)	Variable	Boys (Z-value)	Girls (Z-value)
6	Height	1.67	0.06
	Weight	2.57**	3.9*
	Head Circum.	0.87	0.57
7	Height	2.16**	2.89*
	Weight	5.0*	4.79*
	Head Circum.	0	0.67

* Critical value of Z at 1% level of significance = 2.58
** Critical value of Z at 5% level of significance = 1.96

Almost similar results were observed in case of girls. Girls of NFS were taller at both age levels of 6 and 7 years (differences significant at 0.01 level) as compared to those in the NPS (Table 4).

Similarly, girls of both the eco-settings had almost similar head circumferences. As with boys, the mean weight of girls of NPS was more as compared to those in the NFS.

Discussion

The results indicate that respondents (both boys and girls) of NFS were better than their counterparts in NPS with respect to height. On the other hand, those in NPS were heavier than those in NFS, when their mean weights were compared. They were similar with respect to their head circumferences.

The adverse effect of overt plumbism on physical growth has long been recognized (Nye, 1929, Johnson & Tenuta, 1979). The effect of low lead (Pb) level exposure on physical growth was first explored by Schwartz et al (1986), using data from the National Health and Nutrition Examination Survey (NHANES) II of 1976-1980. From the NHANES II data of 2695, seven years old children predicted that blood lead level (BPb) range of 4 to 35 (µg/dl) was a statistically significant predictor of children's height and weight, with control for age, race, sex and nutritional covariates.

The results of subsequent studies have been inconsistent. A retrospective study of the growth of 54 children from birth to 48 months of age suggested a negative correlation between weight gain and higher BPb between 15 and 24 months of age (Angle & Kunzelman, 1989). Two longitudinal studies did not find any significant association between BPb and physical growth (Sachs & Moel, 1989; Greene & Ernhart, 1991). Covariate adjusted heights at 15 and 33 months of age were negatively associated with postnatal BPb concentration (Shukla et al., 1989 and Shukla et al., 1991). Frisancho and Ryan (1991) reported an inverse relationship between BPb concentration in the range of 0.14-1.92 µm0l/l with stature of 1454 Mexican American children aged 5-12 years i.e. growth retardation was associated even with moderate concentration of BPb. The children with BPb concentration above the median for age and sex were approximately 1.2 cm. shorter than their counterparts with BPb concentration below the median. Ballew et al (1999) found significant negative association between BPb concentration and stature and head circumference among children through 1 to 7 years. Stanek et al (1998) reported negative relationship between head circumference and BPb level of 21 children aged 18 to 36 months residing in Omaha, Nebraska. The children (boys and girls) of present study from Neurotoxicants Polluted Setting (NPS) were shorter in stature by 2-3 cm. when compared with their counterparts from Neurotoxicants Free Setting (NFS) and the differences were statistically significant.

The deleterious effects of Pb have also been reported on animals. Hamilton and Oflaherty (1994) in an experimental model exposed rats to lead acetate and found that tail length was shorter in Pb exposed rats. The reduction in tail growth suggested a Pb-induced inhibition of the development of the distal vertebrae. Given the importance of vertebral development on an individual's height, this finding may explain reports of shorter height in children who live in industrial areas that are highly contaminated with Pb as in the present study. Anderson and Danylchuk (1977) in an experimental study in dogs, found that chronic exposure to Pb decreased bone formation. Hass et al (1967) reported similar findings in an experimental study in rabbits. Similarly, Miyahara et al (1995) observed that Pb increased bone resorption in bone cultures, except when the culture had been treated previously with calcitonin, a hormone that has a strong inhibitory effect on osteoclastic activity (Chambers et al., 1986), the principal cell involved in bone resorption. Escribano et al (1997) in a study on 35, 50 day-old female Wistar rats reported that Pb did not affect the longitudinal growth of peripheral long bones, but did affect the development of the axial skeleton. Lead exposure in rats also produced important changes in bone remodeling that caused reduction in bone mass as measured by histomorphoniety produced mainly by enhanced resorption and an increase in bone mass, as measured by densitometry, produced by Pb accumulation in bone.

Even previous investigations of human populations with moderate to low Pb exposure have demonstrated a strong positive and relatively linear relationship of both tibia and patella bone and Pb with age (Somerville et al., 1985; Hu et al., 1990; Kosnett et al., 1994 & Watanabe et al., 1994). In the study by Hernandez-Avita et al (1996) as well, tibia and patella Pb levels were positively related with age.

Contrasting results have been found regarding effect of neurotoxicants on weight on animals. Levis et al (1988) found no effect on weight, head circumference, crown-rump or crown-heel length in rhesus monkey observed over the first six months of life and dosed from birth having BPb levels of 25-45 µg/dl. Bushnell (1978) found no effect on body weight in rhesus monkeys observed over the first year of life, dosed from birth and divided into three cohorts totaling 38 monkeys. Similarly Rice (1996) found no evidence of reduced weight as a result of Pb exposure in 34 female and 18 male monkeys in which body weight was modeled from infancy through adulthood and in which BPb concentration were always above 40 g/dl.

The findings of the present investigation do point to the negative effect of Pb on stature. The exact mechanism whereby Pb may retard growth is not known. Here, a possible explanation for the observed association may be that nutritional deficits that retard growth also increase Pb absorption e.g. iron deficiency, as found in number of children who are anaemic. In fact iron deficiency does increase Pb absorption as reported by Danford (1982) and Lin-Fu (1982). Pounds et al (1982, 1983) and Rosen (1983) have also attributed the negative affect on weight and height in human children to the lead's effect on heme-dependent enzymes or calcium messengers.

Reduced pituitary responsiveness to hypothalamic stimuli in terms of growth hormone releasing factor or thyrotropin releasing hormone has been postulated as a pathophysiologic mechanism for lead's effect on physical growth (Huseman et al., 1992). They showed that peak human growth hormone and insulin like growth factor I responses to the L-dopa insulin test were low in Pb-poisoned children. They thus, concluded that Pb-induced reduction in stature may be due to diminished human growth hormone secretion which in turn results in reduced insulin like growth factor I secretion, or that Pb may directly inhibit insulin like growth factor I formation. Blunted response of thyroid-stimulating hormone and growth hormone to stimulatory challenge have been observed in Pb-poisoned children (Huseman et al., 1987) as well as in rats exposed to low-level Pb (Camoratto et al., 1993).

There are few studies reporting effect of pollutants on weight of children. The present study, has observed significantly higher body weight of children on NPS. Similar findings have been reported by Kim et al (1995) who in a cross-sectional and longitudinal investigation assessing the relationship between chronic exposure to Pb and physical growth among a cohort of children re-assessed 13 years after initial examination found that dentin Pb level was positively associated with body mass index suggesting that chronic Pb exposure in childhood may result in obesity that persists into adulthood.

Conclusion

Decrease in height and head circumference and increase in weight of the respondents could be attributed to the excess consumption of neurotoxicants via food chain and water in NPS. A critical analysis of the whole scenario further reveals that weight is the only physical variable that significantly differentiates between the respondents of the two eco-settings at both the age groups and in both the sexes. The effect of toxicity on height becomes more pronounced with increase in age.

References

Anderson, C., and Danylchuk, K. D. 1977. The effect of chronic low-level lead intoxication on the haversian remodeling system in dogs. *Laboratory Investigations*., **37**:466-69.

Angle, C. R., and Kunzelman, D. R. 1989. Increased erythrocyte protoporphyrins and blood lead – a pilot study of childhood growth patterns. *Journal of Toxicology and Environmental Health* **26**:149-56.

Ballew, C., Khan, L. K, and Kautmann, R. 1999. Blood lead concentration and children's anthropometric dimensions in the Third National Health and Nutrition Examination Survey (NHANES III) 1988-1994. *Journal of Pediatrics*., **134**:623-30.

Bushnell, P. J. 1978. *Behavioral toxicology of lead in the infant rhesus monkeys*. Doctoral Thesis, University of Wisconsin, Madison.

Camoratto, A. M., White, L. M, and Lau, Y. S. 1993. Effect of exposure to low level lead on growth and growth hormone release in rats. *Toxicology*., **83**:101-04.

Chambers, T. J., Chambers, J. C., and Symonds, J. 1986. The effect of human calcitonin on the cytoplasmic spreading of rat osteoclast. *Journal of Clinical Endocrinological Metabolism*., **63**:1080-85.

Danford, D. E. 1982. Pica and nutrition. *Annual Review Nutrition.*, **2**:303-22.

Escribano, A., Revilla, M., and Hernandez, E. R. 1997. Effect of lead on bone development and bone mass: A morphometric, densitometric and histomorphometric study in growing rats. *Calcif Tissue Int*., **60**:200-03.

Frisancho, A.R., and Ryan, A. S. 1991. Decreased stature associated with moderate blood lead concentrations in Mexican-American children. *American Journal of Clinical Nutrition.,* **54**:516-19.

Greene, T., and Ernhart, C. B. 1991. Prenatal and preschool age lead exposure: Relationship with size. *Neurotoxicology and Teratology*.,**13**:417-27.

Hamilton, J. D., and Oflaherty, E. J. 1994. Effects of lead exposure on skeletal development in rats. Fundamental Applied Toxicology., **22**:594-604.

Harnandez-Avila, M., Gonzalez-Cossio, T., and Palazuelos, E. 1996. Dietary and environmental determinants of blood and bone lead levels in lactating postpartum women living in Mexico City. *Environmental Health Perspectives.*, **104**:1076-82.

Hass, G. M., Landerholm, W., and Hemmens, A. 1967. Inhibition of intercellular matrix synthesis during ingestion of inorganic lead. *American Journal of Pathology*.,**50**:815-45.

Hu, H., Milder, F., and Burger, D. E. 1990. X-ray fluorescence measurements of lead burden in subjects with low-level community lead exposures. *Archives of Environmental Health*., **45**:335-41.

Huseman, C. A., Varma, M. M., and Angle, C. R. 1992. Neuroendocrine effects of toxic and low blood lead levels in children. *Pediatrics.*,**90**:186-89.

Huseman, C. A., Moriarty, C. M., and Angle, C. R. 1987. Childhood lead toxicity and impaired release of thyrotropin stimulating hormone. *Environmental Research.,* **42**:524-33.

Johnson, N. E., and Tenuta, K. 1979. Diets and lead blood levels of children who practice pica. *Environmental Research*.,**18**:369-76.

Kim, R., Hu, H., and Rotnitzky, A. 1995. A longitudinal study of chronic lead exposure and physical growth in Boston children. *Environmental Health Perspectives*., **103**:952-57.

Kosnett, M. J., Becker, C. E., and Osterloh, J. D. 1994. Factors influencing blood lead concentration in a suburban community assessed by non-invasive K X-ray fluorescence. *Journal of American Medical Association.*, **271**:197-203.

Levis, E. D., Schneider, M. L., and Ferguson, S. A. 1988. Behavioral effects of developmental lead exposure in rhesus monkeys. *Developmental Psychobiology.*, **2**:371-82.

Lin-Fu, J. S. 1982. The evolution of childhood lead poisoning as a public health problem. In: *Lead absorption in children. Ed:* Chrisholm, J. J., O'Hara, D. M. Baltimore: Urban & Schwarzenberg. 1-10.

Miyahara, T., Komiyama H., and Miyanishi, A. 1995. Stimulative effects of lead on bone resorption in organ culture. *Toxicology*., **97**:191-97.

Nye, L.J.J. 1929. An investigation of the extraordinary incidence of chronic nephritis in young people in Queensland. *Medical Journal of Aris.,* **2**:145-59.

Pounds, J. G., and Mittelstaedt, R. A. 1983. Mobilization of cellular Ca-45 and lead-210: Effect of physiologic Stimuli. *Science*., **220**:308-10.

Pounds, J. G., Wright, R., and Kodell, R. L. 1982. Cellular metabolism of lead: a kinetic analysis in the isolated rat hepatocyte. *Toxicology & Applied Pharmacology*., **66**:88-101.

Rice, D. C. 1996. Effect of long term lead exposure on hematology, blood biochemistry and growth curves in monkeys. *Neurotoxicology.*, **18**:221-36.

Rosen, J, F. 1983. The metabolism of lead in isolated bone cell populations: Interactions between lead and calcium. *Toxicology & Applied Pharmacology*., **71**:101-12.

Sachs, H. K, and Moel, D. I. 1989. Height and weight following lead poisoning in childhood. *American Journal of Diseases of Childhood*.,**143**:820-22.

Schwartz, J., Angle, C., and Pitcher, H. 1986. Relationship between childhood blood lead levels and stature. *Pediatrics.*,**77**:281-88.

Sciarillo, W.G., and Alexander, G. 1991. Lead exposure and child behaviour. *American Journal of Public Health.,* **82**:1356-60.

Shukla, R., Bomschein, R. L., and Dietrich, K. N. 1989. Foetal and infant lead exposure: effects on growth in stature. *Pediatrics*., **84**:604-12.

Shukla, R., Dietrich, K. N., Bomschein, R. L., and Buncher, C. R. 1991. Lead exposure and growth in the early preschool childhood. *Pediatrics.,* **88**:886-92.

Somervaille, L. J., Chettle, D. R., and Scot, M. C. 1985. In vivo measurement of lead in bone using X-ray fluorescence. *Physical Medicine & Biology*., **30**:929-43.

Stanek, K., Manton, R. D. W., and Angle, C. 1998. Lead consumption of 18 to 36 months old children as determined from duplicate diet collections: Nutrient intakes, blood lead levels and effect on growth. *Journal of American Diet Association.*, **98**:155-58.

Wasserman, G. A., Graziano, J. H., and Factor-Litvak, P. 1994. Consequences of lead exposure and iron supplementation on childhood development at age 4 years. *Neurotoxicol Teratology*., **16**:233-40.

Watanabe, H., Hu, H, and Rotnitzky, A. 1994. Correlates of bone and blood lead levels in carpenters. *American Journal of Medicine*., **26**:255-64.

Weiner, J. S., and Luurie, J.A. 1969. Human biology: a guide to field methods In: *Growth and physique*. Ed: Tanner, J. M., Heirnaux, J., and Jarman, S. Oxford: Blackwell Scientific Publications.

Growth Spurt, Relative Fat Distribution and Physical Activity of Senegalese Rural Male Adolescents

Benefice, Eric

Epidemiology and Prevention, Research Unit R024, IRD (Institut de Recherche pour le Développement, Av H Siles #5297 * Esquina 7 de obrajes, PoBox: 9214, La Paz (Bolivia)

Abstract

This study examines the height growth spurt of a group of 378 adolescent boys from rural Senegal (West Africa), along with their subcutaneous fat changes through puberty. Habitual physical activity was qualitatively estimated in a subsample of 40 adolescents via a questionnaire; it was quantitatively assessed by an accelerometer worn for 3 consecutive days. Using the Preece-Baine model, a delay of about 3 years in the growth spurt was discernable compared with CDC reference data. Despite this delay, older adolescents reached a final stature of around the 50^{th} percentile of the reference. Subcutaneous fat increased after the age at take-off, with substantial trunk fat deposition. These adolescents appeared to be fairly active, spending 38% of their time during the day performing vigorous activities. These results are in line with other African studies describing a slow and prolonged growth process. The fat regional deposition pattern also conformed to that of adolescents from industrialized countries. No significant relationship between physical activity and nutritional status was evidenced..

Key Words: Adolescence, Peak Height Velocity, Body Composition, Accelerometry, Senegal

Introduction

A pattern of slow but continuous growth was described several years ago in rural African children (Little and Johnson 1987). This resulted in a blunted spurt which was even more pronounced in boys than in girls (Little and Johnson 1987; Simondon and others 1997). Sexual maturity was also frequently delayed (Cameron and others 1993; Campbell and others 2005). A profile of leanness and slow growth would appear to be habitual in populations living in the dry savannahs of Africa (Glew and others 2003; Gray and others 2004). Likewise, more than two decades ago, a phenomenon of catch-up growth at the end of puberty was reported (Kulin and others 1982) and was later confirmed in rural Mali (Pawloski 2003). This phenomenon, sometimes termed "compensatory growth", was concomitant with an increase in fatness, occurring mainly after the peak of height velocity (Cameron and others 1994).

Among the causes frequently advanced to explain this slow growth, chronic undernutrition is most often cited (Martorell and others 1992). Global energy dietary deprivation is widespread in rural Africa; however, certain micronutrient deficiencies (essential amino acids and zinc) could also lead to stunting (Golden 1991). This might be the case in Senegalese agricultural communities at the end of the dry season (Benefice and Simondon 1993). Indeed, physical activity is a potent regulator of energy balance and hence of nutritional status. In rural Africa, adolescents and children are continuously involved in daily tasks at the household level, and this may represent a high level of energy expenditure. This is especially evident in the case of adolescent girls (Benefice and others 2001a). Studies among African rural boys are less common, and there is a need to provide new information (Larsen and others 2004).

A paradoxical long-term consequence of stunting is the possible existence of a link with fatness or obesity

(Sawaya and Roberts 2003). This was recently described in South Africa *(Kruger and others 2004)*, especially in urbanized areas where a process of nutritional transition is in progress (Mukuddem-Petersen and Kruger 2004). Likewise, an association between stunting during infancy and higher subsequent trunk fat accumulation was also reported among adolescent girls (*Benefice and others 2001b)*. One plausible explanation could be a lower rate of fat oxidation in previously malnourished children (Sawaya and Roberts 2003).

Causes and long-term consequences of stunting are complex and not fully understood. More investigations are needed, especially in the most severely affected areas, so as to better evaluate this condition and provide appropriate recommendations for public health policies. Hence, the main objective of the present study was to analyze the pubertal growth spurt in a sample of Senegalese boys exposed to chronic malnutrition, in relation to fat deposition patterns. In addition, the role of physical activity as a possible modulator of nutritional status and growth was studied.

Materials and Methods

Ecological setting

The study was performed in the Niakhar district of Senegal 120 km southeast of the capital city Dakar. It belongs to the ancient kingdom of the Siin in the so-called “groundnut basin”. This district comprises 33,000 inhabitants mainly belonging to the Sereer ethnic group; 74% of them are Muslims and 23% Christians. The climate is Sahelian, with a long dry season and a short rainy season (June to October). The productive activity consists of groundnut and millet cultivation. The study was carried out between March and June 2000.

Sampling

From the demographic database of the Niakhar project: (http://www.ird.sn/activites/niakhar/presentation/index.html), 3427 boys 10-to-17-years-old were censused. A total of 400 were randomly drawn to participate in the study. The final sample included 378 boys who were measured.

Ethic

The study protocol was approved by the review board of the Institut de Recherche pour le Développement (IRD, Centre de Dakar) and by an annual agreement on the part of the Senegalese Ministry of Research. The aims of the study were individually explained to the boys, their parents and village leaders. Oral consent was requested, since most subjects were illiterate. The study followed the principles of the Helsinki Declaration.

Anthropometric measurements and indices

The following measurements were carried out in accordance with standardized recommended techniques (Lohman and others 1988): 1) body weight (kg), lightly clothed and barefoot with an electronic scale (accuracy 100 g); standing height (cm) with a Harpenden ® anthropometer; measurement of 7 subcutaneous fatfolds (in mm) with a Holtain ® caliper at the tricipital (tric), bicipital (bic), subscapular (sca), supra-iliac (sil), umbilical (umb), anterior thigh (thigh) and media-calf (calf) sites. Measurements were done in duplicate after marking the sites. A mean of 2 measurements was used to minimize variance. In addition, mid-arm circumference (MAC, cm) was measured with an unstretchable tape.

Indices of malnutrition were calculated according to the World Health Organization (WHO 1995) height for age (H-age) and weight for age (W-age). They were computed using Anthro software and expressed as z-scores (Centers for Diseases Control: http://www.cdc.gov). BMI was calculated as weight (kg) /stature (m) ^{2}.

The Preece and Baines model (*Preece and Baines 1978*) was used to fit a height velocity curve. This model allows for calculation of the following indices: age at height take-off (TO; years), velocity at TO (cm/year); age at peak height velocity (PHV; years); velocity at PHV (cm/year); and prediction of adult final stature (cm). Since it was not possible under field conditions to accurately assess the sexual maturity of the boys, age at TO and age PV were used as proxies for pubertal maturity.

The sum of the 7 skinfolds (sum 7 SKF, mm) was used as an index of subcutaneous fat mass and as a proxy for total fat mass. Principal component analysis (PCA) was performed on the 7 skinfold measurements to assess relative fat distribution. It followed the protocol of Healy and Tanner *(Healy and others 1981)* modified by Mueller *(Mueller and others 1982)*. As a first step, each skinfold was transformed into its natural log and then each log-transformed skinfold was regressed on the mean of the six log-transformed skinfolds. Residuals of regressions were used in PCA. The first step eliminated the total subcutaneous fatness component which usually accounts for 80% of variance *(Baumgartner and others 1986)*. Factor scores obtained for each adolescent were generated and then used for group comparisons.

Because two measurers participated in the surveys, standardization was carried out at the beginning based on 25 children. The technical error in measurement and the variation coefficient were calculated *(Lohman and others 1988)*. The technical error was very small (0.1 to 0.5). Variability between observers was also weak: 0.3% for longitudinal measurements. Variability was higher for subscapular skinfolds (5.7%) but was within the limits published in the specialized literature *(Malina 1995a)*.

