An Anthropological Approach to the Evaluation of Children Exposed to Pesticides in Mexico

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Abstract

Major difficulties exist in evaluating the effects of pesticide exposure on children. One reason is that, within the United States, the majority of children tend to differ in physical, environmental, cultural and social experiences that influence growth and development. Genetic backgrounds differ, creating morphologic variation within and between groups of individuals. Families move into and out of areas, complicating issues regarding historical and present exposures to contaminants both for types and degree of bodily intake. Taken a step further, variations in parental exposure complicates the issues regarding the effects of contaminants on genetic aberrations in sperm and ova, plus the amount of maternal transference during preganacy and lactation. The multitudes of diverse social factors, including socioeconomic status, the multiple facets of traditional customs and/or acculturaltion, and dietary patterns add additional drawbacks for both matching the study group with a similar, but less pesticide-exposed control group and the interpretation of findings regarding the two groups. Frequently, these factors are used to question, criticize, and even discount, research findings involving the impact of pesticides on a child's growth and development.

Research on children has generally concentrated on the interaction between a single contaminant, usually passed from mother to child in-utero and through lactation, with the child's growth and development. Studies performed in this manner indicate that in-utero and lactational exposure to polychlorinated biphenyls (PCBs) impairs mental and motor abilities, including a lowering of intelligence {Jacobson, 1996 #5}. Multiple birth defects also have been associated with maternal exposure to chlorphyrifos (Dursban) {Sherman, 1995 #12}. Unfortunately, such studies usually arise when pregnant women are accidentally exposured to contamination. Although findings should be considered valid, a similar accident, to provide additional strength to the research through repetition, is unlikely to occur. Also, we readily accept the paradigm that a single contaminant, or class of contaminants, creates its own unique syndrome of human aberrations. One danger is that this resulting “syndrome” may be preselected with limited end-points that reflect the researcher’s area of expertise. In addition, it is easy to assume that the child has experienced no additional deleterious exposures, especially in relationship to longitudinal studies involving the initial study cohort.

Other studies take an analytical epidemiological approach, investigating health changes over a period of time. This avoids single agent paradigm, instead substituting “environmental change” as the causitive factor. Assorted population changes, ranging from a decline in the proportion of males being born in Denmark to a temporal rise in general cancer rates amoung younger children {Adami, 1994 #21} have been investigated with this aproach. Other studies indicate apparent increases in cryptorchidism and testicular cancer over time, in which unknown environmental change has occurred {Toppari, 1996 #25}. Contamination is a suspected major environmental contributor but can not be not definitively identified {Sharpe, 1993 #26}. Also, each population under study also incorperates a host of varied biological, social and technological factors influencing the environment.

AN EXPANDED APPROACH FOR EVALUATING CHILDREN EXPOSED TO MULTIPLE PESTICIDES

Much of our knowledge about the physiological mechanisms of pesticides that lead to detrimental effects, is the result of wildlife and laboratory studies. These studies have led to the hypothesis that pesticide- or industrial contaminant-related hormonal disruptions can modify human physiologic functioning {McLachlan, 1993 #28; Colborn, 1993 #24}. Exposure to endocrine disrupting contaminants may occur in utero and result in modification of normal anatomical development. Such modification may be observable immediately at birth or expressed later in life {Guillette, 1995 #29}. Additional exposure can continue after birth.

Although blood levels of pesticides indicate a presence in the body, there is no readily available means to identify when an individual was first exposed to a single compound or mixure of chemicals, nor the amounts of exposure occurring during critical windows of embryonic or neonatal development. Additionally, it is difficult to establish reliable exposure patterns for most individuals over time. Therefore, it is important to select a study population in which all mothers and their children experience relative equality in their contact with pesticides. Only then, can it be assumed that the children under study have a similar probabilitiy of timing of exposure, levels of exposure and mixtures of pesticides -- both in utero and following birth. In turn, the control population must meet the requirement of equal but minimal exposures. In today's world, complete avoidance of exposure is an impossibility.

The multiple, assorted variables that confound pesticide studies must also be addressed. Delemarre-van de Wall {Delemarre-van de Waal, 1993 #10} delineates a host of environmental factors influencing growth and development, including diet. Diet is frequently implicated for birth defects, mental deficiencies and growth retardation, all of which are associated with pesticide exposure {Colborn, 1992 #23}. The two research groups must have a very comparable diet in all aspects. In developing countries, where tradition remain strong, and diets retain symbolic culture values, diet is fairly uniform regardless of income {Jerome, 1980 #14}. American diets tend to be influenced more by family preferences and finances than by historic cultural practices and food item availability, thus varying among households {Digest, 1994 #8}. Dietary history may be used to decrease the variable, but dietary recall, including the foods eaten even in the past week, is notoriously inaccurate {Bernard, 1994 #7}. As well as families having varied diets, differences among ethnic groups in body metabolism and organ function are documented {Polednak, 1989 #6}. Differing physiological response to pesticides in relationship to ethnicity is unknown, and remains to be investigated. Therefore, a similar genetic make-up should be shared among and between members of the study and reference groups. Finally, the role of socio-cultural practices, including stress, parenting practices and standards of living are known to influence learning and behavior {Delemarre-van de Waal, 1993 #10}. As neurological dysfunction had been related to contaminant exposure, the socio-cultural atmosphere, including standards of behavior, of all participants should be as similar as possible. Is it possible to fulfill these requirements? The answer is probably no if we insist on limiting ourselves to research at convenient sites in the developed nations. However, the mentioned requirements can be met elsewhere, where families remain in place and superimpose their traditional practices and lifestyles on daily life even with advances in modernization.

A second aspect in developing an ideal study is to admit that we honestly do no know everything that we should be investigating. Dysfunction in the reproductive, immune, neurological and skeletal systems is implied, as demonstrated in wildlife exposed to pesticides (see {Colborn, 1993 #24; Guillette, 1994 #33; Crain, 1996 #35}. Similar dysfunction is noted with human subpopulations following massive "accidental" exposure (for examples, see {Jacobson, 1990 #31; Chen, 1992 #38; Guo, 1993 #36; Jacobson, 1996 #5}. These epidemiological and case studies provide indications that thought and behavioral processes are altered and their long term ramifications to the individual, their family and society need to be considered. Are the same delitarious effects found in the residents of areas where pesticides are used according to accepted agricultural practice? We must begin to consider the broader picture. How does exposure to contaminants influence the total health and daily functioning of a child. Finally, as we enter the time frame of multigenerational exposure to pesticides, is the total health and the related normal activities of the population at risk? All of this must be combined in order to provide a multidimensional approach for a complex, multifaceted problem.

A RAPID ASSESSMENT TO DIRECT PESTICIDE RESEARCH

The purpose of this study was to develop a rapid assessment tool for the evaluation of children living in a contaminated environment. The aim was twofold: to determine if exposure put children at risk in terms of normal growth and development and to identify areas where additional research is needed. Instead of a specific disease or deficit-centered approach, an attempt was made to evaluate the child holistically. Specifically, this included multiple aspects of body growth and the functional ability for normal childhood activities.

MATERIALS AND METHODS

The Study Population: A search was conducted to find a population which minimized the variables that can affect the outcome of a pesticide study on child growth and development (see above). The population had to meet the requirements of similar genetic origin, exposure to environmental factors, plus related cultural and social values and behaviors, all of which are necessary for comparable study and reference groups. A site visit prior to selection confirmed that the two study groups were as identical as possible, differing apparently only in the degree of pesticide exposure.

The Yaqui are an indigenous group living and working in the environs of the Yaqui Valley of Sonora, Mexico. Traditionally, the Yaqui Valley has been an agricultural region, with numeros residents embracing pesticides and chemical fertilizers in the late 1940s. Concurrently, farm operations become mechanized, and irrigation and transport systems were established. The result was a "Green Revolution" with farming becoming big business {Perkins, 1990 #41}. Yaqui families from the nearby mountains moved into the valley for employment, while some valley residents moved into the mountains in protest of the change. Others remained in place {Hewitt de Alcantara, 1976 #2}.

Today, the Yaqui of both regions accept the technological advances provided by modernization but tenaciously resist changes in their social and cultural identity {II, 1995 #4; Jacobo, 1995 #3}. Relatives separated by the "Green Revolution", report visiting between areas, but there is no household relocation between the high and low lands. Culturally, Yaqui marry Yaqui. Observations during a site-determination visit indicate that family structure remains strong, with aging parents living with an adult child and grandchildren. Educational and health services, introduced in the 1950s, are well accepted and are similar in both areas {Informationcan, 1995 #19}. Children are usually breast fed, then weaned onto household foods. Diet continues to be based on traditional patterns involving fresh potatoes, corn, chiles, beans and tortillas with occasional meat {II, 1995 #4}. These foods, produced locally, are almost always purchased. Processed foods were not observed in households. The historical high degree of poverty has continued to exist in both areas {Hewitt de Alcantara, 1976 #2; Informationcan, 1995 #19}. Thus, there are two groups sharing genetic, cultural and social traits but separated by location and type of employment -- ranching in the highlands versus agriculture in the lowlands.