Physical activity

Physical activity was studied in a subsample of 40 subjects with the same age range, geographic location and familial characteristics as the main sample. Physical activity was quantitatively studied using a CSA accelerometer. Accelerometers are small (5 * 4 * 1.5 cm), light (42.5 g) electronic monitors attached at the left hip in a small pouch. We used the CSA (Computer Science and Applications Inc, Shalimar, Florida) model 7164. It has a single vertical piezoelectric sensor which generates a signal at each body center mass acceleration. It can record accelerations ranging from 0.05 to 2 Gs. The interval time was set at one minute and the instrument was worn for 72 consecutives hours (3 complete days and 3 nights). This interval of time was chosen because no significant improvement in data reliability was manifest after 3 days of observation (*Benefice* and Cames 1999). Data were collected through an interface unit connected to a personal computer. Activity intensity was expressed as numbers of counts per minute (counts/minute or cpm). We used 2 cut-off points: 613 bpm (corresponding to 3 Mets) and 941 bpm (6 Mets), established from a regression equation between observation scores and accelerometry counts in a group of girls*(Benefice and Cames 1999)*. These thresholds enable dividing activity intensity into 3 levels. Activity below 3 Mets was considered to be light or sedentary; activity between 3 and 6 Mets as moderate; and activity over 6 Mets as vigorous. The complete daily cycle was divided into 3 periods: morning from 7:00 to 12:59; afternoon from 13:00 to 18:59; and night from 19:00 pm to 6:59.

Statistical analysis

All data were entered in duplicate and quality control was performed with Epi Info software. Accelerometry counts were transferred to an Excel file. Statistical analyses were done using NCSS software, release 2004 (http://www.ncss.com/). Variables were checked and normality of distribution verified. For comparison purposes, a simple Student test or one-way analysis of variance was used. Scheffe's multiple comparison post hoc tests were used. In case of abnormally distributed variables, a log transformation was applied. If the distribution continued to be abnormal, the Kruskall-Wallis one-way ANOVA non-parametric test was employed. Associations between variables were studied using Pearson or Spearman rank correlations.

Results

Adolescents were divided into 3 age groups; anthropometric characteristics appear in Table 1. As indicated by H-age and W-age indices, boys were below the international references, and the growth delay was apparently greater in older boys. BMI values were under the 3rd percentile in children older than 13 years of age and just at the 10th percentile for younger boys.

Table 1. Anthropometric characteristics

	Age (years)	Mean	SD
Weight (kg)	10 to 13 (N=142)	29.17	3.79
	13.1 to 15 (N=98)	35.59	6.26
	>15 (N=139)	44.53	8.80
	10 to 13 (N=142)	137.58	7.16
Height (cm)	13.1 to 15 (N=98)	147.39	9.09
	>15 (N=139)	160.16	10.54
	10 to 13 (N=142)	17.95	1.29
MAC (cm)	13.1 to 15 (N=98)	19.54	1.75
	>15 (N=139)	21.56	2.31
	10 to 13 (N=142)	37.67	8.06
Sum 7 skf (mm)	13.1 to 15 (N=98)	41.15	7.95
	>15 (N=139)	44.02	9.61
	10 to 13 (N=142)	-1.30	0.94
H-age (z-score)	13.1 to 15 (N=98)	-1.89	1.01
	>15 (N=139)	-2.09	1.34
	10 to 13 (N=142)	-1.43	0.61
W-age (z-score)	13.1 to 15 (N=98)	-1.95	0.73
	>15 (N=139)	-2.25	0.86
	10 to 13 (N=142)	15.35	0.98
BMI (kg/m^2)	13.1 to 15 (N=98)	16.25	1.28
	>15 (N=139)	17.25	1.68

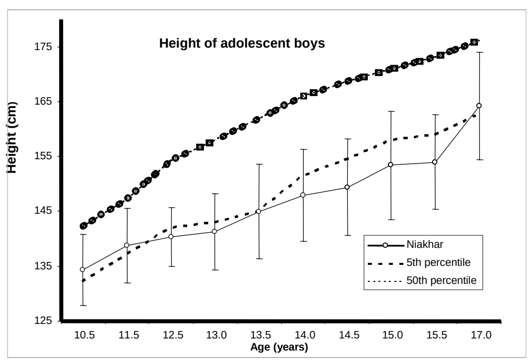

Figure 1. Growth of Senegalese adolescent boys in comparison with percentiles of the international CDC/NCHS reference

Figure 1 provides an illustration of growth delays. Mean stature at all ages was at or just below the 5th percentile. Figure 2 shows distance and velocity curves calculated using the Preece and Baines' model (Preece and Baines 1978). In addition, mean height values for age from the NCHS/CDC database were also computed. An examination of the velocity curves revealed that Senegalese adolescents were characterized by a delay in age at peak velocity (PHV) of more then 3 years. The peak was smooth and the maximum velocity attained was lower than the reference. Interestingly, distance curves fitted from the model appeared to be quite similar after a shift of 3 years. Table 2 gives more details on biological parameters of the growth spurt and on differences between Senegalese adolescents and the CDC reference. The differences in height attained at PHV (10.8 cm) and adulthood (1.1 cm) suggest that lower velocity goes hand in hand with a prolonged time of positive growth velocity, allowing for a catch-up in early adolescence.

Table 2. Biological parameters of growth in Senegalese boys (adjusted with the Preece and Baine's model)

Parameters	Niakhar	CDC/NCHS	Absolute value of difference
Age take-off (year)	11.2	5.9	5.3
Velocity take-off (TO; cm/year)	3.6	2.7	0.9
Age at peak velocity (PV; year)	16.4	13.0	3.4
Velocity PV (cm/year)	5.6	7.3	1.7
Dist TO-PV (cm)	22.8	30.7	7.9
Acceleration TP-PV (cm^2/year)	2.0	4.6	2.6
Height value at TO (cm)	136.5	125.8	10.8
% Adult stature	72.2	70.6	1.6
Height value at PHV (cm)	159.3	156.5	2.9
% Adult stature	90.1	87.9	2.2
Dist PV-adult (cm)	17.6	21.6	4.0
Adult value (cm)	176.9	178.0	1.1

Table 1 reveals a clear increase in total fat mass (as represented by the sum of 7 skinfolds; Sum 7 skf**)** with age. The difference was statistically significant (F=19.0, p<0.0001). In order to examine the influence of pubertal growth, boys were divided into 3 groups:

- Group 1 =age < TO (< 11.2-years-old) or "prepubertal" group (n=55).
- Group 2= between TO and PHV (11.2<age<16.4) or "pubertal" group (n=244).
- Group 3= older than age at PHV (>16.4-years-old) or "end of puberty" group (n=80).

Total fatness was significantly greater in "pubertal" and "end of puberty" than in "prepubertal" children (non-parametric one-way analysis of variance, Kruskall-Wallis test: χ^2=32.0, p<0.0001). However, there was no difference between "pubertal" and "end of puberty" children.

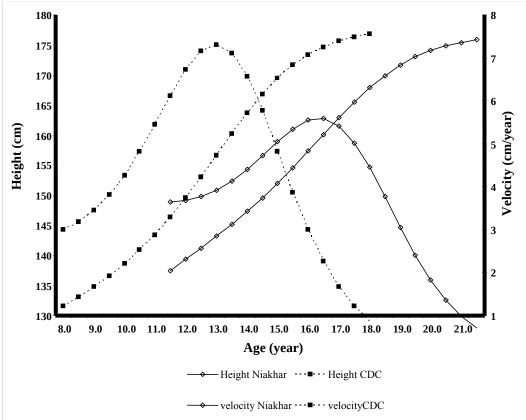

Figure 2. Curves of height velocity and distance of Senegalese boys compared with CDC/NCHS reference values

Fat regional deposition during puberty was evaluated through a principal component procedure as presented above. Two principal components with an Eigen value greater then 1 emerged, explaining respectively 36.2% and 19.8% of total variance in subcutaneous fatness. The first principal component (PC1) contrasted the trunk (positive loading) with member (negative loading) fatness. It was termed "trunk-members". The second component (PC2) contrasted arm (negative loading) to leg (positive loading) fatness. It was termed "leg-arm". Comparisons according to pubertal growth groups are indicated in Figure 3. For PC1, differences were significant between groups 1-2 and group 3 ($F=29.9$, $p<0.0001$), implying that "prepubertal" and "pubertal" children had less trunk fat deposition then "end of puberty" children. For PC2, differences were significant between group 1 and groups 2-3 ($F=4.3$, $p<0.001$): "prepubertal" children had smaller leg deposits of fat than "pubertal" or "end of puberty children".

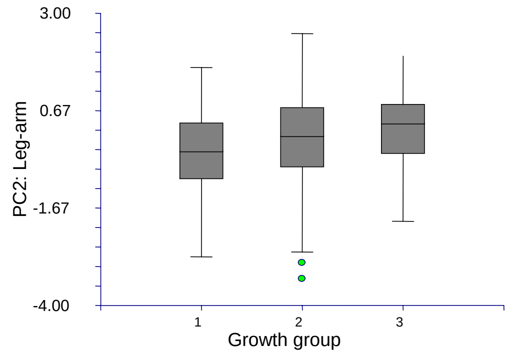

Figure 3. Factor scores in 1st and 2nd principal component according to growth group

The subsample of children monitored for habitual activity (n=40) belonged to the pubertal group. It did not differ from the other children with respect to age and anthropometric characteristics. There was no day-to-day variability in levels of activity. The 3 days of monitoring were thus pooled. During the day, boys spent 41% of their time engaged in personal activities (such as resting, visiting, eating, bathing); 5% in leisure or sports activities; 23% in traveling (walking for personal or domestic purposes); 2.3% in light domestic activity; 1.3% in handicraft or small trading; and 7.5% in agricultural tasks (carrying grain, harvesting, clearing fields, caring for animals). A detailed description of these activities has already been published in a master's thesis (Vanacker 2000). Figure 4 shows the activity profile according to accelerometry counts. Boys awoke early in the morning, before 7:00 am and as early as 5:00 am in some case. In the morning, levels of activity were not as high as during the afternoon, where they peaked between 18:00 and 19:00. There was a period of low activity or rest between 1:00 and 2:00.

Table 3. Percent of time spent during the day and at night in different levels of activity of Senegalese adolescents

Period	Light	Moderate	Vigorous	Total (%)
Morning	36.0	24.4	39.6	100.0
Afternoon	40.4	23.2	36.4	100.0
Total day	38.2	23.8	38.0	100.0
Night	81.4	8.2	10.4	100.0

Table 3 presents the distribution of activity intensity averaged at 3 levels. On the whole during the day, adolescents spent the same percent of time engaged in both light and vigorous activities. Interestingly, they also spent 10% of their time at vigorous activities in the evening. The latter concerned activity (sports, playing or dancing) between 19:00 and 22:00 hours.

Interestingly, the relationship between activity and age was negative ($r=-0.34$, $p<0.02$). The same trend was noted with stature, but without reaching a significance level.

Finally, relationships between physical activity and body build and nutritional status of adolescents were explored. There existed a non-significant trend toward stronger adolescents being more active (correlation between BMI and total activity: $r=0.21$, $p=0.10$).

Discussion

To our knowledge, this is the first study reporting fat patterns related to growth spurt in West African adolescents. While the present study largely confirms the pattern of slow growth during puberty already reported in Africa *(Little and Johnson 1987; Pawloski 2003; Simondon and others 1997),* it also provides new elements. Chronic malnutrition, represented by H-age and W-age Z-scores under the international reference, is an indisputable fact. Among the 372 boys in the sample, a total of 72% were below the -1 z-score and 36.8% below the -2 z-score of the H-age index. The apparent increase with age in the prevalence of growth retardation can no doubt be explained by a delay in the adolescent growth spurt and a difference between the chronological and biological age. The peak of height velocity, while smooth in comparison with populations from Europe and the USA *(Hamill and others 1979; Tanner and others 1966),* was nevertheless clearly marked. Interestingly, this growth profile is close to that observed in Turkana boys: velocity at PHV is quite similar (5.6 versus 5.5 in Turkana boys, cm/year); however, Senegalese boys take off earlier (11.2 versus 14.0 years) and reach the PHV at an earlier age (16.4 versus 17.0 years in Turkanas) *(Little and Johnson 1987; Walker and others 2006).* Finally, predicted adult size in Senegal (176.9 cm) was similar to that observed in Tukanas (175 cm). It should be noted that both populations were native to a dry savannah environment, and their predominant economic activities involved herding and agriculture. Recent theory has proposed an evolutionary process and environmental pressure to explain growth trajectories within a life-history framework *(Little and Johnson 1987; Walker and others 2006).* It could be assumed that the same causes produced the same growth effects in these African boys living in a dry environment and exposed to chronic energy deficiency. One limitation of these observations is that they are based on cross-sectional data that tend to blunt variability. However, a recent longitudinal analysis performed in girls from the same district confirmed the slow growth tempo reported here *(Garnier and others 2005).* While the final stature reached by adult men is not precisely known, in adolescents older then 17 years of age the 75th percentile was 173.8 cm, and the 90th was 176.2 cm. This indicates that older adolescents were apparently recovering a stature corresponding to roughly one 50th of the international NCHS/CDC reference. These findings support the hypothesis of "compensatory growth" during puberty through prolonged growth and positive velocity *(Cameron and others 1994).*

Another important facet of this study was the increase in fat accretion and trunk fat patterning through puberty. These adolescents underwent a steep rise in total fatness occurring after TO. This is in line with other studies indicating that fat accretion occurred during the growth spurt and was influenced by the rhythm of puberty *(Malina and others 1999).* Similarly, the pattern of adult fat deposition emerges during adolescence and is related to the puberty tempo *(Koziel and Malina 2005)*. Indeed, principal component analysis indicates that adolescents accrue more fat at the trunk and leg during PHV. Likewise, a longitudinal study from Belgium confirmed that in male adolescents, early maturers tended to accumulate more fat in the trunk than in the extremities *(Beunen and others 1994).* The authors concluded that late maturers were somewhat protected from metabolic diseases during adulthood because of the relationship between elevated abdominal fatness and metabolic complications *(Alberti and others 2005).* In some ways, our adolescents could be considered late maturers. We cannot exclude the possibility of a relationship between fat patterning and metabolic risk in a chronically malnourished population presumed to be free of lipid-related diseases. Indeed, there is some evidence relating stunting during infancy and childhood with later overweight and obesity *(Sawaya and Roberts 2003).* The explanation could lie in a low rate of fat oxidation in stunted children *(Hoffman and others 2000)*. However, up until now, this hypothesis has not been fully supported by empirical evidence *(Sichieri and others 2003).* The risk exists only in countries, mainly Asian or Latin American, which are undergoing nutritional transition. In the case of Sahel countries like Senegal, food security continues to be a major problem.

The subsample of children monitored for physical activity proved to be fairly active: they spent 14 h to 16 h a day in movement and 38% in vigorous activity. As a whole, this represents an activity volume greater than that observed in girls (601.0 ± 22.3 bpm in boys versus 385.5 ± 6.7 bpm in girls) *(Benefice and Cames 1999).* Girls spent 50% of the daytime in sedentary activities and 25% in vigorous activities, versus 38.2% and 38.0%, respectively in boys. Girls tended to decrease their activity at the beginning of puberty, while boys maintained a high level up to the end of puberty *(Malina 1995b).* In the present study area, for example, boys were adept at fierce sports like soccer, wrestling, tree-climbing and racing, while girls were more peaceful. Boys were also in charge of somewhat heavier agricultural tasks like planting and hoeing, and had to care for small animals. Indeed, the trend toward a decrease in the activity volume with age is in line with the general literature *(Malina 1995b)*. Due to the small sample size and lack of variance, we were unable to find a clear-cut relationship between activity, body build and fatness. There existed a non-significant trend with BMI. This positive correlation was unexpected; however, BMI in lightweight children is more an indicator of heaviness and muscle mass than of fatness.

In the present paper, we report new data on physical growth and activity of adolescent males from Senegal. They presented a growth spurt which was delayed for more than 3 years compared to children from industrialized countries, while apparently reaching a final stature in line with the international reference. While being classified as "chronically malnourished", these adolescents displayed a high level of activity. This indicates that international reference data should be interpreted with caution after 10 years of age in the absence of indicators of pubertal status. Hence, the growth trajectory of these Senegalese adolescents appeared to successfully evolve concomitant with the environmental constraints they endured.

Acknowledgement: This study was made possible by the financial support of the R024 Research Unit of IRD (Institut de Recherche pour le Developpement, France). The study was carried out within the framework of a longitudinal survey on growth at adolescence. I thank you very much Frederique Vanacker who participated in the study as Master's student. Many thanks are also due to Denis Garnier (PhD) and to Tofene Ndiaye (Research assistant) who supervised the field work. I am especially grateful to all children and adolescents who were involved in the studies.

References

Alberti, K.G., Zimmet P, Shaw J. 2005. The metabolic syndrome--a new worldwide definition. Lancet **366(9491)**:1059-62.

Baumgartner RN, Roche AF, Guo S, Lohman T, Boileau RA, Slaughter MH. 1986. Adipose tissue distribution: the stability of principal components by sex, ethnicity and maturation stage. Hum Biol **58(5)**:719-35.

Benefice E, Cames C. 1999. Physical activity patterns of rural Senegalese adolescent girls during the dry and rainy seasons measured by movement registration and direct observation methods. Eur J Clin Nutr **53(8)**:636-43.

Benefice E, Garnier D, Ndiaye G. 2001a. High levels of habitual physical activity in west African adolescent girls and relationship to maturation, growth, and nutritional status: results from a 3-year prospective study. Am J Hum Biol **13(6)**:808-20.

Benefice E, Garnier D, Simondon KB, Malina RM. 2001b. Relationship between stunting in infancy and growth and fat distribution during adolescence in Senegalese girls. Eur J Clin Nutr **55(1)**:50-8.

Benefice E, Simondon K. 1993. Agricultural development and nutrition among rural populations: a case study of the middle valley in Senegal. Ecology of Food and Nutrition **31**:45-66.

Beunen G, Malina RM, Lefevre J, Claessens AL, Renson R, Simons J, Maes H, Vanreusel B, Lysens R. 1994. Size, fatness and relative fat distribution of males of contrasting maturity status during adolescence and as adults. Int J Obes Relat Metab Disord **18(10)**:670-8.

Cameron N, Gordon-Larsen P, Wrchota EM. 1994. Longitudinal analysis of adolescent growth in height, fatness, and fat patterning in rural South African black children. Am J Phys Anthropol **93(3)**:307-21.

Cameron N, Grieve CA, Kruger A, Leschner KF. 1993. Secondary sexual development in rural and urban South African black children. Ann Hum Biol **20(6)**:583-93.

Campbell BC, Leslie PW, Little MA, Campbell KL. 2005. Pubertal timing, hormones, and body composition among adolescent Turkana males. Am J Phys Anthropol **128(4)**:896-905.

Garnier D, Simondon KB, Benefice E. 2005. Longitudinal estimates of puberty timing in Senegalese adolescent girls. Am J Hum Biol **17(6)**:718-30.

Glew RH, Conn CA, Bhanji R, Calderon P, Barnes C, VanderJagt DJ. 2003. Survey of the growth characteristics and body composition of Fulani children in a rural hamlet in northern Nigeria. J Trop Pediatr **49(5)**:313-22.

Golden MH. 1991. The nature of nutritional deficiency in relation to growth failure and poverty. Acta Paediatr Scand Suppl **374**:95-110.

Gray SJ, Wiebusch B, Akol HA. 2004. Cross-sectional growth of pastoralist Karimojong and Turkana children. Am J Phys Anthropol **125(2)**:193-202.

Hamill PV, Drizd TA, Johnson CL, Reed RB, Roche AF, Moore WM. 1979. Physical growth: National Center for Health Statistics percentiles. Am J Clin Nutr **32(3)**:607-29.

Healy MR, Tanner J, 46. 1981. Size and shape in relation to growth and form. Symposia of the Zoological Society of London:19-35.

Hoffman DJ, Sawaya AL, Verreschi I, Tucker KL, Roberts SB. 2000. Why are nutritionally stunted children at increased risk of obesity? Studies of metabolic rate and fat oxidation in shantytown children from Sao Paulo, Brazil. Am J Clin Nutr **72(3)**:702-7.

Koziel S, Malina RM. 2005. Variation in relative fat distribution associated with maturational timing: The Wroclaw Growth study. Ann Hum Biol **32(6)**:691-701.

Kruger HS, Margetts BM, Vorster HH. 2004. Evidence for relatively greater subcutaneous fat deposition in stunted girls in the North West Province, South Africa, as compared with non-stunted girls. Nutrition **20(6)**:564-9.

Kulin HE, Bwibo N, Mutie D, Santner SJ. 1982. The effect of chronic childhood malnutrition on pubertal growth and development. Am J Clin Nutr **36(3)**:527-36.

Larsen HB, Christensen DL, Nolan T, Sondergaard H. 2004. Body dimensions, exercise capacity and physical activity level of adolescent Nandi boys in western Kenya. Ann Hum Biol **31(2)**:159-73.

Little MA, Johnson BR, Jr. 1987. Mixed-longitudinal growth of nomadic Turkana pastoralists. Hum Biol **59(4)**:695-707.

Lohman TG, Roche A, Martorell R. 1988. Anthropometric standardization reference manual. Champaign, Illinois: Human kinetics Books. 177 p.

Malina R. 1995a. Anthropometry. In: Maud P, Foster C, editors. Physiological Assessment of Human Fitness. Champaign, Illinois: Human Kinetics. p 205-219.

Malina R. 1995b. Physical activity and fitness of children and youth: questions and implications. Medicine, Exercise, Nutrition, and Health **4**:125-137.

Malina RM, Koziel S, Bielicki T. 1999. Variation in subcutaneous adipose tissue distribution associated with age, sex, and maturation. Am J Human Biol **11(2)**:189-200.

Martorell R, Rivera J, Kaplowitz H, Pollitt E. 1992. Long-term consequences of growth retardation during early childhood. In: Hernandez M, Argente J, editors. Human growth: Basic and clinical aspects. B.V.: Elsevier Science Publishers. p 143-149.