Pesticide use is high in the lowland agricultural communities, with aerial spraying, mechanical and hand application {Garcia B., 1991 #15}. Farmers report that applications may number up to 45 times before a crop is harvested. Compounds include multiple organophosphate and organoclorine mixtures and pyrethroids. A history of thirty three different compounds, from the period of 1959 to 1990, exists for the control of cotton pests alone. This list includes DDT, Deildrin, Endosulfan, Endrin, Heptachlor, and Parathion methyl, to name but a few {Covarrubias, 1991 #1}. A recently as 1986, 163 different pesticide formulation were sold in southern region of the state of Sonora, Mexico, with banned substances such as lindane and endrin available {Camara, 1992 #40}. Use is increasingly wide spread and continues throughout the year, with little governmental control {Garcia B., 1991 #15}. Contamination of the resident human population is documented, with milk concentrations of lindane, heptachlor, BHC, aldrin and endrin all above FAO limits after one month of lactation (see Table 1) {Garcia B., 1991 #15}. An initial site visit revealed that household bug sprays are applied, usually daily, throughout the year in the lowland homes. In contrast, the foothill residents, maintain traditional intercropping for pest control in gardens and swatting of bugs in the home. These people cite their only exposure to pesticide is with the annual spraying for the control of malaria.

Sampling Proceedure: The sampling methods, research design, and test instuments, were examined and approved by the Gobierno del Estado de Sonora, Secretaria de Salud Publica (Secretary of Public Health, Sonora, Mexico). All children selected for study were between the ages of 48 months and 62 months (four and five year olds). The 33 children exposed to elevated levels of pesticides, hereafter referred to as valley children, came from three towns and corresponding rural area within the Yaqui Valley. The towns were Quetchehueca (N=10), Bacum (N=12) and Pueblo Yaqui (N=11), all 10 to 30 feet above sea level. The criteria for town selection included a historical, continual use of pesticide since 1950 as based on data from Hewitt de Alcanara {Hewitt de Alcantara, 1976 #2}, and historical Yaqui Indian settlement. A previous study, examining the village of Pueblo Yaqui, observed elevated levels of a number of pesticides or metabolites in 100% of the cord blood and mother's milk samples (see Table 1). Tesopaco, located in the foothills of the mountains (400 meters), is also a Yaqui settlement and was used as the source of reference children (N=17). Both towns are similar in infrastructure and the interfacing of tradition with modernization {Informationcan, 1995 #19}.

Homes were approached along streets on the north, south, east and west and center of each town and in outlying areas. Children were found by asking if the household contained 4 or 5 year olds. Criteria for child selection included age, Yaqui heritage and a history of residency for both parents and the grandparents. Participation involved a 30 minute interview with the mother concurrent with a 30 minute evaluation of the child. All interviews occurred in the home. Approximately 90% percent of families with eligible children agreed to participate.

<u>The Research Instruments</u>: The research instruments were based on the hypothesis that endocrine disruptors could influence all body systems influenced by the endocrine system. Physical growth patterns were considered in addition to physiological and mental functioning. A major end-point was to determine if a rapid assessment could identify specific areas for further investigation.

The questionaire for mothers centered on her pregnancies, types and frequency of family illness, including the child under study, diet, general life style practices and perceived exposure to pesticides. Along with obtaining an obstretrical history, this interview served to validate similarities in environmental and genetic variables affecting growth and development. Each interview was contucted by one of the two Spanish speaking researchers.

Evaluation of the child was also conducted in Spanish, by one of two Mexican graduate students. The format was based on a play approach to evaluate physical stamina, coordination and mental processes . Each evaluation was introduced with" Hello, my name is ___. I will ask a few questions and we will play some games. When I am finished I will give you a red balloon. (As some of the children did not know the colors by name, an object was pointed out as being red) Do you like balloons?" The testing then began with exercises interpreted by the child as normal play. Hesitancy was eliminated or decreased when siblings participated in the initial physical exercises, although only the child under study was actually evaluated for performance.