Mueller WH, Shoup RF, Malina RM. 1982. Fat patterning in athletes in relation to ethnic origin and sport. Ann Hum Biol 9(4):371-6.

Mukuddem-Petersen J, Kruger HS. 2004. Association between stunting and overweight among 10-15-y-old children in the North West Province of South Africa: the THUSA BANA Study. Int J Obes Relat Metab Disord **28(7)**:842-51.

Pawloski LR. 2003. Mixed-longitudinal analysis of growth data from Malian adolescent girls: evidence for compensatory gain? Am J Hum Biol **15(2)**:178-86.

Preece MA, Baines MJ. 1978. A new family of mathematical models describing the human growth curve. Ann Hum Biol **5(1)**:1-24.

Sawaya AL, Roberts S. 2003. Stunting and future risk of obesity: principal physiological mechanisms. Cad Saude Publica 19:Suppl, 1 S21-S28.

Sichieri R, Silva CV, Moura AS. 2003. Combined effect of short stature and socioeconomic status on body mass index and weight gain during reproductive age in Brazilian women. Braz J Med Biol Res **36(10)**:1319-25.

Simondon KB, Simon I, Simondon F. 1997. Nutritional status and age at menarche of Senegalese adolescents. Ann Hum Biol **24(6)**:521-32.

Tanner JM, Whitehouse RH, Takaishi M. 1966. Standards from birth to maturity for height, weight, height velocity, and weight velocity: British children, 1965. II. Arch Dis Child **41(220)**:613-35.

Vanacker F. 2000. Etude de la croissance, de la consommation alimentaire et de l'activité physique d'adolescents sénégalais de milieu rural. [Mémoire pour l'obtention du DESS " Nutrition et Alimentation dans les Pays en Développement "]. Monpellier: Université de Montpellier II. 85 p.

Walker R, Gurven M, Hill K, Migliano A, Chagnon N, De Souza R, Djurovic G, Hames R, Hurtado AM, Kaplan H and others. 2006. Growth rates and life histories in twenty-two small-scale societies. Am J Hum Biol **18(3)**:295-311.

Physical Growth of Deaf Mute Boys of Punjab

Singh, Sukhdeep and Singh, S. P.

Department of Human Biology, Punjabi University, Patiala-147002, PUNJAB

Abstract

The present study has been designed to provide information about any possible differentiation between the growth of deaf-mutes and the normal boys. A cross-sectional sample of 267 deaf-mute boys from 5 to 18 years was collected from various educational institutes of Punjab specially meant to teach hearing impaired children who were otherwise normal. Various anthropometric measurements were taken on each subject with the help of techniques given by Lohman et al. (1988) which included weight and height, humerus and femur bicondylar diameter, upper arm and calf circumferences, skinfolds at triceps and subscapular. In a nutshell, it has been found that the deaf-mute boys of the present study lag behind the normal in early years of life in height, have significantly smaller elbow widths and are more fatty at triceps skinfold. The ecological factors and mental attitude of the populace have not changed from those of the past in case of deafmutes while there is a tremendous improvement in the otherwise living standards of the general population. While the normal children seem to experience secular drifts in height, perhaps the deaf children remained mute spectators to the onward march of their normal peers in growth and development.

Key Words: Deaf-Mute, Punjab, Height, Weight, Skinfolds

Introduction

Deafness is one of the most ridiculed handicapping impairments of the child which causes lots of problems to them from birth. It is one of the less talked about disabilities and also one of the least studied one. The deaf people lose their ability of verbal communication and the only way left to communicate is by way of writing and by the use of sign language. Children with hearing loss greater than 90 decibels are designated as deaf. According to *Hunt (1964)*, "The deaf have been described as those whose hearing is of no practical importance for the purpose of communication with others." The condition of hearing impairment may be from the time of birth or it may be acquired later on. The deafness at birth is known as congenital deafness, while deafness that occurs after birth is called adventitious deafness. The most common cause of hearing impairment is otitis media followed by the impacted wax *(Smith and Hatcher, 1992).*

In order to find out the effect of deafness on physical growth of children *Abolfotouh (2000)* studied 75 blind and 155 deaf subjects and concluded that both blind and deaf mutes attain normal sexual maturity later in life than controls. The deaf mutes and visually challenged have lower height and weight values than controls which reflects a delaying effect of hearing and visual impairment on the physical growth of these children. In another study, *Abolfotouh and Telmesani (1993)* found that the visual handicap affects the growth of children in such a way that 76 percent blinds were below the 50^{th} centile for body weight which meant a considerable growth lag in them.

A mixed longitudinal study was conducted by Malina and *Gorzycki (1973)* on height and weight growth patterns of deaf children of age 6 to 17 years. It was found that the height of deaf boys and girls, on average, was considerably below the standards from age 6 to 10 years. Between 11 and 17 years, deaf children belonging to White and Negro races were very close to the standards indicating parity in growth of children with general population. But the deaf-mutes of Mexican-American origin were below the height standards. In body weight, deaf boys were slightly below the weight standards from 6 to 11 years of age but were above the standards from 12 to 17 years of age. It may be concluded that a growth lag occurs only during the early years of life in American Whites and Negroes. *Umlawska and Staniszewska (2006)* studied children between the years 1995 and 2000 with hearing and visual disabilities and found that they have much lower body measurements than those of normals.

Falkner (1962) longitudinally investigated the height velocity curves for deaf children and found a close incremental parity with the standards. The height velocity curve, however, appeared to peak, on an average, about one year earlier in deaf children indicating their faster tempo of growth. *Thommessen et al. (1989)* studied the deaf and blind children from their nutrition and growth perspective and found that these children had energy intake below or in the lower range of reference values (Recommended Dietary Allowances - RDA). These subjects also suffered from serious feeding problems during weaning. All pupils were found to be strikingly thin while growing up despite being low on physical activities. The physical characteristics of deaf-mute boys were studied by *Yamaguchi (1956)* which indicated a body form that is characterized by extremely slender limbs and thick subcutaneous tissues resembling that of person with low metabolic rate and thus approaching feminine type. The study indicates weakness of muscles and bones in deaf-mute boys. Also they had a slightly shorter limbs and stature, narrower shoulders and slender hip breadth. The motor functions were also found to be generally lower than the normal children.

In North India, one of the earliest growth studies on head and face measurements in congenital deaf-mute children was done by *Singh and Dhir (1976).* According to this study the deafness affected only the upper portion of head and face in which the hearing impaired children had smaller measurements. A study by *Chitkara (1990)* on deaf mute children of Punjab indicated that the deaf mute boys and girls have smaller values than their normal counterparts for various parameters of height, weight and facial measurements. These differences were more prominent in children with congenital deafness. However, they experienced adolescent spurt a year earlier than the controls. However, keeping in mind the sample size and the cross-sectional nature of the study, it is difficult to comment on the timing of adolescent spurt and hence this conclusion must be taken with a lot of caution.

The information on physical characteristics of deaf-mute children and their growth is scanty in north Indian population. Keeping in mind this paucity of data on deaf-mutes, the present study has been designed which aims at providing information about any possible difference between deaf-mutes and the normal boys in order to make a comment on the growth process.

Materials and Methods

A cross-sectional sample of 267 deaf-mute boys was collected from various educational institutes of Punjab specially meant to teach hearing impaired children. These children were otherwise normal except for this defect. The subjects ranged in age from 5 to 18 years. Various anthropometric measurements were taken on each subject with the help of techniques given by *Lohman et al. (1988)* which included weight and height, humerus and femur bicondylar diameter, upper arm and calf circumferences, skinfolds at triceps and subscapular. For the sake of comparisons, two studies were taken with a similar socioeconomic background and from the same areas. The study by *Singh et al (2001)* is based on 6653 children while that of *Abha Mandira (1992)* includes 985 children.

Results

Table 1. Comparison of Height (cm) in deaf-mute and control males.

Age (yrs)	Control[a]			Deaf-mutes				t-value
	Mean	S.D.	S.E.M	N	Mean	S.D.	S.E.M	
5	107.8	7.10	0.70	7	110.4	8.24	3.11	0.81
6	112.3	7.74	0.72	13	116.0	10.09	2.80	1.29
7	119.1	8.06	0.58	13	117.6	4.51	1.25	1.15
8	124.8	7.68	0.48	13	118.4	5.93	1.65	3.75*
9	130.1	9.14	0.61	25	126.7	9.83	1.97	1.63
10	134.5	7.51	0.40	21	130.9	8.95	1.95	1.82
11	140.1	8.77	0.41	25	139.8	10.05	2.01	0.14
12	144.2	8.78	0.45	23	141.7	6.77	1.41	1.67
13	152.1	9.60	0.48	23	148.2	7.04	1.46	2.51*
14	156.1	11.20	0.55	12	152.0	10.82	3.12	1.29
15	161.0	10.50	0.58	22	159.8	8.59	1.83	0.64
16	164.8	8.90	0.58	12	161.9	6.8	1.96	1.41
17	162.3	12.7	1.18	29	165.4	7.37	1.36	1.72
18	168.8	7.03	0.79	29	167.1	6.61	1.23	1.15

* $p < 0.05$, Control[a] – Singh *et. al.,* (2001)

The height of deaf-mute boys is smaller than that of the controls at all ages but the deaf-mutes are significantly shorter than controls only at 8 and 13 years of age (Table 1 & Fig 1). Body weight of the deaf-mutes is significantly more than the controls at 5 and 6 years of age but the reverse is true at 9 years (Table 2 & Fig 2).

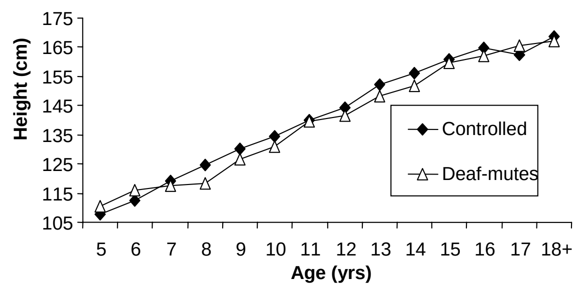

Figure 1. Comparison of Height (cm) of Deaf-Mute boys with Controls

Table 2. Comparison Weight (kg) in deaf-mute and control males.

Age (yrs)	Control[a]			Deaf-mutes			t-value
	Mean	S.D.	S.E.M	Mean	S.D.	S.E.M	
5	15.62	1.17	0.11	16.85	1.11	0.42	2.88*
6	17.09	1.23	0.12	19.38	3.64	1.01	2.27*
7	19.55	1.23	0.09	21.03	2.73	0.76	1.93
8	22.34	1.20	0.08	22.26	7.57	2.10	0.03
9	24.39	1.24	0.08	24.44	5.25	1.05	0.04
10	26.72	1.22	0.06	26.04	5.00	1.09	0.62
11	30.26	1.24	0.06	28.08	4.30	0.86	2.53*
12	33.02	1.25	0.06	32.00	5.68	1.18	0.86
13	37.91	1.25	0.06	35.73	6.53	1.36	1.59
14	40.18	1.27	0.06	41.08	8.78	2.53	0.35
15	44.70	1.25	0.07	44.79	8.17	1.74	0.05
16	47.24	1.25	0.08	47.54	5.37	1.55	0.19
17	50.08	1.23	0.11	50.09	6.89	1.28	0.05
18	54.82	1.23	0.14	55.89	10.11	1.88	0.56

- $p < 0.05$, Control[a] – Singh *et. al.,* (2001)

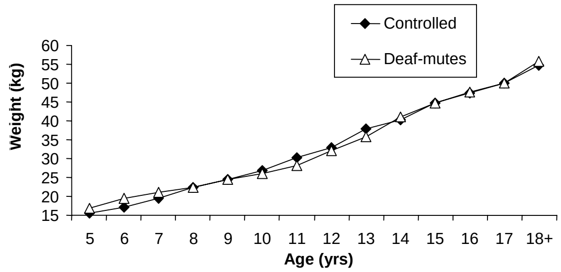

Figure 2. Comparison of Weight (kg) of Deaf-Mute boys with Controls.

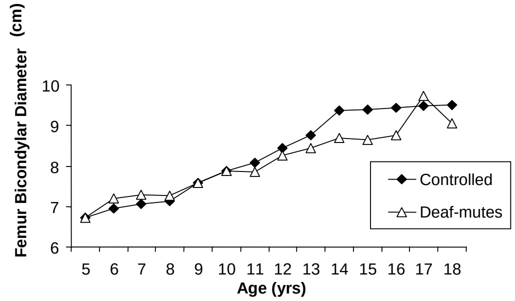

Figure 4. Comparison of Femur Bicondylar Diameter (cm) of Deaf- Mute boys with Controls

Table 3. Comparison of Humerus Bicondylar Diameter (cm) in deaf-mute and control males.

Age (yrs)	Control[a]			Deaf-mutes			t-value
	Mean	S.D.	S.E.M	Mean	S.D.	S.E.M	
5	5.09	0.28	0.04	4.52	0.17	0.06	7.90*
6	5.20	0.50	0.09	4.79	0.35	0.09	3.22*
7	5.32	0.39	0.06	4.74	0.32	0.08	5.80*
8	5.46	0.41	0.07	4.86	0.45	0.12	4.32*
9	5.61	0.50	0.08	5.30	0.55	0.11	2.28*
10	5.92	0.54	0.08	5.31	0.44	0.09	5.07*
11	6.25	0.49	0.07	5.43	0.34	0.06	8.89*
12	6.52	0.45	0.07	5.77	0.41	0.08	7.06*
13	6.74	0.36	0.06	5.89	0.36	0.07	9.22*
14	7.21	0.57	0.09	6.10	0.55	0.16	6.05*
15	7.30	0.55	0.09	6.52	0.49	0.10	5.80*
16	7.38	0.53	0.08	6.50	0.34	0.09	7.31*
17	7.35	0.33	0.03	6.54	0.50	0.09	8.54*
18	7.39	0.45	0.04	6.63	0.38	0.07	9.43*

* $p < 0.05$, Control[a] – Abha Mandira (1992)

Table 4. Comparison of Femur Bicondylar Diameter (cm) in deaf-mute and control males.

Age (yrs)	Control[a]			Deaf-mutes			t-value
	Mean	S.D.	S.E.M	Mean	S.D.	S.E.M	
5	6.73	0.34	0.05	6.72	0.45	0.17	0.06
6	6.95	0.47	0.08	7.20	0.73	0.20	1.16
7	7.06	0.39	0.06	7.28	0.33	0.09	2.03*
8	7.12	0.51	0.08	7.26	0.50	0.13	0.91
9	7.58	0.49	0.08	7.58	0.43	0.08	0.00
10	7.87	0.60	0.01	7.87	0.58	0.12	0.00
11	8.09	0.61	0.09	7.85	0.52	0.10	1.78
12	8.44	0.54	0.09	8.27	0.41	0.08	1.41
13	8.76	0.93	0.16	8.43	0.57	0.12	1.65
14	9.36	0.74	0.12	8.68	0.66	0.19	3.03*
15	9.39	1.45	0.22	8.64	0.67	0.14	2.88*
16	9.44	0.74	0.11	8.75	0.49	0.14	3.88*
17	9.49	0.58	0.11	9.72	0.53	0.09	5.45*
18	9.50	0.58	0.11	9.04	0.44	0.08	3.38*

* $p < 0.05$, Control[a] – Abha Mandira (1992)

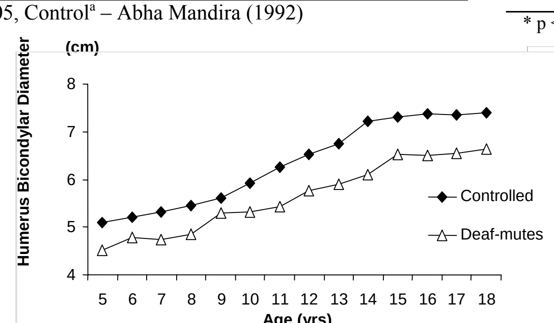

Figure 3. Comparison of Humerus Bicondylar Diameter (cm) of Deaf- Mute boys with Controls.

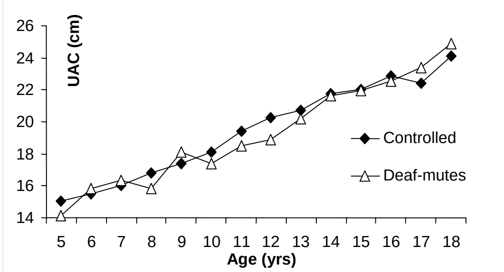

Figure 5. Comparison of Upper Arm Circumference (cm) of Deaf-Mute boys with Controls.

Table 5. Comparison of Upper arm circumference (cm) in deaf-mute and control males.

Age (yrs)	Control[a]			Deaf-mutes			t-value
	Mean	S.D.	S.E.M	Mean	S.D.	S.E.M	
5	15.06	1.29	0.13	14.11	1.01	0.38	2.37*
6	15.50	1.31	0.12	15.81	1.43	0.40	0.75
7	16.00	1.64	0.19	16.35	1.64	0.46	0.74
8	16.80	1.93	0.12	15.80	1.77	0.49	1.98*
9	17.40	2.22	0.15	18.08	3.70	0.74	0.90
10	18.10	2.34	0.12	17.37	3.35	0.73	0.98
11	19.40	3.86	0.18	18.48	2.91	0.59	1.51
12	20.28	2.78	0.14	18.89	2.98	0.62	2.18*
13	20.70	3.06	0.15	20.22	2.18	0.45	1.00
14	21.79	3.40	0.17	21.65	2.82	0.81	0.16
15	22.03	3.30	0.18	21.94	2.14	0.46	0.18
16	22.90	3.20	0.21	22.55	1.95	0.54	0.60
17	22.40	3.01	0.28	23.42	2.40	0.44	1.94
18	24.10	3.01	0.34	24.90	2.58	0.48	1.36

* $p < 0.05$, Control[a] – Singh *et. al.,* (2001)

Table 6. Comparison of Calf circumference (cm) in deaf-mute and control males.

Age (yrs)	Control[a]			Deaf-mutes			t-value
	Mean	S.D.	S.E.M	Mean	S.D.	S.E.M	
5	20.4	2.0	0.4	19.40	1.02	0.38	1.81
6	21.0	1.8	0.3	20.87	1.85	0.51	0.22
7	21.6	2.4	0.4	21.53	2.24	0.62	0.09
8	22.0	1.3	0.2	20.45	2.07	0.57	2.57*
9	22.2	2.0	0.3	22.53	2.02	0.40	0.66
10	23.4	2.3	0.4	22.99	2.95	0.64	0.54
11	24.3	1.9	0.3	24.04	2.51	0.50	0.45
12	25.9	2.3	0.3	25.60	2.10	0.43	0.57
13	28.7	2.1	0.4	25.57	1.68	0.35	1.56
14	28.7	2.6	0.4	28.64	2.09	0.60	0.08
15	29.0	2.8	0.5	28.81	2.74	0.58	0.25
16	29.8	4.1	0.8	29.31	1.59	0.45	0.53
17	30.1	2.3	0.5	29.75	2.37	0.43	0.53
18	29.9	0.8	0.2	29.73	3.34	0.61	0.26

* $p < 0.05$, Control[a] – Singh *et. al.,* (2001)

Humerus bicondylar diameter in deaf-mutes is significantly smaller at all ages than the controls (Table3 & Fig 3). The deaf mutes possessed larger values of femur bicondylar diameter than controls at 7 and 17 years whereas the controls had larger values at 14, 15, 16 and 18 years (Table 4 & Fig 4).

The upper arm circumference in deaf-mutes is smaller at 5, 8 and 12 years than the controls (Table 5 and Fig 5). The deaf-mutes are similar to controls in calf circumference at all ages except at 8 years (Table 6 & Fig 6).

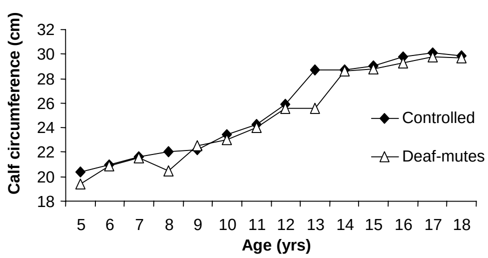

Figure 6. Comparison of Calf Circumference (cm) of Deaf-Mute boys with Controls.

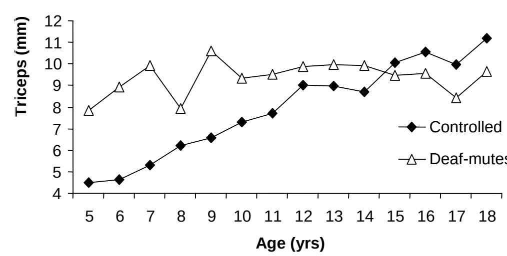

Figure 7. Comparison of Triceps (mm) of Deaf-Mute boys with Controls.

Table 7. Comparison of Triceps (mm) in deaf-mute and control males.

Age (yrs)	Control[a]			Deaf-mutes			t-value
	Mean	S.D.	S.E.M	Mean	S.D.	S.E.M	
5	4.50	1.900	0.19	7.86	2.54	0.96	3.42*
6	4.64	1.335	0.13	8.92	2.43	0.67	6.28*
7	5.29	2.225	0.12	9.92	3.52	0.98	4.67*
8	6.21	2.795	0.12	7.92	1.93	0.54	3.02*
9	6.56	3.395	0.15	10.6	3.08	0.62	6.15*
10	7.31	3.365	0.12	9.33	2.16	0.57	3.35*
11	7.69	3.365	0.18	9.52	2.53	0.51	3.43*
12	9.00	4.140	0.14	9.86	3.63	0.76	1.09
13	8.95	4.610	0.15	9.96	3.14	0.65	1.45
14	8.70	4.555	0.17	9.91	4.62	1.33	0.89
15	10.07	5.405	0.18	9.45	2.40	0.51	1.04
16	10.56	6.000	0.20	9.58	2.81	0.81	1.08
17	9.95	5.380	0.28	8.42	2.54	0.47	2.13*
18+	11.2	4.620	0.33	9.66	2.84	0.53	2.09*

* $p < 0.05$, Control[a] – *Singh et. al., (2001)*

Table 8. Comparison of Subscapular skinfold (mm) in deaf-mute and control males.

Age (yrs)	Control[a]			Deaf-mutes			t-value
	Mean	S.D.	S.E.M	Mean	S.D.	S.E.M	
5	4.8	0.8	0.2	8.42	2.14	0.81	4.31*
6	5.1	1.3	0.2	5.46	1.19	0.33	0.78
7	6.2	2.6	0.4	6.38	2.32	0.64	0.13
8	5.0	1.3	0.2	5.53	1.26	0.35	1.24
9	5.1	0.9	0.1	6.92	2.53	0.50	3.53*
10	5.4	1.4	0.2	6.04	1.39	0.30	1.66
11	5.3	1.1	0.2	6.48	1.75	0.35	2.93*
12	6.6	3.0	0.4	7.21	1.95	0.40	1.06
13	6.4	2.2	0.4	7.08	1.64	0.34	1.14
14	6.9	3.2	0.5	10.66	6.67	1.92	1.86
15	7.0	1.6	0.3	8.31	2.49	0.53	2.13*
16	8.7	3.0	0.6	9.25	2.05	0.59	0.60
17	8.0	1.8	0.4	9.31	2.68	0.49	2.06*
18	7.3	0.7	0.1	9.72	2.83	0.41	5.69*

* $p < 0.05$, Control[a] – *Abha Mandira (1992)*

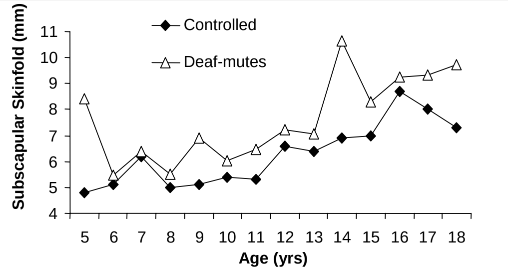

Figure 8. Comparison of Subscapular Skinfold (mm) of Deaf-Mute boys with Controls.

The skin and subcutaneous tissue folds over triceps have greater thickness in deaf-mutes from age 5 to 11 years. On the other hand, the controls have greater thickness of triceps skinfold during 17 an d 18 years (Table 7 & Fig 7). The deaf mutes have siginificantly larger values of subscapular skinfold than normals at 5, 9, 11, 15, 17 and 18 years (Table 8 & Fig 8).

Discussion

The deaf-mute boys of the present study are smaller than their control counterparts at all ages but the significant differences appear only at 8 and 13 years of age. The deaf mute boys studied during 1990 by *Chitkara (1990)* from Punjab were comparatively taller than the controls, for all ages from 7 to 12 years except at 10 years where the controls had overtaken the affected ones. *Kumar (1974)* observed that the height of deaf mute boys of Punjab studied during 1974 was more than controls in early years from 6 through 14 years. But the trend was just opposite in later years with controls being taller than deaf mutes from 15 through 17 years of age. It revealed that adolescent spurt in height of affected individuals appears one year later as compared to controls.

The studies by *Kumar (1974)* and *Chitkara (1990)* have concluded that the deaf-mutes are taller in height than the controls especially during the younger ages whereas the subjects of the present study are shorter than the controls. The reason for this may be found in the differential status of living standards at present between the deaf-mutes and the controls. It seems reasonable to assume that the overall living standards have improved a lot for the general population during the last two to three decades. There is a possibility of the secular changes occurring in this region in height of the children. On the other hand, the care and general upkeep of the deaf-mutes has not undergone perceptible changes. Therefore for them the ecological factors have not changed from those of the past. So while the normal children experienced secular drifts in height perhaps the deaf-mutes remained mute spectators to the onward march of their normal peers in growth and development.

A study by *Abolfotouh (2000)* found from a sample of 155 deaf mutes of 6-12 years of age of Saudi Arabia that 90.9% deaf mutes have their height below 50th percentile out of which 69% fall below 10^{th} percentile. *Malina and Gorzycki (1973)* studied the deaf mutes of different races of America and observed that the height of White, Negro and Mexico-American boys was below the pediatric standards from 6 through 10 years of age. Between 11 and 17 years, deaf White and Negro boys approximated the standard, while the Mexican-American were found below the standards. The study revealed that the height velocity curves approach to peak on the average about one year earlier in deaf children. Findings from the present study especially during the preadolescent years conform to the above studies on Saudi and American children in a sense that the deaf mutes are laggards in growth.

Body weight of the deaf-mutes of the present study is significantly more than the controls at 5 and 6 years of age but the reverse is true at 9 years. The two groups do not differ from each other at all other ages. Deaf mute males of Punjab and Delhi are heavier in their early years of life (from 8 to 13 years) as compared to the controls *(Kumar 1974).* But after adolescence, they became lighter than the controls. He observed the adolescence spurt at age of 14 years in deaf mute males. *Chitkara (1990)* found that the deaf mute children had less weight in age group of 6 to 10 years. But they were heavier than controls at 11 to 14 years of age. The findings in body weight indicating an initial growth lag in deaf-mutes in the present study were similarly found by *Kumar (1974)* and *Chitkara (1990)* from the same settings.

The US deaf boys were at or slightly below the American standards from 6 to 11 years and slightly above the weight standard from 12 to 17 years *(Malina and Gorzycki 1973).* The weight velocity curve for deaf boys paralleled closely to the incremental standards of *Falkner (1962).* As many as 87.7% of the deaf mute children of age ranging from 6 to 12 years from Saudi Arabia were below the 50^{th} percentile of weight *(Abolfotouh 2000).*

The skin and subcutaneous tissue folds over triceps in deaf-mutes of the present study have greater thickness whereas the controls overtake the deaf-mutes in the thickness of triceps skinfold during 17 an d 18 years. *Suzuki et al. (1991)* found that obesity was more prevalent in deaf boys especially in later age of 15 to 19 as compared to other disabilities.. Study by *Yamaguchi (1956)* reveals that deaf mute male of 15 to 17 years of age have higher values for triceps skinfold as compared to the control and have feminine type of subcutaneous fat deposition. The sedentary life style of deaf mute children has been pointed out as the main reason for them being fattier than the controls.

In a nutshell, it has been found that the deaf-mute boys of the present study lag behind the normal in early years of life in height, have significantly smaller elbow widths and are more fatty at triceps skinfold.

References

Abha Mandira 1992. *Physical growth and sexual maturation of Khatri boys and girls of semi-urban areas of Punjab aged 6 to 19 years*. Ph.D. Thesis (Unpublished). Punjabi University, Patiala.

Abolfotouh, M.A. 2000. Growth and sexual maturation of blind and deaf male students in Abha city, Saudi Arabia. *Annals of Saudi Medicine*, **20** : 374-379.

Abolfotouh, M. A. and Telmesani, A. 1993. A study of some psycho-social characteristics of blind and deaf male students in Abha City, Asir region, Saudi Arabia. *Public Health*. **107**: 261-269.

Chitkara, A. 1990. *Hearing impaired : their physical status and congnitive behaviour.* M.Sc. Dissertation (unpublished), Punjabi University, Patiala.

Falkner, F. 1962. The physical development of children – a guide to interpretation of growth, charts and development assessment and a commentary on contemporary and future problems. *Pediatrics*, 29 : 448.

Hunt, V.V. 1964. *Recreation for Handicapped*. Prentice Hall, Physical Education Series, USA.

Lohman, T.G., Roche, A.F. and Martorell, R. 1988. *Anthropometric Standardization Reference Manual.* Human Kinetics, Champaign.

Kumar, S. 1974. *An ecological study of deaf and dumb*. M.Sc. Dissertation (Unpublished), Punjabi University, Patiala.

Malina, R.M. and Gorzycki, P.A. 1973. Height and weight growth patterns of school age deaf children. *Am. J. Phys. Anthropol.,* **38** : 135-43.

Singh, L. and Dhir, S.K. 1976. Head and face measurements in congenital deaf-mute children. *Acta Medica Auxologica*, **8**: 2 45-251.

Singh. S.P., Singal, P., Bhatnagar, D.P. 2001. *Growth Standards 2001: Evaluation of Physical Growth of Punjabi Children*. Human Biology Department. Patiala.

Smith, A. and Hatcher, J. 1992. Preventing deafness in Africa's children. *African Health,* **15**: 33-35.

Suzuki, M., Saitoh, S., Tasaki, Y., Shimomura, R. and Hosoya, N. 1991. Nutritional status and daily physical activity of handicapped students in Tokyo metropolitan school for deaf, blind, mentally retarded and physically handicapped individuals. *Am. J. Clin. Nutr*., **54**: 110-111.

Thommessen, M., Trygg, K., Riis, G. and Kase, B.F. 1989. Nutrition and growth retardation in children with congenital deaf-blindness. *J. Am. Diet. Assoc*., **89**: 69-73.

Umlawska, W., Staniszewska, A., 2006, Influence des affections des organes des sens sur le développement physique des enfants et des jeunes. Antropo, **11**, 25-32. www.didac.ehu.es/antropo

Yamaguchi, B. 1956. Some physical peculiarities of deaf mute boys. *Hum. Biol*., **28** : 308-315.

Physical Growth of Punjabi Girls in Government and Public Schools in Punjab

Mehta, P., Dhawan, S. and Singh, S.P.
Department of Human Biology, Punjabi University, Patiala.

Abstract

The present study has been conducted with the objective of finding out the growth differential between the girls studying in government and public schools so as to highlight the biological disparity resulting from a diverse socio-economic scenario obtaining in the state of Punjab. Data on 790 school girls ranging in age from 11-15 years and inhabiting the cities of Kotkapura and Mohali, Punjab, were collected separately from Government and Private/Public Schools during the month of January, 2006. It must be mentioned here that the Government Schools provide practically free education as the fee structure is very nominal. Every child was measured for height, body weight, upper arm circumference, biacromial and bicristal diameter and biceps and triceps skinfold employing the techniques of *Lohman et al. (1988).*The girls studying in government schools have significantly smaller values of height, weight, mid arm circumference, diameters and skinfolds than their peer studying in public schools. The average annualized deficit in the growth of height and weight of public and government school girls is around 5.9cm and 6.9 kg, respectively. To transform this backlog in years, it would amount to around one and a half year in height and 2.4 years in weight. Not only are the public school girls significantly taller and heavier than the government school girls but they have also significantly larger values of BMI. The larger values of Body Mass index in public school girls indicates that they are relatively greater in body weight than the government schools when the height is kept constant. The finding of the present study indicates the role of social diversity on the biological outcome of the children.

Key Words: Public School, Government School, Punjabi, Weight, Height, Growth

Introduction

It is a widely known fact that the unfavorable environments of the third world hamper the growth and development of children. The developmental strategies bring in improvements in the living standards of the people along with an overall improvement in nutrition and these situations are helpful in the optimal physical growth of children throughout the globe. Malnutrition is a double-edged sword having one side of under nutrition resulting in stunted growth and the other the over nutrition leading to obesity and overweight *(Singh 2002). Alderman et al. (2006)* found from his studies that malnutrition emerges from poverty and it shows strong associations with an inadequate diet, poor health and sanitation services and inadequate care for young children. Thus in order to play down the effect of malnutrition, two pronged strategy of income growth and nutrition interventions is required. The regional variations in physical growth of children arise not only due to the geographical characteristics but also due to the marginal resource availability in many areas of the world *(Eveleth and Tanner 1990)*.

Eiben and Mascie-Taylor (2004) reported the effect of family size on physical growth of children from the Hungarian National Growth Study on 39,035 children and youth aged 3–18 years and found that children where the family members are numerous are shorter, have lower body mass with smaller skinfold thicknesses. The paternal age, mother's profession and birth order did not elicit any associations with body measurements in both sexes. Major historical calamities also seem to play a significant role on the growth of children as these wipe away the resources to levels not able to sustain the proper growth of children, even the survival seems to be at stake sometimes. Annual regional time series analysis of height in Japan worked out by *Bassino (2006)* shows the emergence of provincial and group similarity in heights of its populace before the First World War. That is a reflection of convergence of biological welfare. But after the war, heights started showing divergence indicating biological inequality. This is a clear indication of the dark side of the war widening the gap between haves and have-nots. The children living in the outskirts of Ankara (Turkey) have recorded lower growth performance than those of the mid-town *(Gultekin et al. 2006).* The main reason for this growth differential between these two groups of children has been cited as the poor socio-economic status and lower standard of the people living in the outskirts of Ankara. The bodily growth differences amongst 22 groups of small-scale societies (cross-sectional height and weight velocity) have been reported by *Walker et al. (2006).* Substantial differences are reported among hunter-gatherers vis-à-vis groups thriving more on horticulture. The societies living under more favorable conditions exhibit better growth with advanced puberty. But, this faster maturation in females is associated with higher and earlier mortality. According to *Walker et al. (2006)* the higher mortality might be putting selective pressures for faster growth and earlier maturation in these societies so that the reproductive process and lineage may not be affected.

Singh et al. (1987) conducted a study on government and public schoolchildren in Patiala and came to a conclusion that the government school children were retarded in physical growth than their public school peer. Weight-for-age, height-for-age, weight-for-height, mid arm circumference and triceps skinfold have been used as indicators for judging the level of malnutrition in various populations of Punjab by many authors showing variations in the frequency of malnourished children obtained by them *(Singh et al. 2003, 2005, Kaur 2005).* According to all these studies, the general population has some proportion of children who are stunted or wasted. Another study by *Singh et al. (2001)* based on 6653 children brings about differences in physical growth of urban and rural children besides commenting on other factors and providing growth standards.

On the other hand, modernization is bringing in rapid changes in the living style of the people and the children are becoming obese and overweight. The adolescent girls of Tonga have been found to be obese to the tune of around 20% of the total sample (Fukuyama et al. 2005). The BMI in case of girls in Tonga showed a positive correlation with fat mass indicating that the higher BMI is actually due to the higher fat mass. Contrary to the girls, the boys did not show any correlation of their BMI with fat mass which showed that their higher BMI may not be due to excessive fat mass. Thus the girls in this study are more prone to adolescent obesity than the boys. In Punjab also, the affluent schoolchildren are becoming overweight and obese. *Sidhu et al. (2006)* found that 12.24% of boys and 14.31% of girls were overweight, whereas 5.92% boys and 6.27% girls were designated as obese. This situation of overweight and obesity in Punjab is alarming and seems to be as high or higher as in some of the developed countries.

The region of Punjab is fast undergoing change in its landscape, occupation and industrialization. The overall standard of living of its population has improved a lot. It is important to put on record the changes occurring in physical growth of these children over a period of time and repeat them. The present study has been conducted with the objective of finding out the growth differential between the girls studying in government and public schools so as to highlight the biological disparity resulting from a diverse socio-economic scenario obtaining in the state of Punjab.

Materials and Methods

Data on 790 school girls ranging in age from 11-15 years and inhabiting the cities of Kotkapura and Mohali, Punjab, were collected separately from government and private/public schools during the month of January, 2006. It must be mentioned here that the government schools provide practically free education as the fee structure is very nominal. Moreover, it is also alleged that the level of education in these schools is very dismal. Therefore it is by compulsion of economic factors that the parents send their wards to government schools. On the other hand, public schools charge very heavy fees as compared to government schools and thus cater to the needs of upper and upper middle strata of the society. Thus the type of school attended by the child is a good way of making a distinction between the different social strata. Every child was measured for height, body weight, upper arm circumference, biacromial and bicristal diameter and biceps and triceps skinfold employing the techniques of *Lohman et al. (1988).*

Results

Table 1. Height (cm) of Government and public school girls of Punjab

Age (yr)	Private School			Government School			D	t
	Mean	SD	SEM	Mean	SD	SEM		
11	143.26	7.96	0.93	136.87	8.07	1.24	6.39	4.12*
12	147.43	7.12	0.62	142.41	8.75	1.15	5.02	3.86*
13	150.24	6.89	0.63	145.26	7.06	1.02	4.98	4.15*
14	154.19	5.49	0.50	149.03	5.28	0.75	5.16	5.74*
15	159.19	4.89	0.49	151.22	4.63	0.69	7.96	4.67*

*p < 0.05

Table 2. Body weight (kg) of Government and public school girls of Punjab

Age (yr)	Private School			Government School			D	t
	Mean	SD	SEM	Mean	SD	SEM		
11	35.13	7.29	0.85	28.71	6.27	0.97	6.42	4.98*
12	39.57	9.21	0.79	31.26	5.78	0.76	8.31	7.58*
13	40.80	9.70	0.88	34.43	7.00	1.01	6.37	4.75*
14	44.68	9.68	0.87	38.52	6.94	0.98	6.16	4.70*
15	45.19	8.38	0.84	38.03	5.48	0.83	7.16	6.06*

*p < 0.05

The height of girls studying in private/public schools is significantly greater than those of government schools from age 11 to 15 years. Body weight of the government school girls is also significantly lower than that of the public school girls from 11 to 15 years (Table 2). In the case of upper arm circumference and skinfold at biceps the public school girls have shown significantly greater thickness than those of the government school girls (Tables 3, 4, 5).The biacromial and bicristal diameters are also significantly bigger in the case of public school girls as compared to the government school girls (Tables 6, 7).

Table 3. Upper arm circumference (cm) of government and public school girls of Punjab

Age (yr)	Private School Mean	SD	SEM	Government School Mean	SD	SEM	D	t-value
11	20.00	2.82	0.33	17.82	2.40	0.37	2.18	4.40*
12	20.78	3.32	0.29	18.20	1.86	0.24	2.58	6.86*
13	21.04	3.13	0.29	19.26	2.75	0.39	1.78	3.66*
14	22.19	3.02	0.27	20.21	2.50	0.35	1.98	4.50*
15	22.46	2.88	0.28	19.98	1.79	0.26	2.48	6.49*

*p<0.05

Table 4. Biceps skinfold (mm) of Government and public school girls of Punjab

Age (yr)	Private School Mean	SD	SEM	Government School Mean	SD	SEM	D	t - value
11	8.88	2.79	0.33	6.85	1.91	0.29	2.03	4.62*
12	9.82	3.19	0.28	7.55	2.54	0.33	2.27	5.26*
13	9.53	3.21	0.25	7.64	2.65	0.38	1.89	4.15*
14	10.32	3.00	0.28	8.16	2.85	0.40	2.16	4.43*
15	10.14	2.85	0.29	7.61	2.34	0.35	2.53	5.56*

*p<0.05

Table 5. Triceps skinfold (mm) of Government and public school girls of Punjab

Age (yr)	Private School Mean	SD	SEM	Government School Mean	SD	SEM	D	t - value
11	14.93	4.58	0.54	13.56	3.56	0.55	1.37	1.78
12	17.13	5.31	0.46	15.52	4.23	0.56	1.61	2.22*
13	16.22	5.20	0.47	15.56	3.92	0.57	0.66	0.89
14	16.40	4.53	0.41	17.54	5.18	0.73	1.14	1.36
15	15.95	4.58	0.46	16.53	4.19	0.63	0.58	0.74

*p<0.05

Table 6. Biacromial diameter (cm) of Government and public school girls of Punjab

Age (yr)	Private School Mean	SD	SEM	Government School Mean	SD	SEM	D	t - value
11	30.06	2.12	0.25	28.16	2.05	0.32	1.90	4.68*
12	30.98	2.25	0.19	28.86	1.90	0.25	2.12	6.75*
13	31.33	2.18	0.19	29.44	1.92	0.28	1.89	5.59*
14	31.98	2.08	0.18	31.09	1.97	0.28	0.89	2.68*
15	32.13	1.94	0.19	31.15	1.99	0.29	0.98	2.88*

*p<0.05

Not only are the public school girls significantly taller and heavier than the government school girls but they have also significantly larger values of BMI (Table 8). The larger values of Body Mass index in public school girls indicates that they are relatively greater in body weight than the government school girls when the height is kept constant.