The first activity was designed to evaluate gross motor coordination. The child was to catch a 30.5 cm diameter ball at 1, 2, and 3 meters. This exercise was repeated with a 6.5 cm tennis ball at the same distances. The sense of balance was tested by asking the child to stand on one foot as long as possible, first with eyes open and then closed. Stamina was regarded as the time a child could jumping in place before quiting from shortness of breath. Quieter activities followed. The child was asked to draw a person to investigate perception abilities. (Scoring was based on one point each for head, body, arms, legs, and facial features placed in correct spatial orientation: total possible score = 5). Number repetition indicated short term memory abilities. Fine eye-hand and motor coordination was tested by dropping raisins in a bottle cap from a distance of 15 cm. The named exercises took about thirty minutes to complete. The child was then asked to recall what they were to receive, asking the color if it was omitted. All were given the balloon, regardless if they remembered the object or its color.

The session ended by obtaining physical body measurements. Physical growth measurements included head circumference, head breath and length, chest circumference, along with height and weight. Long bone growth was appproximated by subtracting sitting height from standing height.

Statistical Analysis: Data were analyzed using various analyses based on data type. Morphometric data on children from the reference and exposed populations were compared for significance by ANOVA, followed by Scheffe's F tests. Significance was set at $P < 0.05$. Stamina, where time was the measurement, and activities where the calculation of success was based on real number units (number of raisins dropped in a cap) were examined in a similar manner. Where scores consisted of nonparametric data, such as scores on stick figure drawings, data were anaylzed for significance using Mann-Whitney U tests. Comparisons of frequency data were analyzed using Chi square. All analyses were performed on a computer using commercial statistical software (Stat-view II, Abacus Concepts, Inc., Berkeley, CA, 1988).

RESULTS

MOTHERS: No significant differences were found in regards to the number of pregnancies and number of living children between the valley and foothill mothers. Although more valley mothers experienced multiple problems associated with pregnancies, there was no statistical difference between the groups in spontaneous abortion rates, prematurity, neonatal death and birth defects (Table 2.). The children's initial food intake of breast milk, followed with regular diet was also not significantly different. Although not directly measured, mothers did believe the valley children ate more fresh vegetables and fruit because of cost and availability.

CHILDREN: The foothill and valley children were similar in terms of ages (60.7 months and 58.7 months, respectively). No statistical differences were found in regards to height, weight, chest or head circumference, head breath and length (Table 3). The subtraction of sitting height from standing height, which can be thought of as reflective of long leg bone growth, showed no significant difference (Table 3).

Although apparently similiar in physical growth, a comparison of functional abilitities showed differences among the study groups. Generalized physical endurance, measured by having the child jump in place for as long as possible, demonstrated foothill children had more stamina ($F = 4.1$; d.f. = 1, 43; $P=.05$). Jumping was considered a game, with the child trying to jump longer than the interviewer. The longest a valley child jumped was 110 seconds, compared to 336 seconds for a foothill child (mean ± 1 SE: valley = 52.2 ± 5.4; foothill = 86.9 ± 22.2). An attempt to evaluate the sense of balance by having the child stand on one foot with eyes open, and then stand one footed with eyes closed, failed. Urban Mexican children were able to perform these activities without difficulty during pretesting. Yaqui children, however, are taught that standing on one foot causes a person to fall and injure themselves. Many refused to try at all, and those who did, insisted on holding on to a wall or person.

Valley children had a significant decrease in their ability to catch the large ball ($P=0.034$) only at the distance of three meters. This inability to catch a ball increased as the ball size decreased. Foothill children outperformed the valley children in catching the tennis ball at 1, 2, and 3 meters ($P=0.05$, 0.01 and 0.003, respectively). A stronger difference was found between the two groups in regards to fine eye-hand coordination with foothill children better able to drop a raisin into a bottle cap ($F = 7.3$; d.f. = 1, 44; $P=0.009$). Interestingly, whereas the location of the child's home -- valley versus foothills -- had a significant effect on these measurements, the child's sex had no relationship to any of these outcomes.

Children in both locations performed equally well in the immediate recall of numbers, up to four digits. The valley children had more difficulty grasping the concept of repeating the numbers, although marked differences were found between towns. Children with such difficulty were encouraged to repeat one, then two, vowel sounds made by the interviewer. The movement into repeating numbers became more comprehensible. Marked differences in recall was seen with 30 minute memory ($X^2 = 14.3$; $P = 0.027$). In recalling their gift, 59% of the 17 foothill children remembered both the object and its color, with all but one of the remaining children remembering just the balloon. In contrast, 27% of the 33 valley children recalled the balloon and color, 55% recalled balloon only and 18% could recall neither the object or color.