Table 7. Bicristal diameter (cm) of Government and public school girls of Punjab

Age (yr)	Private School Mean	SD	SEM	Government School Mean	SD	SEM	D	t - value
11	26.02	2.39	0.28	25.40	1.79	0.28	0.62	1.57
12	26.99	2.24	0.19	25.95	1.77	0.23	1.04	3.47*
13	27.50	2.35	0.22	26.17	1.50	0.21	1.33	4.37*
14	28.43	1.98	0.18	27.64	1.72	0.24	0.79	2.63*
15	28.77	1.84	0.18	27.68	1.53	0.23	1.09	3.89*

*p<0.05

Table 8. Body Mass Index (BMI) of Government and public school girls of Punjab

Age (yr)	Private school Mean	SD	SEM	Government School Mean	SD	SEM	D	t - value
11	17.05	2.84	0.33	15.25	2.66	0.46	1.80	3.18*
12	18.06	3.33	0.29	15.35	2.13	0.28	2.71	6.72*
13	17.98	3.67	0.33	16.26	2.88	0.42	1.72	3.22*
14	18.73	3.66	0.33	17.29	2.68	0.38	1.44	2.86*
15	18.76	3.31	0.33	16.6	2.05	0.31	2.16	4.78*

*p<0.05

Discussion

The children of the present investigation studying in government schools have significantly smaller values of height, weight, mid arm circumference, diameters and skinfolds than their peer studying in public schools. The average annualized growth rate in height of girls of the present study in public schools is around 4 cm/yr during 11 to 15 years. The average annualized deficit in the growth of height between public and government school girls is around 5.9cm/yr. To transform this backlog in years, it would amount to around one and a half year. It means that the 15 year old girls studying in government schools are roughly comparable in height to 13.5 year old girls of public schools. The average deficit in the growth of weight between the government and the public school girls of

11 to 15 years is around 6.9 kg. Considering an annual increment in body weight of 2.5 kg per year of public school girls during this period, the government school girls seem to be lagging behind by as much as 2.4 years. Transforming this growth lag it may be projected that the 15 year old government school girls are comparable in body weight to 12.6 year old public school girls. In other words, the children whose parents are unable to afford them better and costly education suffer from growth retardation. Actually the type of school attended by the child in Punjab also is a reflection of the socio-economic status of the parents because of the very high range of fee charged by them. Hence these differentials in physical growth of children can be kept at par with those emanating from socio-economic differences. Compared to these differences in the Indian settings which are very large, the results on the effect of social class from Britain indicate that the seven-year old boys from the managerial classes and the unskilled workers were different only by a margin of 3.3 cm *(Goldstein 1971).*

A comparison of difference in height between the government school and the public school girls of the present study and those investigated during 1973 by *Singh et al. (1987)* reveals that the difference was 10.7 cm during the year 1973 whereas it is 5.9 cm in the present study. These figures point towards the secular changes taking place in this region over a period of three decades. The lower social class people at present who are sending their wards to government schools may also be enjoying better health care, sanitation and quality of life which were not available some three decades back to the similarly placed people. While there seems to be greater stresses on the growth of children then, the situation seems to have eased out a little now. However, still the existence of difference in height between the higher and lower strata reveals that the backlog in growth exists but only the magnitude of it has become a little smaller.

Almost all over the world over, the higher social class children perform much better than their lower class peer *(Goldstein 1971, Hauspie et al. 1980, Rona 1981, Bogin 1988, Macintyre 1988, Walker et al. 1988, Eveleth and Tanner 1990, Kuh et al. 1991, Gulliford et al. 1991, Ulijaszek et al. 1998).* Studies on north Indian children by *Sharma and Kaul (1970)* and *Singh et al. (1987)* also found that the growth lag in lower social class children is very substantial which may run into a year's growth or longer. The finding of the present study indicates the role of social diversity on the biological variation in the growth of the children.

References

Alderman, H., Hoogeveen, H. and Ross, M. 2006. Reducing child malnutrition in Tanzania: Combined effects of income growth and program interventions. *Economics & Human Biology* **4**, 1-23. Bassino, J-P. 2006. Inequality in Japan (1892–1941): Physical stature, income, and health. *Economics & Human Biology, **4**, 62-88.*

Bogin, B. 1988. Patterns of Human Growth. Cambridge University, Press, Cambridge.

Caino, S., Kelmansky, D., Adamo, P. and Lejarraga, H. 2006. Short-term growth in healthy infants, schoolchildren and adolescent girls. *Ann. Hum. Biol*., 33, 213-226.

Eiben, O.G. and Mascie-Taylor, C.G.N. 2004. Children's growth and socio-economic status in Hungary. *Economics & Human Biology*, 2, 295-320.

Eveleth, P.B. and Tanner, J.M. 1990. *Worldwide variations in human growth*. Cambridge university Press, Cambridge.

Fukuyama, S., Inaoka, T., Matsumura, Y., Yamauchi, T., Natsuhara, K., Kimura, R. and Ohtsuka, R. 2005.Anthropometry of 5–19-year-old Tongan children with special interest in the high prevalence of obesity among adolescent girls. *Ann. Hum. Biol.*, 32, 714-723.

Goldstein, H. 1971. Factors influencing the height of seven year old children. Results from the

National Child Development Study. *Hum. Biol*., **43**, 92-111.

Gulliford, M.C., Chinn, S.D. and Rona, R. 1991. Social environment and height: England and Scotland 1987 and 1988. *Arch. Dis. Child*., **66**, 235-240.

Gultekin, T., Hauspie, R., Susanne, C. and Gulec, E. 2006. Growth of children living in the outskirts of Ankara: Impact of low socio-economic status. *Ann. Hum. Biol*., **33**, 43-54.

Hauspie, R.C., Das, S.R., Preece, M.A. and Tanner, J.M. 1980. A longitudinal study of the growth in height of boys and girls of West Bengal (India) aged six months to 20 years. Ann. Hum. Biol., **7**, 429-440.

Kaur, G., Kang, H.S., Singal, P. and Singh, S.P. 2005. Nutritional Status: Anthropometric Perspective of Pre-School Children. *The Anthropologist*, **7**, 99-103.

Kuh, D.L. Power, C. and Rodgers, B. 1991. Secular trends in social class and sex differences in adult height. *Int. J. Epidemiol*., **20**, 1001-1009.

Lohman, T.G., Roche, A.F. and Martorell, R. 1988. *Anthropometric Standardization Reference Manual.* Human Kinetics, Champaign.

Macintyre, S. 1988. A review of social patterning and significance of measures of height weight blood pressure and respiratory functions. Soc. Sci. Med., **27**, 327-337.

Rona, R. 1981. Genetic and environmental factors in growth in childhood. *Brit. M. Bull.* **37**, 265-272.

Sharma, J.C. and Kaul, S.S. 1970. Socioeconomic differences in the growth of Punjabi boys. The Anthropologist, **17**, 43-55.

Sidhu, S., Kaur, N and Kaur, R. 2006. Overweight and obesity in affluent school children of Punjab. *Ann. Hum. Biol*., **33**, 255-259.

Singh, A.P, Singal, P. Kaur, R. and Singh, S.P. 2003. Assessment of Malnutrition in Punjabi Urban Males According to Body Mass Index (BMI) and Weight for Height Criteria. *The Anthropologist,* **5**, 189-191.

Singh, A.P, Singal, P. and Singh, S.P. 2005. Arm Muscle and Fat Components in Adolescent Boys of Punjab, *The Anthropologist*, **7**, 161-163.

Singh, S.P. 2002. Anthropometric perspective on nutritional status. In "*Anthropology: Trends and Applications*", eds., M.K. Bhasin, S.L. Malik. Anthropologist special issue, **1**, 73-82.

Singh, S.P., Sidhu, L.S., Malhotra, P. 1987. Growth performance of Punjabi children aged 6 to 12 years. *Ann. Hum. Biol*., **4**, 169-179.

Singh, S.P., Singal, P., Bhatnagar, D.P. 2001. *Growth Standards 2001: Evaluation of Physical Growth of Punjabi Children*. Human Biology Department, Patiala.

Ulijaszek, S.J., Johnston, F.E. and Preece, A.M. 1998. *The Cambridge Encyclopedia of Human Growth and Development.* Cambridge University, Press.

Walker, M., Shephard, A.G. and Wannamethee, G. 1988. Height and social class in middle-aged British men. *J. Epidemiol. Comm. Hlth*., **42**, 299-303.

Walker, R., Gurven, M., Hill, K., Migliano, A., Chagnon, N., DeSouza, R., Djurovic, G., Hames, R., Hurtado, A.M., Kaplan, H., Kramer, K., Oliver, W.J., Valeggia, C. and Yamauchi, T. 2006. Growth rates and life histories in twenty-two small-scale societies. *Am. J. Hum. Biol*. **18**:295-311.

Sex Differences in Lower Limb Measurements among Jats of Haryana

Nath, S. and Dwivedi, A.

Department of Anthropology, University Of Delhi, Delhi-110007

Abstract

An attempt has been made in the present study to observe the developmental sequence of growth sex differences in stature and measures of the lower limb among Jats of Haryana. A total of 1035 Jats (502 males and 533 females) ranging in age from 9 to 17 years were measured for stature, total lower extremity length, thigh length, lower leg length and foot length in accordance with the standard measurement techniques. Analysis of the data reveals that the female Jats are not only taller than their mail counterparts in stature but also have longer total lower extremity length ,thigh length and lower leg length from 9 to 13 years. However males have longer feet than the females at all ages. Notwithstanding the variations in all the measurements of lower limb and stature between the sexes the differential trends reveal significant variations between 14 and 17 years for stature, lower extremity length and lower leg length while in case of thigh length and foot length the differences are significant from 12 to17 years.

Key Words: Hawkin's Test, Isometric Abduction, Isometric External Rotation, Injury

Introduction

Human growth is an incessant process while the pace at which it proceeds is inconsistent for every growing individual. The individual development generally occurs in spurts, with different body components growing at a variable rate, time and intensity.

It is a known fact that trunk and leg segments have equal proportion within the body by about 14 years where after the legs outgrows the trunk and remains longer for the remaining period of growth. Similarly the arms are longer than the legs only during prenatal period, with regards to the growth of different body segments.

Krogman (1973) emphasized that during postnatal period the hand and neck segment increases twice in size, trunk three times, arms four times and the legs five times in their respective proportions.

These main body segments are further divided into certain sub segments or components, for example, the arm segment comprises of upper arm, fore arm and hand, while the leg segment comprises of thigh, calf and the foot. Most of the studies conducted by Indian researchers pertain to the general patterns of growth among different communities. However, pattern of change in the components of the upper or the lower extremities has not attracted attention of researchers, due to which only a few studies covered this aspect. The present study has been attempted to observe the sex and age changes in components of the leg segment among the Jats of Haryana.

Materials and Methods

Data for the present study comprises of 1035 Jats (502 males and 533 females), ranging in age from 9 to 17 years All the subjects were measured cross sectionally for the following dimensions: stature, total leg length, thigh length, lower leg length, and foot length as per standard measurement techniques recommended by Martin and Saller (1959), Weiner and Lourie (1969).

Age of each subject was obtained from the school records and converted into decimal notation following decimal age calendar (Tanner, 1966) by subtracting the date of birth of an individual from the date of measurement. The age grouping was done in accordance with the following system, e.g., age group 9 includes all such subjects whose age ranges between 8.500 and 9.499 years, thereby providing mean age as 9.000 years. Age group 10 includes all subjects who fall in the age range of 9.500 to 10.499 years thereby giving mean age as 10.000 years and so on up to 17 years of age.

Results & Discussion

Data for the present study have been analyzed to obtain the results pertaining to the assessment of patterns of growth among male and female Jats of Haryana in the age range of 9 through 17 years, besides evaluating the sex differences, if any in different measures of the lower extremity and stature among jats.

Table 1. Sex differences in Stature among Jats of Haryana

	Males		Females		
Age (yrs)	Mean (cm)	S.E.M.	Mean (cm)	S.E.M.	Value of t
9.0	128.2	0.89	130.5	1.02	0.30
10.0	133.5	0.78	134.6	1.8	0.83
11.0	141.0	1.10	141.5	1.21	0.07
12.0	145.7	1.32	146.0	0.96	0.18
13.0	148.7	1.33	150.5	0.74	1.18
14.0	158.0	1.07	153.0	0.61	4.07*
15.0	165.4	0.87	153.9	0.61	10.84*
16.0	168.4	0.93	157.1	0.84	9.52*
17.0	172.6	0.63	159.9	0.51	9.08*

*Significant at 5 % level

Table 1 presents the basic statistical constants for stature among male and female Jats in the range of 9 to 17 years along with the values of t-test. It is evident from the table that male and female Jats exhibit an increase in stature with enhancement in age from 9 to 17 years

The male Jats exhibits an overall increase of 44.4 cm in stature from 9 to 17 years in contrast to 29.4 cm among females. The increase in stature among males is about 1.5 times greater than that of females. The maximum yearly increase in stature occurs earlier among females (10 and 11 years) than the males (13 and 14 years).

It is further observed that the females are taller than the males from 9 to 13 years, while the males outgrow them between 14 and 17 years In spite of being taller between 9 and 13 years than the males, the sex differences are non significant during this period.

On the other hand, the differential trends as observed through t-test reveal that males are significantly taller than the females from 14 to 17 years.

Table 2. Sex differences in Total lower extremity length among Jats of Haryana

	Males		Females		
Age (yrs)	Mean (cm)	S.E.M.	Mean (cm)	S.E.M.	Value of - t
9.0	72.9	0.59	73.7	0.61	0.94
10.0	74.3	0.54	75.3	0.65	1.18
11.0	78.1	0.63	78.8	0.71	0.32
12.0	82.3	0.80	82.8	0.66	0.48
13.0	84.1	0.78	85.1	0.54	1.04
14.0	89.9	0.68	85.9	0.45	4.81*
15.0	92.9	0.53	86.8	0.53	9.03*
16.0	93.1	0.58	88.0	0.75	4.79*
17.0	93.3	0.56	88.5	0.49	6.58*

*Significant at 5 % level

Table 2 presents the basic statistical constants for total lower extremity length among male and female Jats in the age range of 9 to 17 years along with the values of t-test. It is observed that both male and female Jats exhibit an increase in total lower extremity length from 9 years through 17 years. It is further witnessed that the male Jats exhibit an overall increase of 20.4 cm in total lower extremity length from 9 to 17 years in contrast to 14.8 cm increase attained by females. The female Jats possess longer lower extremities than the males from 9 to 13 years where after from 14 to 17 years the males outgrow the females. The differential trends as assessed through t-test reveal that the males possess significantly lower extremity length than the females from 14 to 17 years while the female Jats, despite possessing longer lower extremity length from 9 to 13 years, exhibit non significant sex differences.

The maximum yearly increase in lower extremity length occurs between 13 and 14 years among males while females exhibit it two year earlier, i.e. between 11 and 12 years This pattern is identical to the one observed in case of stature for male Jats while in case of females the maximum annual increase in stature occurs a year before, i. e. between 10 and 11 years.

Table 3. Sex differences in Thigh length among Jats of Haryana

Age (yrs)	Males Mean (cm)	Males S.E.M.	Females Mean (cm)	Females S.E.M.	Value of t
9.0	36.9	0.34	37.0	0.50	0.17
10.0	37.6	0.34	38.4	0.61	1.15
11.0	40.1	0.48	40.8	0.48	1.05
12.0	41.5	0.46	43.0	0.49	2.23*
13.0	42.3	0.47	44.1	0.47	2.71*
14.0	45.9	0.47	44.3	0.39	2.15*
15.0	47.4	0.56	45.2	0.35	7.23*
16.0	47.6	0.42	45.7	0.57	3,67*
17.0	47.8	0.46	46.0	0.46	2.77*

*Significant at 5 % level

Table 3 exhibits the basic statistical constants for thigh length among male and female Jats in the age range of 9 to 17 years along with the values of t- test. It is apparent from the table that male and female Jats of Haryana exhibit an increase in thigh length from 9 years to 17 years. Table 3 further reveals that the males Jats attain an overall increase of 10.9 cm in thigh length from 9 to 17 years in contrast to 9.0 cm increase attained by the females in this age range. In spite of exhibiting lesser overall increase the females possess longer thighs than the males from 9 to 13 years, thereafter till 17 years the males outgrow them.

The maximum yearly increase, in thigh length, occurs earlier among females (11 and 12 years) than males (13 and 14 years). Although the females possess longer thighs than the males' upto 13 years of age, the differential trends as assessed through t-test reveal significant sex differences from 12 to 17 years only.

Table 4. Sex differences in Lower leg length among Jats of Haryana

Age (yrs)	Males Mean (cm)	Males S.E.M.	Females Mean (cm)	Females S.E.M.	Value of t
9.0	30.7	0.33	31.5	0.32	1.74
10.0	31.4	0.30	31.9	0.40	0.76
11.0	33.2	0.34	32.6	0.45	1.77
12.0	35.2	0.46	34.8	0.43	1.43
13.0	36.0	0.48	35.5	0.45	1.52
14.0	38.7	0.42	36.1	0.30	5.04*
15.0	38.9	0.43	36.3	0.31	4.15*
16.0	39.2	0.37	36.5	0.46	5.59*
17.0	39.5	0.34	36.7	0.29	5.06*

*Significant at 5 % level

Table 4 expounds the basic statistical constants of lower leg length among male and female Jats in the age range of 9 to 17 years along with the values of t-test. It is evident from the table that the lower leg length increases with advancement in age from 9 through 17 years for male and female Jats of Haryana It is also observed that the overall increase in the lower leg length is greater (8.8 cm) among males than the females (5.2 cm) in this age range. The increase in lower leg length among males is little over1.5 times than that of the one observed among females. Male Jats possess longer lower leg length at all ages except for 9 and 10 years where females out grow them.

The maximum yearly increase, in lower leg length, occurs among males between 13 and 14 years while in case of females it occurs between 11 and 12 years. This pattern is similar to the one observed in case of total lower extremity length and thigh length. However in case of stature the females exhibit this phenomenon earlier between 10 and 11 years while male Jats exhibit it at 13-14 years only. The differential trends as observed on applying t-test reveal that the males possess significantly longer lower legs than their female counterparts from 14 to 17 years only, while at remaining ages the apparent variations observed in the lower leg length the differences are non significant.

Table 5. Sex differences in Foot length among Jats of Haryana

Age (yrs)	Males Mean (cm)	S.E.M.	Females Mean (cm)	S.E.M.	Value of t
9.0	20.8	0.16	20.5	0.18	0.67
10.0	21.3	0.14	21.1	0.13	.043
11.0	22.0	0.25	21.6	0.20	1.88
12.0	22.9	0.24	22.6	0.14	3.61*
13.0	23.4	0.32	22.9	0.12	2.25*
14.0	25.0	0.17	23.3	0.16	5,68*
15.0	25.4	0.18	23.5	0.13	5.24*
16.0	25.7	0.16	23.7	0.16	6.78*
17.0	25.9	0.19	23.8	0.18	7.67*

*Significant at 5 % level

Table 5 exhibits the basic statistical constants of foot length among male and female Jats in the age range of 9 to 17 years along with the values of t-test. It is observed that both male and female Jats exhibit an increase in foot length with advancement in age from 9 to 17 years Male Jats attain an overall increase of 3.7 cm in foot length from 9 to 17 years of age in contrast to 2.3 cm increase attained by the female Jats. The increase in foot length among males is approximately 1.6 times greater than that of females during this age range. It is further observed that unlike other measurements of the lower extremity and stature, males Jats possess longer feet than their female counterparts at each age from 9 to 17 years.

The maximum yearly increase, in foot length, occurs earlier among females (11 and 12 years) than the males (13 and 14 years). Despite the apparent variations observed in the foot length at each age between male and female Jats, the differential trends reveal that the males possess significantly longer feet from 14 to 17 while at remaining ages the sex differences are non–significant.

The results of the present study revealed that all the dimensions of lower extremity exhibits a progressive increase with increase in age from 9 – 17 years for both males and females Jats of Haryana. It is further observed that the female Jats possesses greater dimensions than males from 9 to 13 years for stature, lower extremity length and thigh length where after the males out grow them till 17 years. In case of lower leg length this patter varies as the females exhibit greater dimensions than males only at 9 and 10 years where after the males possess longer lower legs. This pattern is completely reversed in case of foot length as males exhibit longer feet than the females at each age from 9 to 17 years.

The yearly gain in different measurements of the lower extremity and stature reveal more or less an identical pattern as males attain maximum annual increase for all the measurements between 13 and 14 years, however the intensity of increase is variable for different measurements. Stature attains the maximum gain during this period followed by total lower extremity length, thigh length, lower leg length and foot length On the other hand, the intensity of increase is relatively low in all the measurements of lower extremity and stature among females but they follow an identical pattern as observed in case of males.

The apparent variations in the mean values of all the measurements of lower extremity and stature among Jats of Haryana reveal significant variations at the higher ages in contrast to the younger age groups. Stature, Total lower extremity length and lower leg length exhibit significant sex differences from 14 to 17 years, while thigh length and foot length reveal significant variations between 12 and 17 years.

References

Dwivedi, A.2000. Assessment of growth patterns and sex differences in different body dimensions among Jats of Gurgaon. Unpublished Doctoral thesis. University of Delhi, Delhi.

Krogman, W.M. 1972. Child Growth. University of Michigan Press. Ann Arbor.

Martin, R and K. Saller, 1959. Lehrbuch der Anthropologie. Gustav FischerVerlag. Stuttgart.

Sachdeva, V. and S. Nath 1995. Developmental pattern of different body segments among Bengali females. Man in India.**75**:261-267.

Sathyavathi, K.S. K.N.Agarwal and D.K.Agarwal, 1981. The growth pattern of upper and lower extremity during adolescence. Ind. Pediatr. **18**: 563-575.

Scammon, R.E. 1953. Developmental Anatomy. In 11th edition of Morris Human Anatomy (ed.) J.P.Schaeffer. Mc Graw Hill Book Co. Inc.

Sinclair, D 1973. Human Growth after birth.2nd edition. Oxford Medical Publications, New York

Tanner, J.M. 1973. Growing Up. Scientific American, **229**: 35-45.

Tanner, J.M. 1978. Foetus in to Man: Physical growth from Conception to maturity. Open Book Publication Limited. London.

Weiner, J.S. and J.A. Lourie. 1969. Human Biology: A Guide to Field Methods.I.B.P. Handbook No. **9**. Oxford and Blackwell scientific Publications. Edinburgh.

.

The Healthy Growth Study: Findings from Year Four

Taylor, W.C., Chan, W., Cummings, S. and Lei, L.
The University of Texas Health Science Center at Houston, School of Public Health, Center for Health Promotion and Prevention Research, 7000 Fannin Street, Suite 2670, Houston, Texas 77030;
Email address: Wendell.C.Taylor@uth.tmc.edu.

Abstract

Objectives: For African American girls, the research questions were: 1) Do body fat, maturity, and physical activity predict blood pressure values? 2) Do body fat, maturity, and psychosocial and environmental variables predict physical activity? 3) Do maturity and physical activity predict body fat? *Methods:* The design was a four year observational study and measures were taken twice a year. The anthropometric measures and interviews were completed by trained staff. *Results:* Moderate-to-vigorous physical activity decreased and sedentary behavior increased over time. Age, body mass index, and height were significant predictors of systolic blood pressure. Height was the only significant predictor of diastolic blood pressure. Age (negative relationship), cognitive and social factors were significant predictors of moderate-to-vigorous physical activity. Age and maturity (more advanced breast stages) were significant predictors of body mass index. *Conclusions:* Promoting healthy lifestyles in adolescent, African American girls should include preventing the decline in physical activity by developing positive social networks.

Key Words: Longitudinal Study, Physical Activity, Body Mass Index, Blood Pressure, Obesity, African American Girls

Introduction

Obesity and related health compromising conditions (e.g., diabetes and hypertension) are the primary public health challenges in the United States (U. S. Department of Health and Human Services, 2000) and possibly the world (Kettaneh et al., 2005). In the United States, the prevalence of overweight and obesity among children and adolescents has more than doubled during the past three decades and the trend is escalating (Miech et al., 2006, Ogden et al., 2006, Ogden et al., 2002, Troiano et al., 1998). The associated consequences of overweight status are type 2 diabetes, hypertension, poor quality of life in childhood and increased morbidity and mortality in adulthood (Daniels et al., 2005, Ebbeling et al., 2002, Miech et al., 2006, Schwimmer et al., 2003, U. S. Department of Health and Human Services, 2000, Williams et al., 2005).

African American females are at greater risk for overweight, physical inactivity, and the related consequences of excess weight and physical inactivity compared to other racial/ethnic groups (females and males) and males of all racial/ethnic groups (Mensah et al., 2005, U. S. Department of Health and Human Services, 2000). Identifying, describing, and understanding the predictors of overweight status, physical activity, and sedentary behaviors are critical in developing effective interventions and prevention programs; however, few longitudinal studies have been conducted, particularly in adolescents and children. In one longitudinal study, Finnish girls who remained active over six years had significantly lower subscapular skinfold thickness, but not body mass index (BMI), compared to sedentary girls (Raitakari et al., 1994). Only one longitudinal study with African American girls was found (Kimm et al., 2005, 2002, 2002, & 2000); the results were that each decline in physical activity of 10 metabolic equivalent-times per week was associated with an increase in BMI of .14 kg/m^2 and in sum of skinfold thickness of .62 mm for African American girls (Kimm et al., 2005). In the Kimm et al., (2005) study, the physical activity measure was self-report in which the girls recalled physical activities outside school hours during the previous year. In the current longitudinal study, the physical activity measure was a bi-annual, self-report of the previous seven days' physical activities. This study's activity assessment was more frequent and comprehensive (all physical activities) compared to previous research. Additionally, the current longitudinal study is unique because the patterns and predictors of physical activity, blood pressure, and body mass index were included in the four year study of African American girls, starting at age twelve or thirteen. The specific research questions were:

1) Do body fat, maturity, and physical activity predict blood pressure values?
2) Do body fat, maturity, and psychosocial and environmental variables predict physical activity?
3) Do maturity and physical activity predict body fat?

Findings from this longitudinal study combined with data from other studies can guide the development of effective interventions to prevent overweight status and physical inactivity in vulnerable populations, particularly African American girls.

Methods

Subjects and Recruitment

Sixth grade is an important developmental period for health behaviors and physical maturation. We recruited all 120 sixth grade girls from one middle school in a large, urban, southwestern city in the United States, which was predominantly African American (93% African American, 6% Hispanic, 1% non-Hispanic white). Approximately 54% of the students were on the federal program for free or reduced lunch. The school had relatively low mobility rates (i.e., movement into, out of, or within the school district during a school year), simple feeder patterns (i.e., most students attended the same high school), and a supportive school administration (i.e., enthusiastic principal, assistant principals, and teachers). The school district and the university's internal review board approved the study, which included parental consent and child assent forms. The methods for each measurement are described below.

Anthropometry

The anthropometry measures included height, weight, circumferences, and skinfolds. Reliable and valid assessments were used in this study. Height was taken without shoes on a portable Harpenden stadiometer. Weight was taken on a balance beam scale. Four circumferences were taken with a retractable inelastic tape on the arm, abdomen, hip and lower thigh. Five skinfolds were measured with a Holtain skinfold caliper on the medial calf, lower thigh, triceps, subscapular, and abdominal. Measurement procedures followed Lohman et al., (1988), except for the lower thigh skinfold. The technique for the lower thigh skinfold is described in Sangi et al., 1992. Based on previous research (Mueller et al., 1987), the lower thigh skinfold is a valid indicator of lower body subcutaneous fat in adults. Also, we computed a waist/thigh ratio because this ratio was the first abdominal adiposity index devised using circumferences (Ashwell et al., 1982). Moreover, in a cross-sectional study of 10 to 14 year old children, the waist/thigh ratio was consistent with skinfold measures in statistically reflecting the contours of the human body as far as distinguishing abdominal versus lower body patterns of fat distribution, whereas the waist/hip ratio was not (Mueller et al., 1990).

The reliability of Healthy Growth's anthropometric measures was at an acceptable and very high level with intra-class correlations of 0.95 or greater for most measures except skinfolds (typically > 0.90) and circumference ratios (waist/hip and waist/thigh that ranged from 0.83 to 0.90). For example, the intra-class correlation coefficients for both same observer and different observer repeated measures were above 0.95 for height, weight, BMI (weight/height^2), abdominal circumference, arm circumference, hip circumference, and thigh circumference and above 0.93 for calf skinfold, subscapular skinfold, and abdominal skinfold. All correlations have been reported in detail earlier (Mueller et al., 1996).

The set of skinfolds and circumferences provide a complete list of variables useful in studies of fatness or obesity and anatomic fat distribution. Circumferences and skinfolds were taken on the right side of the body. Skinfold measurements are potentially less reliable than other anthropometric measures (Hass and Flegal, 1981). Thus, skinfolds over 20 mm were remeasured and the resultant values averaged to improve reliability, which tends to diminish with increasing skinfold thickness (Marks et al., 1989). The measurements were taken with one technician performing the procedures and another acting as a recorder. Standard anthropometric techniques in terms of site and instruments were followed (Cameron, 1984).

Blood Pressure

The blood pressure measures were systolic and diastolic blood pressures, mean arterial pressure, and pulse. The Dinamap 8100 automatic monitor was used to assess these values. The equipment was calibrated before data collection began. All staff was trained for about two hours on the use of the instrument. Before the measurement, each subject sat quietly for several minutes (a five minute rest period) while the staff member explained the procedure. The staff member then selected the appropriate size cuff based on the measured circumference of the right arm. Five cuff sizes were available. The cuff was placed on the right arm (Update on the Task Force Report, 1996) and the subject sat on a chair with her feet flat on the floor with her arm elevated to the heart level. Two measurements were taken exactly one minute apart and were then averaged for analyses. Between the two measurements, the subjects were instructed to raise their arms, and open and close their fists three times. This procedure allows for filling of the blood vessels thus preventing artificially lowering the blood pressure due to the recent constriction (Labarthe, 1991).

Physical Activity

The frequency, duration, and intensity of physical activity were assessed. The project investigators developed a physical activity frequency interview. It included a list of 41 activities from sedentary behaviors to high intensity physical activities. Observations of girl's physical activity behaviors and published literature were used to develop the list of activities appropriate for our population (e.g., Ross et al., 1985). An intensity index was used to classify the activities as light, moderate, or vigorous. The items per category were: sleeping (n = 1), sedentary (n = 6), light activity (n = 2), moderate activity (n = 11) and vigorous (n = 21). Each activity was assigned a MET value based on previous research (American College of Sports Medicine, 1991; Blair, 1991). One MET is equivalent to an oxygen uptake of 3.5 $ml \cdot kg^{-1} \cdot min^{-117}$. Sleeping had a MET value of 1, sedentary behaviors had a MET value of 1.5, light activities had a MET value of 2, moderate activities had MET values of 3, 4.5, or 5; and vigorous activities had MET values of 6.5, 7, or 8.5. With the MET value, minutes in the activity, and body weight, we calculated kilocalories burned. The following standard formula (American College of Sports Medicine, 1991) was used to calculate average daily kilocalories burned in activities:

(weekly hours in activity X MET value of activity X weight in kilograms) / 7

During the interview, the subjects were asked if they participated in each activity in the last seven days, how many times they participated, and how long they participated. For the physical activities, subjects were also asked if the activity made them breathe fast or their heart beat faster. If so, they were asked how long their breathing and heartbeat were faster than usual. A higher MET value (1.5 was added to the MET value) was assigned for the minutes that the subject's breathing or heartbeat was increased during an activity. This procedure was used to accurately account for the intensity of an activity because the same activity can be performed at a low, moderate, or high intensity. The reliability and validity of this interview procedure and instrument have been documented (Simons-Morton et al., 1994). Intra-observer and inter-observer test-retest reliabilities were conducted on a sample of 21 girls who completed a second interview after the first interview. The correlation coefficients for the test-retest reliabilities ranged from .70 to .92.

At the end of the interview, the interviewer rated the overall quality of the girl's responsiveness on a scale of 1 to 5 with one being poor and five being excellent. The criteria for the ratings were attentiveness, ability to recall activities, ability to estimate time, and overall quality of interview. The purpose of the ratings was to identify girls, who during the interview were very inattentive or disinterested. If the interview's overall quality was rated as poor, the subject was eliminated from the analyses.

Predictors of Physical Activity

Factors and conditions potentially related to physical activity were assessed. A multidimensional model of determinants of physical activity based on operant and cognitive learning theories developed by Sallis and Hovell (1990) was used to assess predictors of physical activity. The model's premise is that learning theories and learning processes provide a comprehensive basis for explaining and influencing behavior. Therefore, the model is a useful conceptual framework to understand the complex behavior of physical activity (Table 1) (Sallis and Hovell, 1990).

Table 1. A Model of Determinants of Physical Activity Based on Learning Theory Adapted From Sallis and Hovell (1990)

Antecedents		Consequences	
Distal	**Proximal**	**Proximal**	**Distal**
Environmental Factors	*Environmental Factors*	*Environmental Factors*	*Environmental Factors*
Climate Air quality	Convenience of facilities Safety of neighborhood	Equipment failure Pleasantness of exercise setting	Hot/cold temperatures
Social Factors	*Social Factors*	*Social Factors*	*Social Factors*
Past modeling and support	Friend modeling Media influences	Praise Criticism Competing opportunities	Physical attractiveness Being in shape
Cognitive Factors	*Cognitive Factors*	*Cognitive Factors*	*Cognitive Factors*
Normative beliefs	Exercise knowledge Self-efficacy	Exhaustion Positive/negative moods	Anticipated health benefits Fear of injury
Physiological Factors	*Physiological Factors*	*Physiological Factors*	*Physiological Factors*
Health Status Coordination	Injury	Heart rate Perspiration Breathing rate	Weight change Fitness Chronic injury
Other Personal Factors	*Other Personal Factors*	*Other Personal Factors*	*Other Personal Factors*
Education Income Weight control history	Diet Other health-related behaviors	Smoking Alcohol use	General risk taking

The multidimensional model (Sallis and Hovell, 1990) has five classifications: 1) environment (e.g., characteristics of the physical environment, climate, convenient access to facilities, safety in neighborhood); 2) social (e.g., modeling, social support, encouragement, praise, teasing, criticism); 3) cognitive (e.g., knowledge, perceptions, intentions, health benefits, fear of injury); 4) physiological (e.g., coordination, fatigue, exertion, perspiration, breathing hard, relaxation, soreness) and 5) other personal factors (e.g.,. education, income, smoking, alcohol use, injury history, other health behaviors). An important structure to the multidimensional model is consequences and antecedents. Within each of the five classifications, variables representing both consequences (effects that can occur after physical activity such as fatigue, praise, health benefits) and antecedents (influences that precede participating in physical activity such as expectations, attitudes, knowledge, encouragement, access to facilities) are included in the model.

We adapted this theoretically based multidimensional model (Sallis and Hovell, 1990) and developed The Predictors of Physical Activity Questionnaire with 54 items. The questionnaire includes 4 environment, 16 social, 18 cognitive, 9 physiological, 1 other personal factor, and 6 self-efficacy items. We added the self-efficacy classification because self- efficacy perceptions can be a strong predictor of behavior (Bandura, 1986). All analyses of this questionnaire were by the six broad classifications and not by the consequences and antecedents dimensions.

The questionnaire was interview administered. The response categories were: yes (4), sort of yes (3), sort of no (2), and no (1). For the self-efficacy subscale only, the response categories were: very sure (4), sort of sure (3), sort of not sure (2), and not sure (1). As a measure of a scale's internal consistency, the Cronbach's alpha coefficient for the questionnaire was .97. The individual subscales Cronbach's alpha coefficients were: cognitive-.91; social-.89; physiological-.84; self efficacy-.79; and environmental-.63. The personal factor classification had only one item and therefore no Cronbach's alpha coefficient was calculated. Cronbach alpha coefficients ≥ 0.70 is the standard criterion for new scales (Nunnally and Bernstein, 1994).

The test-retest (the time frame for the first and second administration was 7 to 36 days) correlation coefficients (Pearson for normally distributed scores or Spearman for distributions not normally distributed) were: overall questionnaire (Pearson r=.82); cognitive (Pearson r=.76); self efficacy (Spearman r=.73); environment (Spearman r=.63); social (Pearson r=.56); and physiological (Pearson r=.22). All correlation coefficients were significant ($p \leq 0.001$) except the physiological classification.

Stage of Maturation

Each subject self-assessed her secondary sex characteristics by comparing her body to drawings of the Tanner stages (Tanner, 1990). Each drawing was accompanied with a detailed description in writing. The drawings depict five successive stages of breast development and pubic hair growth. The first stage is preadolescence and the fifth stage is the mature adult. The five stages of pubic hair development were: 1) no pubic hair, 2) a little long, lightly colored hair, 3) the hair is darker, coarser, and more curled and thinly covers a larger area, 4) the hair is dark, curly, and coarse and has not spread out to the thighs, and 5) the hair has a triangular pattern as it spreads out to the thighs. The five stages of breast development were: 1) the nipple is raised and the rest of the breast is flat, 2) the nipple is raised and the breast is a small mound, 3) the areola and the breast are larger than stage two and the areola does not stick out away from the breast, 4) the areola and the nipple make up a mound that sticks up above the shape of the breast, and 5) the breasts are fully developed, only the nipple sticks out, and the areola has moved back to the general shape of the breast. The self-assessment activity was performed in a private area with instruction from a woman staff member. This procedure is a valid noninvasive method to measure female maturation (Kozinetz, 1986). Additionally, the subjects were asked about onset of menses.

Health Behavior Questionnaire

Health behaviors that affect growth, maturity, fitness, blood pressure, and physical activity were assessed. The Youth Risk Behavior Survey Questionnaire developed in 1990 by the Centers for Disease Control and Prevention was modified to assess alcohol, tobacco, oral contraceptive use, recent medical conditions, and dieting behaviors. The girls were asked to read each question carefully, be completely honest, and know that their responses were confidential.

We selected 26 items from the Youth Risk Behavior Survey

Questionnaire. Seven items asked about cigarette use and chewing tobacco. For example, "How old were you when you smoked a whole cigarette for the first time?" "During your lifetime, how many days have you smoked at least 1 cigarette?" These two questions had seven response categories. Four questions asked about alcohol use. For example, "How old were you when you had your first drink of alcohol other than a few sips?" This question had seven response categories. Six questions asked about body weight. For example, "Do you think of yourself as being: very underweight, slightly underweight, about the right weight, slightly overweight, or very overweight." "Which of the following are you trying to do- lose weight, gain weight, stay the same weight, or I am not trying to do anything about my weight." One question was about the use of oral contraceptives. Eight questions were about illegal drug use. For example, "During your life, how many times have you used marijuana?" For this question there were seven response categories.

A test-retest reliability study of the Youth Risk Behavior Survey Questionnaire was conducted with 1,679 students and the results indicate that students report health behaviors reliably over time (Brener et al., 1995). The validity of self-report measures of illicit drug use, alcohol use, and tobacco use has been documented (Brener et al., 1995).

Analysis Plan

For descriptive purposes, the means and standard deviations for blood pressure, physical activity, and anthropometric measures were calculated for each of the 8 time points. For the 6 important variables in the study, body mass index, weight in kilograms, hours per week of moderate-to-vigorous physical activity, hours per week of sedentary behavior, systolic blood pressure, and diastolic blood pressure, their time-specific means and 95% confidence intervals were further plotted to facilitate detecting trends over time.

The statistical analyses addressed the three research questions: 1) Do body fat, maturity, and physical activity predict blood pressure values? 2) Do body fat, maturity, and predictors of physical activity predict physical activity? 3) Do maturity and physical activity predict body fat? The three dependent variables were modeled in three separate groups of longitudinal regressions.

The following measures were independent variables for the appropriate regressions: (i) a body fatness measure (BMI), a body fat distribution measure (waist-thigh ratio), (ii) maturity measures (breast and menarche stages), (iii) physical activity (moderate to vigorous minutes), (iv) a combination of BMI and moderate to vigorous minutes, (v) psychosocial measures (social and cognitive factors), (vi) physical fitness (VO_{2max}), and (vii) height.

The independent variables were selected from a larger series of measurements in preliminary analyses. The correlations between physical activity (moderate-to-vigorous minutes in physical activity), blood pressure and seven different body fat indices were performed. The body fat measures were: BMI (weight/height^2), Rohrer Index (weight/height^3), abdomen circumference, and sum of five skinfolds—medial calf, lower thigh, triceps, subscapular, and abdomen. The indices of abdominal fat distribution were waist-hip ratio, waist-thigh ratio, and conicity index. Both BMI and waist-thigh ratio were chosen to enter the regression analysis because these variables had the strongest correlations with systolic blood pressure and had the least correlation with each other in the preliminary analysis.

The maturity measure (breast stages) was selected because it had a strong and significant correlation with body mass index (BMI). Furthermore, the variable moderate-to-vigorous minutes of physical activity was selected as the measure of physical activity, because it represents the intensity most associated with health benefits and national standards (U.S. Department of Health and Human Services, 1996, 2000; Sallis, 1994).

A plot of moderate to vigorous physical activity minutes against BMI showed considerable variance in the middle of the graph, indicating perhaps the need for a combination term (RiskBMI) to explore the possible synergism between the two variables. Thus, a combination term was created representing cardiovascular risk: the product of BMI and physical activity reversed (scale values were reversed, i.e., low BMI and high activity are scored as 'lowest risk' and so on).

Cognitive and social factors (psychosocial predictors) were chosen to be included in the regression analysis because they had the highest alpha coefficient values (i.e., the most internally consistent scales).

Mixed model with fixed effect for each independent variable and random intercept among individuals was used in model fitting. Autoregressive 1 covariance structure was also specified in the model to accommodate within-subject correlations over time. These model specifications were the same for both univariate and multivariate analyses. After fitting univariate model for each potent predictor, those with p-value <= 0.25 were chosen to be the first group of candidates in the multivariate analysis, and a backward selection process was completed until the final predictors all having significant p-values of less than 0.05, based either on the Wald's test or the Akaike Information Criteria (AIC). PROC MIXED procedure of SAS® 8.0 was used in modeling.

Height was included in the regression model when BMI and waist thigh ratio were the dependent variables, because height is a measure of overall physical size and maturation, a possible confounder for blood pressure.

Results

Subject retention and attrition

The patterns of subject retention and attrition are presented in Table 2. For each measurement period, any girl enrolled in the school at the grade level for that year could participate in the study. We started with 120 sixth grade girls as the total subject population from which to recruit the participants. At the end of four years, 189 girls participated in the Healthy Growth study; 50 girls participated in one measurement only; 9 girls participated in all 8 measurements (Table 2).

Table 2. Healthy Growth: Subject retention and attrition

	1 time	2 times	3 times	4 times	5 times	6 times	7 times	8 times
n	50	32	31	19	17	11	20	9
% of 189	26.5%	16.9%	16.4%	10.1%	9.0%	5.8%	10.6%	4.8%

Nine participants had systolic blood pressure, diastolic blood pressure, body mass index, and hours per week of moderate-to-vigorous physical activity at all 8 time points.

Selected variables and changes over time (trends)

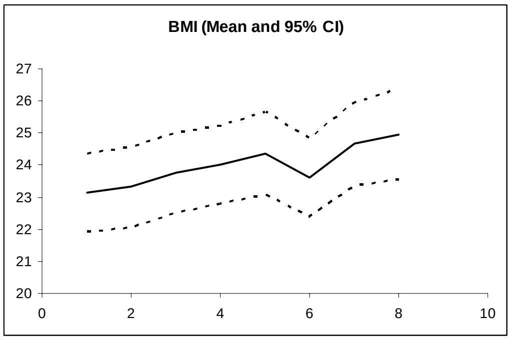

Figure 1. Healthy Growth – Body mass index trends

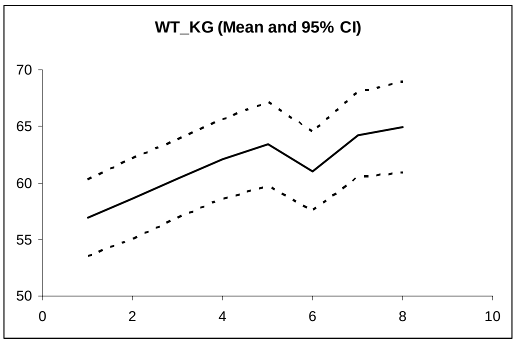

Figure 2. Healthy growth-Weight in kg trends

As expected for adolescents, body mass index and weight increased during each year with a decrease at the sixth measurement period (Figures 1 & 2). Hours per week of moderate-to-vigorous physical activity decreased over time with an increase at the sixth measurement period (Figure 3). The final measurement period (i.e., eighth assessment) showed the lowest subject participation in moderate-to-vigorous physical activity during the entire study (Figure 3). Hours per week of sedentary behavior showed an up and down pattern over the eight measurement periods (Figure 4). For the first measurement, the participants engaged in the least amount of sedentary behavior (approximately 35 hours per week) (Figure 4). For the final measurement (i.e., eighth assessment), the participants reported the most time spent in sedentary behaviors (approximately 45 hours per week) (Figure 4). Systolic (except for a decrease at the third measurement period) and diastolic (except for an increase at the sixth measurement period) remained relatively stable during the four year time period (Figures 5 & 6).