One of the most striking differences between the exposed and unexposed children was in the ability to draw a person ($U = 59.0$; $P < 0.0001$). The valley children averaged 1.6 body parts to a drawing compared to the foothill children's 4.4 body parts. Valley females performed better than males, but still remained significantly below that of foothill children, regardless of their sex (Fig. 1). In addition, it was noticed that foothill children moved the paper about for better positioning in drawing a specific body part and compared their drawing to an actual person to make necessary corrections. Valley children would look at an individual but continue to draw meaningless circles. Representitive drawings are presented in Figure 2.

DISCUSSION

A cursory look at the foothill and valley towns could easily lead one to the conclusion that no discernible differences due to the environment were present in the Yaqui children. Heights varied between the tall and short for age, weights ranged from the ultra-thin to the obese. The lack of physical differences in growth patterns was borne out with anthropometric measurements. Anthropological participant observation {Bernard, 1994 #7} indicated that the type of play was different in the two areas. Group play predominated in the mountains, with pretend parties for dolls and street games, compared to individual play in the valley. Many lowland children sat idly or roamed aimlessly, and were observed hitting their siblings when passing by, and becoming easily upset or angry with a minor corrective comment by a parent. These behaviors were not noted in the highlands. Such clues indicated that additional aspects of development may be affected by the environment, which include chronic exposure to contamination.

The Rapid Assessment for Growth and Development did show that psychological and physiological differences in functional abilities exist between the highland and lowland children, ages four and five years. The jumping assessment, reflecting a decrease in stamina for lowland children, could be an indicator of physiological modifier for the intensity of play. Ball playing or other activities involving gross or fine eye-hand coordination become less exciting or fulfilling when the child can not perform the required skills. Of increased concern are the differences found with activities involving mental/neurological functioning. The inability to remember a meaningful statement after thirty minutes has implications for school performance and performance in social activity. The drawing of a person, often used as a non-verbal screening measure of cognitive ability, could also be a indication of breakdown between visual sensory input and neuromuscular output as found with brain dysfuntion {Kamphaus, 1993 #17}. The decreases in eye-hand coordination, as with catching the ball and dropping raisins into a circumscribed area, could also correlate with this thought of brain dysfunction. This conceptbreaksown between sensory signals and neuromuscular output certainly deserves greater attention in future research.

The development of this rapid field assessment tool points out the need to recognize cultural difference. When working within developing countries, one must be aware of possible differences between the home and host society. We had noticed during a previous visit to the Yaqui Valley that many children played with balls, making us comfortable with the assumption that children had experience with catching. In contrast, tests for knowledge acquisition were eliminated as the assumption could not be made that preschool children were taught similarly to American children. We also noted that many children in both areas did not know the names of colors. Therefore, an article the color of the promised balloon was always pointed out to the child. The unsuccessful testing of balance demonstrates the need to consider group difference within a country and between urban and rural settings. An alternative test for balance could be walking on a two by four plank.

Secondly, we must be aware of possible differences within a circumscribed group of people. For example, during the research period we raised questions about the marked differences in the ability of the two groups of children to draw a person. Valley mothers were questioned about the child's access to paper and pencil. Access was reported to similar with the two groups. Some lowland mothers brought out own their frustration in trying to teach their child how to draw. In addition, three valley children drew pictures composed of boxes, arches and triangles, claiming these pictures were people. The uniqueness of these pictures lead us to inquire if these pictures were a Yaqui representation or symbol. Parents denied this was so. As all children were preschoolers without formal education, any possible differences in the individual school systems were removed as a confonding factor.

The situation of testing in the field deserves consideration. The usual format for evaluating mental abilities involves a large group situation. In contrast, evaluation of physical abilities usually occurs in private. Neither held true in this investigation, nor can privacy be anticipated with most field work in develping countries. In this investigation, siblings and sometimes friends performed the research activities as extended family watched the evaluative process. This promoted good-will, as families saw the children having fun. The sense of being a "test-subject" was removed from the child with participation of other children in the initial activities. Overall, this increased the child's willingness to participate. (Astute observation identified the three children who preferred to perform some of the activities in private.) It was also felt that the participation of others stimulated the children to perform to the best of their ability. The quieter activities of dropping raisins and memory challenges were performed without others participating, but by this time the child felt secure with the interviewer.