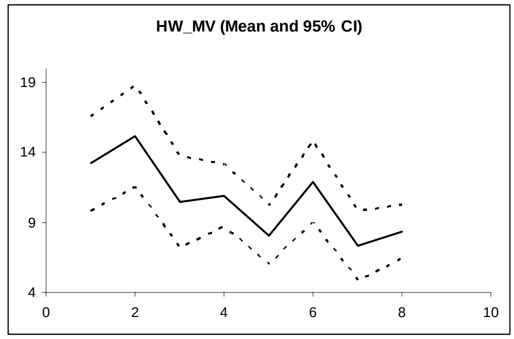

Figure 3. Healthy Growth: Hours per week in moderate-to-vigorous trends

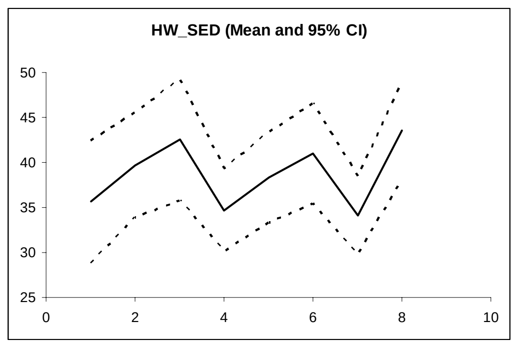

Figure 4. Healthy Growth – Hours per week engaged in sedentary behavior

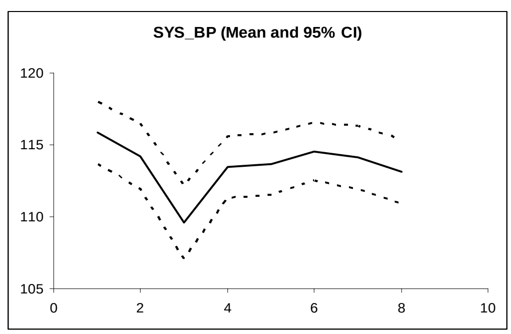

Figure 5. Healthy Growth: Systolic blood pressure trends

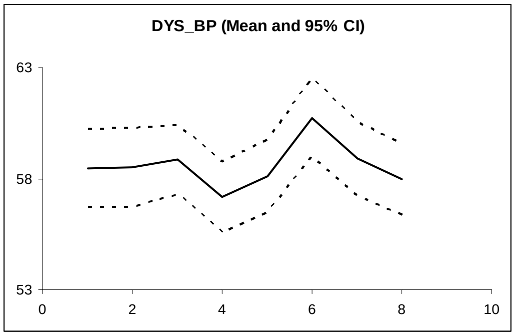

Figure 6. Healthy Growth – Diastolic blood pressure trends

Analyses of three research questions

A mixed model was used to analyze the unbalanced longitudinal design data. Because the dependent variables were not normally distributed, log transformed values were used for the analyses. During the four years of the study, age, body mass index, and height were significant predictors of systolic blood pressure (Table 3).

Table 3: Healthy Growth: Predictors of systolic and diastolic blood pressure, moderate-to-vigorous physical activity, and body mass index (fitting log outcomes)

Outcome	Variable	Estimate	Standard Error	P Value
SYS_BP				
	AGE	-0.13	0.04	0.003
	AGE*AGE	0.00	0.00	0.005
	BMI	0.01	0.00	<.0001
	MIN_MV	0.00	0.00	0.099
	HT	0.26	0.08	0.001
	RISKBMI	0.00	0.00	0.171
DYS_BP				
	MIN_MV	0.00	0.00	0.104
	HT	0.33	0.11	0.003
MIN_MV				
	AGE	-0.20	0.04	<.0001
	COGN	0.51	0.16	0.001
	SOC	0.61	0.14	<.0001
BMI				
	AGE	0.02	0.00	<.0001
	BREAST <= 3	-0.04	0.01	0.001
	BREAST 4	-0.03	0.01	<.0001
	BREAST 5	ref.		
	MENSE	0.01	0.01	0.301
	MIN_MV	0.00	0.00	0.396

Height was the only significant predictor of diastolic blood pressure (Table 3). Age (negative relationship), cognitive and social factors were significant predictors of moderate-to-vigorous physical activity (Table 3). Age and maturity (more advanced breast stages) were significant predictors of body mass index (Table 3).

Discussion

The Healthy Growth Study was unique because there are few longitudinal studies in the United States. Furthermore, there is an absence of longitudinal data (perhaps one or two other studies) about the predictors of blood pressure, physical activity, and body fat in African American girls. We found that height (systolic and diastolic blood pressure), age (systolic blood pressure), and body mass index (systolic blood pressure) were significant predictors of blood pressure. Physical activity was not a significant predictor of blood pressure in this racial/ethnic group for this age range. Moderate-to-vigorous physical activity was negatively related to age and positively related to psychosocial predictors (e.g., social and cognitive factors). Body mass index was significantly related to age and maturity. Blood pressure remained relatively stable during the four years. Hours per week of moderate-to-vigorous physical activity decreased and sedentary behavior increased. In this study, we found that the number of hours per week engaged in sedentary behavior increased over time. Also, another study reported that in youth from 10 to 16 years of age, time watching TV/computer increased with age from 1.4 to 2.2 hours per day (Deheeger, 2002). Sedentary behavior has been associated with obesity in youth (e.g., Robinson, 1999).

During the four years, we found a decrease in physical activity among African American girls. In a review, it was noted that the decline in physical activity with age may be the most consistent finding in physical activity epidemiology (Sallis, 2000). The decline is steepest between the ages of 13 and 18. The decline varies by type and intensity of the physical activity. This decline in physical activity with age is antithetical to public health goals (Sallis, 2000). In the United States, a major initiative has been funded to reverse the decline in physical activity among adolescent girls including African Americans (Rohm-Young et al., 2006). To reverse the decline in physical activity, the predictors and determinants of physical activity should be identified. These factors are essential in developing prevention programs.

In our longitudinal study, social and cognitive factors were significant predictors of physical activity. Consistent with the longitudinal findings from *The Healthy Growth Study,* the Trial of Activity for Adolescent Girls (TAAG), (a randomized, multi-center field trial of 36 middle schools to test an intervention to reduce the decline in physical activity in adolescent girls, starting in sixth grade), is promoting the social aspects of doing activities with a friend (Rohm Young et al., 2006). Similarly, in a cross-sectional analysis with sixth and eighth grade girls, peer social networks (i.e., physical activity with friends) were significantly related to physical activity levels (Voorhees et al., 2005). For adolescent African American girls, we recommend further study of social support and peer networks to increase physical activity and prevent the decline in physical activity during adolescence.

We found a decline in physical activity over the four years but physical activity was not a significant predictor of body mass index. Another study with non-Hispanic white and Black girls (Kimm et al., 2005) reported that the decline in physical activity played a key role in weight gain. Inactive girls had three times greater gains in body mass index and were approximately 10 to 15 pounds heavier in the tenth year of the study. Two major differences may account for the seemingly, discrepant findings. Our study was a 4-year observational study and the Kimm et al., 2005 study was a 10-year observational study. Furthermore, in this paper, we did not analyze our results by active and inactive groups. However, as a public health goal, we believe as do Kimm et al. (2005) and Katteneb et al. (2005) that preventing the decline in physical activity among adolescent girls can have many positive health benefits including maintaining a healthy weight and preventing obesity.

Several limitations of the study should be noted. This project was a one school study with a small sample size in a large urban, southwestern, United States city. We tracked girls for four years with a total of 189 participants and 9 girls completed all 8 assessments. Because of the small sample size, the attrition level, and limited geographical area caution is required in generalizing our results to all African American girls. Nevertheless, our results are unique because there are very few studies with African American girls.

In analyzing longitudinal studies, there are statistical concerns. Our longitudinal data had unbalanced observations in that not all subjects had measurements for all 8 time points. This trend could be either due to loss to follow-up, where all observations after a certain time point are missing, or due to intermittent participation in the study, where there were irregular gaps among the measurements over time. We believe that missing data under both circumstances are unlikely to be due to mechanisms related to the measurement process, and are therefore completely random. This assumption justifies our using the mixed model, which is likelihood-based and not seriously affected by missing data in terms of drawing valid inferences. (Diggle et al., 1994; Littell et al., 1996). After fitting the multivariate models and identifying the predictors for each dependent variable, we did not perform any residual analyses and detect any outliers. This analysis was not performed because of the current lack of proper statistical methods for longitudinal models. We hope to do the diagnostics later, when such methods are developed. However, we did conduct post-hoc analyses. At time 6 when 15 new girls joined the existing cohort, we found no significant differences related to the primary study variables between the new and old participants.

Our longitudinal study had several strengths including the measures and procedures. The physical activity checklist used in this study to assess physical activity is still the standard and has been used in many recent studies with adolescent girls (Grieser et al., 2006). The anthropometric assessments and self-report scales were reliable and valid (Taylor et al., 2002). *The Healthy Growth Study* had the same female project coordinator during the entire study and thus continuity and reliability were maintained with the participants. All assessments were conducted in the schools during the school day; therefore, logistical convenience was provided for the participants.

Conclusion

In the four year observational project, *The Healthy Growth Study,* African American girls decreased their physical activity, increased participation in sedentary behavior, and increased body mass index primarily related to maturity. In our sample, psychosocial predictors of physical activity were social and cognitive factors.

In another study, for a 10-year period from ages 9 to 10 to 19 years old, prevalence of overweight and obesity during adolescence doubled. Half of the Black girls were overweight and one third of the Black girls were obese (Kimm et al., 2002). Furthermore, the prevalence of overweight among children in the United States continues to increase especially among Mexican-American and non-Hispanic Black adolescents *(Ogden et al., 2002).* These statistics should sound an alarm for public health professionals *(Kimm et al., 2002).*

To reduce the effects of obesity on morbidity in childhood and adulthood, identifying critical time periods for the prevention of overweight in vulnerable populations is essential (Dietz 2004). Adolescence is critical period when overweight may occur and increasing rates of weight gain vary by racial/ethnic background (Dietz 2004). Therefore, longitudinal studies such as *The Healthy Growth Study* are needed to develop effective obesity prevention programs in which specific strategies for various cultural and racial/ethnic groups should be considered.

Acknowledgments: This research was partially funded through the National Heart, Lung, and Blood Institute grant number 1R29 HL47659-01.

References

American College of Sports Medicine. 1991. *Guidelines for exercise testing and prescription.* 4th edition. Lea & Febiger, Philadelphia.

Ashwell, M., Chinn, S., Stalley, S. and Garrow, J.S. 1982. Female fat distribution-a simple classification based on two circumference measurements. *International Journal of Obesity*, **6**: 143-152.

Bandura, A. 1986. *Social foundations of thought and action*. Prentice-Hall, Englewood Cliffs, N.J.

Blair S.N. 1991. *Living with exercise*. Health Publishing Company, Dallas.

Brener, N.D., Collins, J.L., Kann, L., Warren, C.W. and Williams B.I. 1995. Reliability of the Youth Risk Behavior Survey Questionnaire. *American Journal of Epidemiology*, **141**: 575-580.

Cameron, N. 1984. *Measurement of human growth*. Room Helm, Sydney.

Daniels, S.R., Arnett, D.K., Eckel R.H., et al. 2005. Overweight in children and adolescents: Pathophysiology, consequences, prevention, and treatment. *Circulation,* **111:** 1999-2012.

Deheeger, M., Bellisle, F. and Rolland-Cacher, M.F. 2002. The French longitudinal study of growth and nutrition: Data in adolescent males and females. *Journal of Human Nutrition Dietetics,* **15:** 429-438**.**

Dietz, W.H. 2004. Overweight in children and adolescents. *The New England Journal of Medicine,* **350:** 855-857.

Dingle, P.J., Liang, K.Y. and Zeger, S.L. 1994. *Analysis of longitudinal data. Oxford.*

Ebbeling, C.B., Pawlak, D.B., and Ludwig, D.S. 2002. Childhood obesity: public-health crisis, common sense cure. *Lancet,* **360:** 473-482.

Grieser, M., Vu, M.V., Bedimo-Rung, A.L., Neumark-Sztainer, D., Moody, J., Young, D. R. and Moe, S.G. 2006. Physical activity attitudes, preferences, and practices in African-American, Hispanic, and Caucasian girls. *Health Education and Behavior*, **33:** 40-51.

Haas, J.D. and Flegal, K.M. 1981. Anthropometric measurements. In: *Nutrition and cancer: etiology and treatment*. Eds: Newell, G.R. and Ellison, N.M. New York: Raven Press. 123-140.

Kettaneh, A., Oppert, J.M., Heude, B., Deschamps, V., Borys, J.M., Lommez, A., Ducimetiere, P., and Charles, M.A. 2005. Changes in physical activity explain paradoxical relationship between baseline physical activity and adiposity changes in adolescent girls: the FLVS II study. *International Journal of Obesity,* **29:** 586-593.

Kimm, S.Y.S., Barton, B.A., and Obarzanek, E. 2002. Obesity development during adolescence in a biracial cohort: The NHLBI Growth and Health Study (NGHS). *Pediatrics,* **110:** e54.

Kimm, S.Y.S., Glynn, N.W., Kriska, A.M., et al. 2002. Decline in physical activity in black and white girls during adolescence. *New England Journal of Medicine,* **347:** 709-715.

Kimm, S.Y.S., Glynn, N.W., Kriska, A.M., et al. 2000. Longitudinal changes in physical activity in a biracial cohort during adolescence. *Medicine and Science in Sports and Exercise.* **32:** 1445-1454.

Kimm, S.Y.S., Glynn, N.W., Obarzanek, E., Kriska, A.M., Daniels, S.R., Barton, B.A., and Liu, K. 2005. Relation between the changes in physical activity and body-mass index during adolescence: A multicentre longitudinal study. *Lancet,* **366:** 301-307.

Kozinetz, C.A. 1986. Two noninvasive methods to measure female maturation. *Journal of School Health*, **56**: 440-442.

Labarthe D.R. 1991. *Program on the epidemiology of blood pressure in childhood, youth, and early adulthood – training manual*. University of Texas Health Science Center, School of Public Health, Houston.

Littel, R.C., Millikin, G.A., Strop, W.W. and Wolfinger, R.D. 1996 *SAS systems for mixed models.* SAS Institute.

Lohman, T.G., Roche, A.F. and Martorell, R. eds. 1988. *Anthropometric standardization reference manual*. Human Kinetics Books, Champaign, IL.

Marks, G.C., Habicht, J.P. and Mueller, W.H. 1989. Reliability, dependability, and precision of anthropometric measures. The Second National Health and Nutrition Examination Survey 1976-1980. *American Journal of Epidemiology*, **130**:578-587.

McArdle, W.D., Katch, F.I. and Katch, V.L. 1986. *Exercise physiology: Energy, nutrition, and human performance.* 2nd edition. Lea & Febiger, Philadelphia.

Mensah, G.A., et al. 2005. State of disparities in cardiovascular health in the United States. *Circulatio,* **111:** 1233-1241.

Miech, R.A., Kumanyika, S.K., Stettler, N., Link, B.G., Phelan, J.C., and Chang, V.W. 2006. Trends in the association of poverty with overweight among US adolescents, 1971-2004. *JAMA,* **295:** 2385-2393.

Mueller W.H., Marbella, A., Harrist, R.B., Kaplowitz, H.J., Grunbaum, J.A. and Labarthe, D.R. 1990. Body circumferences as measures of body fat distribution in 10-14 year old school children. *American Journal of Human Biology*, **2**: 117-124.

Mueller, W.H., Taylor, W.C., Chan, W., Sangi-Haghpeykar, H., Snider, S.A., Hsu, H. 1996. Precision of measuring body fat distribution in adolescent African American girls from the 'Healthy Growth Study'. *American Journal of Human Biology,* **8**: 325-329.

Mueller, W.H., Wear, M.L., Hanis, C.L., Barton, S.A. and Schull, W.J. 1987. Body circumferences as alternatives to skinfold measurements of body fat distribution in Mexican-Americans. *International Journal of Obesity*, **11**:309-318.

Nunnally, J.C. and Bernstein, I.H. 1994. *Psychometric Theory*. 3rd edition. McGraw-Hill, New York.

Ogden, C.L., Carroll, M.D., Curtin L.R., McDowell M.A., Tabak, C.J., and Flegal, K.M. 2006. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA,* **295:** 1549-1555.

Ogden, C.L., Flegal, K.M., Carroll, M.D., and Johnson, C.L. 2002. Prevalence and trends in overweight among US children and adolescents, 1999-2000. *JAMA,* **288:** 1728-1732.

Raitakari, O.T., Porkka, K.V.K., Taimela, S., Telama, R., Rasanen, L., and Viikari, J.S.A. 1994. Effects of persistent physical activity and inactivity on coronary risk factors in children and young adults. *American Journal of Epidemiology,* **140:** 195-205.

Robinson, T.N. 1999. Reducing children's television viewing to prevent obesity: A randomized controlled trial. *JAMA,* **282:** 1561-1567.

Rohm-Young, D., Johnson, C.C., Steckler, A., et al. 2006. Data to action: Using formative research to develop intervention programs to increase physical activity in adolescent girls. *Health Education and Behavior,* **33:** 97-111.

Ross, J.G., Dotson, C.O., Gilbert, G.G. and Katz, S.J. 1985. The National Children and Youth Fitness Study. What are kids doing in school physical education? *JOPERD*, 73-76.

Sallis, J.F. Ed. 1994. Pediatric exercise science. Special issue. Physical activity guidelines for adolescents. Human Kinetics Publishers, Champaign, IL.

Sallis, J.F. 2000. Age-related decline in physical activity: A synthesis of human and animal studies. *Medicine and Science in Sports and Exercise,* **32:** 1598-1600.

Sallis, J.F., Condon, S.A., Goggin, K.J., Roby, J.J., Kolody, B. and Alcaraz, J.E. 1993. The development of self-administered physical activity surveys for 4th grade students. *Research Quarterly for Exercise and Sports*, **64**: 25-31.

Sallis, J.F. and Hovell, M.F. 1990. Determinants of exercise behavior. *Exercise Sport Sciences Review*, **18**: 307-330.

Sangi, H., Mueller, W.H., Harrist, R.B., Rodrigues, B., Grunbaum, J.G., and Labarthe, D.R. 1992. Is body fat distribution associated with cardiovascular risk factors in childhood? *Annals of Human Biology,* **19**:559-578.

Schwimmer, J.B., Burwinkle, T.M. and Varni, J.W. 2003. Health-related quality of life of severely obese children and adolescents. *JAMA,* **289:** 1813-1819.

Simons-Morton, B.G., Taylor, W.C. and Huang, I.W. 1994. Validity of the physical activity interview and Caltrac with preadolescent children. *Research Quarterly for Exercise and Sport*, **65**: 84-88.

Tanner J.M. 1990. *Fetus into man: Physical growth from conception to maturity*.: Harvard University Press, Cambridge.

Taylor, W.C., Chan, W.C., Cummings, S.S., et al., 2002. Healthy Growth: Project description and baseline findings. *Ethnicity and Disease,* **12:** 567-577.

Troiano, R.P., and Flegal, K.M. 1998. Overweight children and adolescents: description, epidemiology, and demographics. *Pediatrics,* **101:** 497-504.

Troiano, R.P., Flegal, K.M., Kuczmarski, R.J., Campbell, S.M., and Johnson, C.L. 1995. Overweight prevalence and trends for children and adolescents: the National Health and Nutrition Examination Surveys 1963 to 1991. *Archives of Pediatric Adolescent Medicine,* **149:** 1085-1091.

Update on the 1987 Task Force Report on High Blood Pressure in Children and Adolescents. 1996. A working group report from the National High Blood Pressure Education Program. *Pediatrics*, **98**: 649-658.

U.S. Department of Health and Human Services. 1996. *Physical activity and health: A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 85-91.

U.S. Department of Health and Human Services. 2000. ***Healthy People 2010. With understanding and improving health and objectives for improving health.*** 2 vols. 2nd edition. Washington, DC: U.S. Government Printing Office.

Voorhees, C. C., Murray, D., Welk, G., et al. 2005. The role of peer social network factors and physical activity in adolescent girls. *American Journal of Health Behavior*, **29:** 183-190.

Williams, J., Wake, M., Hesketh, K., Maher, E., and Waters, E. 2005. Health-related quality of life of overweight and obese children. *JAMA,* **293:** 70-76.