CONCLUSIONS

Many of the genenic and cultural variables influencing the outcome of contaminate exposure on children’s growth and development can be overcome through purposeful selection of the study population. Large numbers of children are thus available for evaluation, although circumstanses limited participants in this initial study. The limited numbers of participants did not defeat the pupuose of the study: to determine if a rapid assessment would identify growth and developmental differences between children differing mainly in the degree of exposure to chemicals in the environment. The amount and types of body contamination are unknown, but the elimination of other suspected causal factors "...implies that that there must be a one-to-one relationship between a factor and its effects" {Fox, 1991 #9}.

The use of an interdiciplinary functional assessment, measuring the abilities to perform normal activities for four and five year olds, identified new directions for future research (i.e., stanima, long-term memory) plus the need for in-depth study of other areas, particularly the role of pesticides on neuromuscular functioning and throught processes. As an initial study, it is recognized the continued refinements are necessary, such tests for balance and investigation into other possible type of environmental contaminants. Other dimensions need to be added to the rapid assessment, particularly in the areas of disease and organ dysfuntion. Equally important is the potential use of rapid assessment to provide a foundation for the building of a longitudinal study to determinine the continuing and delayed impacts of a lifetime of chemical exposure on body fuctioning during puberty and the reproductive years. Environmental change has placed the children of the agricultural area of the Yaqui valley are at risk for functioning as healthy individuals.

Tables

Table 1: Mean (± SD) concentrations in the cord blood at time of birth and in mother's milk one month post partum from women, Pueblo Yaqui, Sonora, Mexico. Data from Garcia and Meza, 1991 [].

Pesticide	Cord Blood (ppm)	Milk (ppm corrected for fat)
N	19	20
α-HCH	0.030 ± 0.03	0.8599 ± 2.75
β-HCH	0	0.3791 ± 1.08
Lindane	0.084 ± 0.06	0.6710 ± 0.59*
Δ-HCH	0.0039 ± 0.1	0.4432 ± 0.84
Heptachlor	0	1.269 ± 1.65*
BHC	0.003 ± 0.002	0.6270 ± 0.66*
Aldrin	0	0.2363 ± 0.59*
Dieldrin	0.159 ± 0.12	0.0487 ± 0.08
Endrin	0.022 ± 0.02	0.5238 ± 1.1*
p,p′-DDE	0.03 ± 0.03	6.31 ± 5.9
ℜDDE	0.0434	6.52*

*All exceed FAO/OMS established limits

Table 2: Data on pregnancies and lactation for Yaqui mothers of the children studied.

	Valley	Foothills
# Pregnancies	3.89 ±0.4	3.12 ± 0.3
Birth Ratio		
# Breast Fed	3.00 ± 0.4	2.25 ± 0.5
Time Breast Fed	10.16 ± 1.8	8.46 ± 1.1
Fertility	0.25 ± 0.1	0
Spontaneous Abortion	0.179 ± 0.07	0.118 ± 0.08
Premature Birth	0.25 ± 0.15	0.12 ± 0.08
Birth Defect	0.21 ± 0.1	0
Death	0.12 ± 0.1	0

Table 3: Morphometric information (mean ± SE) for Yaqui children of the lowland and foothill study populations.

Measurement	Male valley	Male foothill	Female valley	Female foothill
Height	104.5 ± 2.4	108.6 ± 1.8	103.8 ± 2.0	107.6 ± 2.9
Weight	16.7 ± 1.1	17.4 ± 0.9	16.7 ± 0.7	18.2 ± 0.9
Sitting Height	57.2 ± 1.6	57.8 ± 1.4	56.5 ± 0.8	58.6 ± 1.6
Head Circumference	52.4 ± 0.7	51.8 ± 0.8	51.7 ± 0.7	51.6 ± 0.4
Head Breadth	13.5 ± 0.2	13.6 ± 0.1	13.2 ± 0.1	13.5 ± 0.2
Head Length	16.8 ± 0.1	16.6 ± 0.3	16.5 ± 0.2	16.5 ± 0.3
Upper Arm Circumference	17.0 ± 0.6	17.7 ± 0.2	17.8 ± 0.4	18.1 ± 0.5
Chest Circumference	57.3 ± 1.3	57.4 ± 0.7	56.1 ± 0.7	55.8 ± 1.0
Skin Fold	6.9 ± 0.4	7.4 ± 0.4	7.6 ± 0.5	8.4 ± 0.7

Figure Headings

Figure 1: Mean (SE) score for stick drawings by Yaqui children from the valley and foothill study populations. Scores for children from the two locations are significantly different (U = 59.0; P < 0.0001).