Trends of Overweight and Obesity in Affluent School Girls of Punjab between 1996 and 2003

Sidhu, S., Verma, A., Kaur, N. and Prabhjot
Department of Human Genetics, Guru Nanak Dev University, Amritsar (India)

Abstract

To assess the prevalence of overweight and obesity in school girls between 6-15 years of age among the affluent families of Punjab, two studies are compared using body mass index (BMI) as a parameter. The first study done in the year 1996-1997 (Group-I) was compared with the second study in 2003-2004 (Group-II). Group-I had 677 girls and group-II had 727 girls. Overweight and obesity were assessed using age- and sex-specific body mass index cut-off points. Results showed a 10.49% and 13.48% prevalence of overweight and 4.87% and 6.33% prevalence of obesity in girls of group-I and group-II, respectively. This shows that the overall prevalence of overweight and obesity has increased by 2.99% and 1.45%, respectively, in seven-year period. However, the difference in the prevalence of overweight and obesity in the two surveys was statistically non-significant.

Key Words: Body Mass Index, Overweight, Obesity, Punjabi Males

Introduction

Representative data for examining the prevalence of obesity and secular trends in childhood obesity have been collected over the past three decades in many industrialized countries. *Bundred et al. (2001)* studied children of U.K. and observed the prevalence of overweight as 14.7% in 1989 and 23.6% in 1998 while that of obesity increased from 5.4% to 9.2% during this period. Between 1975 and 1995, the prevalence of overweight rose from 10.0% to 16.3% in German boys and from 11.7% to 20.7% in German girls *(Kromeyer-Hauschild et al., 1999).* Among US children and adolescents, the prevalence of overweight, including obesity, has increased from 15.4% in 1971-1974 to 25.6% in 1988-1994 *(Ogden et al., 2002).* In Canada, in 1981, only 11% of boys and 13% of girls were overweight and obese according to IOTF reference while by 1996 these figures reached 33% and 27% for boys and girls, respectively *(Tremblay et al., 2002).*

Data from Brazil and Chile are good examples to show that the rate of increase of obesity among some developing countries is similar or even faster than that in the USA. In Brazil, the prevalence of overweight, including obesity, tripled between 1970's and the late 1990's, increasing from 4.1% to 13.9% among children and adolescents aged 6-18 years *(Wang et al., 2002).* In Japan, between 1974 and 1995, the prevalence of overweight, including obesity, doubled, rising from 5.5% to 10.8% *(Kotani et al., 1997).* Among urban children in China within six-year period between 1991 and 1997, the prevalence of overweight and obesity increased from 7.7% to 12.4% *(Wang et al., 2002).* In Thailand *(Mo-Suwan et al., 1993),* the obesity prevalence increased from 12..2% to 15.6% in two-year period. Only limited data are available on change in prevalence of overweight and obesity with time from Indian subcontinent. *Subramanyam et al. (2003)* reported no significant change in the prevalence rate of obesity in 17-year span among Chennai girls of India. *Saha et al.* (2004) studied Bengalee boys and observed that the prevalence of overweight remained unchanged and obesity has emerged (1.6%) in the later survey (1999-2001) whereas in the baseline survey (1982-1983) it did not occur. There is an urgent need to know the burden of this problem in Punjab, because Punjab is an economically advanced and physically robust state of the country. The children from affluent families in Punjab have a greater risk of overweight and obesity, as their affluence is the result of the fast rate of socio-economic development in the last 50 years. During this period, the fast-developing economy of Punjab with an agricultural base transformed the whole of India from a food-deficient to grain-surplus nation *(Gill, 2004).* Simultaneously, the Punjabi society witnessed a White revolution in addition to the Green one. This resulted in higher *per capita* availability of milk and milk-products. Due to the improved economic conditions and availability of nutritious food-products, the living conditions and nutritional status of the Punjabi population experienced a tremendous upward transformation *(PSCST, 2005).* In this prevailing transitional situation of the state, it appears that there exists an ample opportunity to pursue subsequent studies on assessment of overweight and obesity among Punjabi children in relation to secular factors. Therefore, in the present study, an attempt has been made to study the change in percentage prevalence of obesity among affluent school girls of Punjab in the last seven years.

Materials and Methods

The data sets come from two cross-sectional surveys carried out during the year 1996-1997 (baseline survey) and the other during 2003-2004 (latest survey). All participants of the two surveys were Punjabi and sampled from Public Schools catering to the affluent population of Amritsar and Kapurthala cities of the Punjab. In the baseline survey, data have been collected from 677 girls and in the latest survey data have been collected from 727 girls ranging in age from 6-15 years. All girls were apparently healthy and were free from any treatment. The exact date of birth was collected from each subject with great care either from the concerned school registers or from the birth records. Height and weight measurements were taken on each subject using standard protocol *(Weiner and Lourie, 1969).* Overweight was denoted by body mass index (BMI). International criteria for BMI *(Cole et al., 2000)* were used to classify children as overweight and obese in both the surveys. The data were arranged into 10 age groups, each of one-year duration starting from 6.00 to 6.99 years up to 15.00 to 15.99 years. Informed written consent was obtained from the children's parents and individual school principals. The first study done during the year 1996-1997 constituted the group-I while that conducted during the year 2003-2004 was designated as group-II.

Results

There were 677 girls in group-I (1996-1997) and 727 girls in group-II (2003-2004) between the age 6 and 15 years (Table 1). In girls of group-I, the percentage prevalence of overweight and obesity was 10.49% and 4.87% whereas in girls of group-II was 13.48% and 6.33%, respectively. In girls of group-I, overweight prevalence varied between 4.89% and 13.23% whereas in girls of group-II the prevalence range has been from 6.00% to 17.77%. On the other hand, obesity in girls of group-I ranged between 3.23% to 6.12%

and in girls of group-II, the range of obesity has been from 4.00% to 9.37%.

Table 1. Number and percentage prevalence of overweight and obesity in girls of group-I (1996-1997) and group-II (2003-2004)

Age groups (years)	Total number of subjects		%age prevalence of overweight		Change in prevalence	%age prevalence of obesity		Change in prevalence
	Group		Group			Group		
	I	II	I	II		I	II	
6	80	95	8.75 (7)	11.57 (11)	2.82	5.00 (4)	7.36 (7)	2.36
7	60	80	10.00 (6)	12.50 (10)	2.50	5.00 (3)	6.25 (5)	1.25
8	75	88	10.66 (8)	13.63 (12)	2.97	4.70 (4)	5.68 (6)	0.98
9	70	75	11.43 (8)	14.66 (11)	3.23	4.34 (4)	5.33 (4)	0.99
10	84	82	11.90 (10)	15.85 (13)	3.95	4.00 (3)	4.87 (4)	0.87
11	71	90	12.68 (9)	17.77 (18)	5.09	5.63 (4)	6.66 (6)	1.03
12	68	64	13.23 (9)	15.62 (10)	2.39	5.88 (4)	9.37 (6)	3.49
13	41	57	12.25 (6)	14.03 (8)	1.78	6.12 (3)	7.01 (4)	0.89
14	58	46	8.62 (5)	8.69 (4)	0.07	3.45 (2)	4.34 (2)	0.89
15	62	50	4.84 (3)	6.00 (3)	1.16	3.23 (2)	4.00 (2)	0.77
Total	677	727	10.49 (71)	13.48 (98)	2.99	4.87 (33)	6.33 (46)	1.46

Age-specific changes in the percentage prevalence of overweight and obesity were also apparent from Table 1. This table shows that there was an increase in the prevalence of overweight with age in both the groups i.e. up to 12 years in girls of group-I and up to 11 years in girls of group-II. Afterwards there was a trend of decrease in the percentage prevalence of overweight in both the groups. However, the prevalence of obesity decreases with age i.e. up to 10 years in both the groups. Then again there was an increase in the percentage prevalence of obesity up to 13 years in girls of group-I and up to 12 years in girls of group-II. However, after that there was again a trend of decrease up to 15 years.

Discussion

In girls aged 6-15 years, in Punjab, a stale in rapid epidemiological transition, the prevalence of overweight and obesity has increased by 2.99% and 1.45%, respectively, in seven-years period. The overall prevalence of overweight and obesity was higher among girls of group-II than the girls of group-I. It appears that overall improvement in the standard of living of the Punjabi people for the last one decade may be held as one of the primary factors responsible for the positive trends of obesity in school girls of Punjab. But the difference in the prevalence of overweight/obesity between the two groups was statistically non-significant in total sample and among all age groups, or in other words the present results do not show a significant change in the percentage prevalence of overweight and obesity in a 7-year time span. This was perhaps due to smallness of the sample size or due to short time span between the two surveys.

The changes in the percentage prevalence with time have been reported from various countries. In most countries where trends data were available, childhood obesity has increased with time *(Lobstein et al., 2004).* In some countries, this has been very rapid while, in other countries, it has occurred at a much slower pace. For example, among Australian children and adolescents aged 2-18 years, the prevalence of overweight and obesity nearly doubled in 10 years (1985-1995) from 12% to over 20% *(Magarey et al., 2001).* In China, among urban boys, the prevalence of overweight indicates an increase from 9% to 10% between 1991 and 1993 *(Moreno et al., 2001).* In Japan, between 1974 and 1995, the prevalence of overweight, including obesity, doubled rising from 5.5% to 10.8%. But in some countries, like China *(Wang et al., 2002),* Czech Republic *(Bláha and Vignerova, 2002)* and Hongkong *(Chu et al., 2001),* the prevalence has increased in the 1990's, although the increase was not as dramatic as in the developed countries. *Subramanyam et al. (2003)* and *Saha et al. (2004)* studied Indian girls (Chennai) and boys (Bengalee), respectively, and also observed no significant change in the percentage prevalence of overweight in a 17-year time span.

The study also shows a steady increase in the prevalence of overweight with age. The range of age-specific prevalence of overweight/obesity has increased in the later survey in comparison to the baseline survey. Maximum change in percentage prevalence of overweight and obesity was observed at age 11 and 12 years, respectively. This increase at age group 11 and 12 might be associated with the increase in adipose tissue and body fat during the pubertal growth spurt.

Conclusions

This is perhaps the first study on school girls of affluent families of Punjab that reports the change in prevalence of overweight and obesity with time. This study has revealed that the overall prevalence of overweight and obesity has increased by 2.99% and 1.45%, respectively, in seven-year time span. However, this difference in the prevalence of this problem in two surveys was not statistically significant. This study also shows a steady increase in the prevalence of overweight with age. Maximum change in the percentage prevalence of overweight and obesity was observed at age 11 and 12 years that might be associated with the pubertal growth spurt**.**

References

Bláha, P. and Vignerova, J. 2002. Investigation of the growth of Czech children and adolescents. Prague: National Institute of Public Health.

Bundred, P., Kitchiner, D. and Buchan, I. 2001. Prevalence of overweight and obese children between 1989 and 1998; population based series of cross-sectional studies. *British Medical Journal,* **10**: 326-328.

Chu, N.F. 2001. Prevalence and trends of obesity among school children in Taiwan — The Taipei children heart study. *International Journal of Obesity Related Metabolic Disorders,* **25**: 170-176.

Cole, J.J., Bellizzi, M.C., Flegal, K.M. and Dietz, W.H. 2000. Establishing a standard definition for child overweight and obesity worldwide. International survey. *British Medical Journal,* **320**: 1240-1243.

Gill, S.S. 2004. Socio-economic transition and Scheduled Castes in Punjab. In: *Dalits in Regional Context.* Ed: Puri, H.L. Jaipur: Rawat Publications, pp. 225-257.

Kotani, K., Nishida, M., Yamashita, S., Funahashi, T., Fujioka, S., Tokunaga, K., Ishikawa, K., Tarui, S. and Matsuzawa, Y. 1997. Two decades of annual medical examination in Japanese obese children: Do obese children grow into obese adults. *International Journal of Obesity-Related Metabolic Disorders,* **19**: 423-430.

Kromeyer-Hauschild, K., Zellner, K., Jaeger, U. and Hoyer, H. 1999. Prevalence of overweight and obesity among school children in Jena (Germany). *International Journal of Obesity,* **23**: 1143-1150.

Lobstein, T., Baur, L. and Uauy, R. 2004. Obesity in children and young people: a crisis in public health. Report to the WHO. London: IASO International Obesity Task Force.

Magarey, A., Daniels, L. and Boulton, T. 2001. Prevalence of overweight and obesity in Australian children and adolescents: reassessment of 1985 and 1995 data against new standard international definitions. *Medical Journal of Australia,* **174**: 561-564.

Moreno, L.A., Fleta, I., Sarria, A., Rodriguez, G. and Bueno, M. 2001. Secular increase in body fat percentage in male children of Zaragoza, Spain, 1980-1985. *Preventive Medicine,* **33**: 357-363.

Mo-Suwan, L., Tongkumchum, P. and Puetpaiboon, A. 1998. Determinants of overweight tracking from childhood to adolescence: a 5-year follow-up study based on the Boyd orr cohort. *American Journal of Clinical Nutrition,* **67**: 1111-1118.

Ogden, C.L., Flegal, K.M., Carroll, M.D. and Johnson, C.L. 2002. Prevalence and trendsw in overweight among US children and adolescents, 1999-2000. *Journal of American Medical Association,* **56**: 200-204.

PSCST (Punjab State Council of Science and Technology) 2005. State of environment, Punjab. Report of the Punjab State Council for Science and Technology, Chandigarh.

Saha, R., Sinha, M. and Dasgupta, R. 2004. Nutritional status and level of subcutaneous fatness among the Bengalee boys 7-16 years: secular trends over two decades. In: *Proceedings of the National Seminar on Recent Advances in Human Biology.* Ed: Daschaudhuri, A.B. Kolkata, Calcutta University Press, pp. 27-45.

Subramanyam, V., Jayashree, R. and Raff, M. 2003. Prevalence of overweight in affluent adolescent girls in Chennai in 1981 and 1998. *Indian Pediatrics,* **40**: 332-338.

Tremblay, M.S., Katzmarzyk, P.T. and Williams, J.D. 2002. Temporal trends in overweight and obesity in Canada, 1981-1996. *International Journal of Obesity,* **26**: 538-543.

Wang, Y., Monteiro, C. and Popkin, B.M. 2002. Trend of obesity in older children and adolescents in the United States, Brazil, China and Russia. *American Journal of Clinical Nutrition,* **75**: 971-977.

Weiner, J.S. and Lourie, J.A. (1969). Human Biology: A Guide to Field Methods. Oxford: Blackwell Scientific Publications.

Instructions to Contributors

Journal of Exercise Science and Physiotherapy (JESP) is a scientific peer reviewed journal, publishing research studies and review articles in the field of sports injuries, physiotherapy, exercise physiology, sports rehabilitation, diseases and exercise, sports psychology, nutrition, physical education, sports biomechanics, kinesiology and sports education.

JESP is published annually in June but is planned to be published biannually in the near future. Articles written in English should be sent to the editor of JESP. The research paper for publication in the journal could be sent not only in typed manuscript form but also through the Internet using email attachment. Keeping in view the postal delays, authors, therefore, are encouraged to submit their research material/articles as email directly to ***satishsk1@rediffmail.com*** or ***editor@efha-in.org***

Mission

JESP aims to present easy access to the scientific knowledge for health & sport conscious individuals. The purpose is to minimise the problems like the delays in publishing process of the articles by drawing advantage from electronic medium.

Instructions to Authors

The articles may be submitted to the Editor, JESP (*email: satishsk1@rediffmail.com OR editor@efha-in.org*). Manuscripts are considered if they are submitted only to JESP and therefore should not be under consideration for publication elsewhere, either in part or in whole. Authors are responsible for the scientific context and legal aspects of the articles. Editors may make necessary changes to articles in accordance with "Instructions to Authors". Normally the complete research paper should not exceed 15 typed pages including tables and figures; however under exceptional circumstances this limit can be relaxed. There is no page and reference limitation for the review articles. All files related to manuscripts should be submitted electronically. Internet transmission and e-mail attachments are preferred; CD-ROM is acceptable for large files. Text files should be in Microsoft Word 6.O and later versions. Each figure, table, photograph or other image should be submitted electronically. The manuscripts should be submitted in Times New Roman font, 12-point type, double-spaced with 3 cm margins on all sides. The reference style used by the Journal is the Harvard System of referencing.

Format for Research Article

Include the following sections in research articles without page space:

TITLE: Capital letters.

AUTHORS: Surname followed by initials and institution(s) where the study was conducted.

ABSTRACT Include an abstract of not more than 150 words that includes objectives, methods, results and conclusions.

KEY WORDS*:* To assist in indexing the journal, list up to 6 key words (not from title), which your article could be indexed.

INTRODUCTION

METHODS

RESULTS

DISCUSSION

CONCLUSION

ACKNOWLEDGMENTS: Provide information sufficient to identify sources of support, technical assistance, and intellectual contributions not associated with authorship.

REFERENCES: Each citation in the text must be noted by surname and year in parentheses and must appear in the reference section as an alphabetic order. Example for citation in the text; a) for single author (Gür, 1999), b) for two authors (Gür and Akova, 2001), c) more than two authors (Gür et al., 2000).

Journal Article:

Akova, B., Sürmen-Gür, E., Gür, H., Dirican, M., Sarandöl, E. and Kücükoglu, S. 2001. Exercise-induced oxidative stress and muscular performance in healthy women: role of vitamin E supplementation and endogenous estradiol. *European Journal of Applied Physiology,* **84:** 141-147.

Journal Article, Article not in English:

Seker-Aygül, Z., Akova, B. and Gür, H. 2001. The relationship of stress and stress management factors with injury in soccer players. *Turkish Journal of Sports Medicine,* **36:** 71-80. (In Turkish: English abstract).

Journal Article in press:

Gür, H., Cakin, N., Akova, B., Okay, E. and Kücükoglu, S 2002. Concentric versus combined concentric- eccentric isokinetic training: Effects on functional capacity and symptoms in patients with osteoarthrosis of the knee. *Archives of Physical Medicine and Rehabilitation,* in press.

Journal Article in electronic format:

Weigand, D.A., Carr, S., Petherick, C. and Taylor, A. 2001. Motivational climate in Sport and Physical Education: The role of significant others. ***European Journal of Sports Science (serial online)*** **1(4)**, (13 screens/inclusive page), October. Available from URL: http://www.humankinetics.com/ejss

Book:

Guyton, A.C. and Hall, J.E. 1996. *Textbook of medical physiology.* 9th edition. W. B. Saunders Company, London.

Chapter in edited book:

Wilson, C.H. 1984. Exercise for arthritis. In: *Therapeutic exercise.* Ed: Basmajian, J.V. 4 th edition. Baltimore: Williams and Wilkins. 529-545.

Thesis:

Özyener, F. 2000. *Effects of work intensity on dynamics of pulmonary gas exchange during exercise in humans.* Doctoral thesis, University of London, London. 79.

Thesis not in English:

Özer, Ö. 2001. *The effect of muscle exercise to oxygen kinetics in chronic smoker*s. Doctoral thesis, University of Uludag, Bursa. 1-54. (In Turkish: English abstract).

LEGENDS

AUTHOR BIOGRAPHY: Please include a brief biography, approximately 50 words per author, for each author including (1) academic title/degrees, (2) institution affiliation, (3) research focus, (4) post and e-mail addresses.

TABLES, FIGURES, etc.: The location within the article where e.g. figures and tables appear should be indicated in the text. These materials (e.g. table, figure) should be submitted separately from the text document. Each item should be produced in Microsoft Office (Word, Excel, or PowerPoint), GIF or JPEG format. Submit each item separately and number sequentially as (main author) Figure 1.jpg, (main author) Figure2.jpg, and so on, for example, GurFigure1.jpg and GurTable1.doc.

FORMAT FOR REVIEW ARTICLE

Include the following sections in research articles without page space:

TITLE: Capital letters.

AUTHORS: Surname followed by initials and institution(s) where the study was conducted.

ABSTRACT Include an abstract of not more than 300 words.

KEY WORDS: To assist in indexing the journal, list up to 6 key words (not from title), which your article could be indexed

MAIN TEXT

CONCLUSION

ACKNOWLEDGMENT

REFERENCES*:* Each citation in the text must be noted by surname and year in parentheses and must appear in the reference section as an alphabetic order. Example for citation in the text; a) for single author (Gür, 1999), b) for two authors (Gür and Akova, 2001), c) more than two authors (Gür et al., 2000). See the reference section of research article for detail.

LEGENDS

AUTHOR BIOGRAPHY: For detail see the author biography section of research article.

TABLES, FIGURES, etc.: For details see the tables, figures, section of research article.

REVIEW AND PUBLISHING POLICY

Upon receipt of a manuscript the editor will notify the main author that the submission has been received. The manuscript will undergo a blinded review process. Under this process the editor will forward (electronically) the manuscript to two independent reviewers. Normally the review process will take approximately 4 weeks. After the review process has been completed the main author will be notified via E-mail either of acceptance, revision or rejection of the manuscript. If the main author has not been informed of the results of the review process after 8 weeks from the date of confirmation of receipt of the manuscript (by the editor), the author should notify the editor-in-chief directly. If revision was recommended, this should be completed and returned to the editor within 4 weeks; failure to return the revised manuscript within the allotted time span will lead to rejection of the manuscript. When a manuscript has been accepted for publication it will be forwarded to the editor-in-chief for final approval. The editor-in-chief will work with the main author to make necessary revisions in order for the manuscript to appear in the Journal of Exercise Science and Physiotherapy. The final proof of the manuscript will be sent to the main author as an E-mail attachment. If the main author requires any minor changes to the finished work, these should be submitted electronically to the editor-in-chief within one week. Manuscript accepted in the first half of the year will be published not later than the second half of the year.

Checklist for Authors

- Double-space manuscript text and use 3cm margins on all sides, and Times New Roman, 12-point type, English and SI units.
- Include with text a title, abstract, key words, figure and table lists, figure and table legends.
- Submit all materials electronically.
- Include complete author names, addresses, e-mail, phone and fax numbers.
- Include a short (~50 words) author biography for each author.

Editor-in-Chief,
JESP