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A SEARCH FOR GENETIC EFFECTS OF ATOMIC BOMB RADIATION ON THE GROWTH AND DEVELOPMENT OF THE F_1 GENERATION

1. STATURE OF 15- TO 17-YEAR-OLD SENIOR HIGH SCHOOL STUDENTS IN HIROSHIMA

原爆放射線の F_1 世代への成長発育に及ぼす遺伝的影響に関する研究

1. 広島の15歳から17歳までの高校生の身長について

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1. 広島の15歳から17歳までの高校生の身長について

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SUMMARY

In a search for possible genetic effects of atomic bomb radiation on the growth and development of offspring of A-bomb survivors a survey was made in 1965 on approximately 200,000 children of all primary schools, junior high schools, and senior high schools in the cities of Hiroshima and Nagasaki. Of the collected data, those pertaining to senior high school students 15 to 17 years of age of Hiroshima City were analyzed to determine if there was any genetic effect of A-bomb radiation on stature.

Comparisons were made with regard to the mean stature and variance of the offspring and the covariance and correlation between one parent or the sum for both parents and offspring for the exposed group and the nonexposed group. The observed differences included those with both positive and negative signs, but none were statistically significant nor did they demonstrate any specific tendency. A comparison was made with a similar study reported by Neel and Schull. Furthermore, estimation of the regression coefficients of the mean stature, variance, covariance, and correlation between one parent or the sum for both parents and offspring by parental radiation dose also did not show any specific tendency.

要　約

原爆放射線が被爆者の子供の成長発育に及ぼす遺伝的影響を調べるために，1965年に広島・長崎両市の全小学校，中学校，および高校の児童生徒約20万人について調査を行った．収集した資料のうち，広島の15歳から17歳までの高校生の資料について，原爆放射線が身長に及ぼす遺伝的影響を調べるために分析を行った．

被爆群と非被爆群について子の平均身長と分散および片親と子または両親の和と子の間の共分散と相関について比較検討した．両群間の差は正と負の両符号を持つが，統計的に有意なものはなく特定の傾向を示さなかった．Neel と Schull が報告した同様の研究結果と比較検討した．さらに，子の平均身長と分散および片親と子または両親の和と子の間の共分散と相関について親の被曝線量による回帰係数を推定したが，この場合も特定の傾向を示さなかった．

Though the genetic effects of A-bomb radiation on stature could not be accurately estimated in the current series of analyses, the stature data of 6- to 14-year-old children in Hiroshima and those of 6- to 17-year-old children in Nagasaki will soon be studied, which should permit a more comprehensive and extensive analysis and evaluation of the possible genetic effects of radiation on stature.

これら一連の分析からは原爆放射線が身長に及ぼす遺伝的影響を正確に推定することはできなかったが，広島の6歳から14歳までの子および長崎の6歳から17歳までの子の身長に関する資料の検討が間もなく行われるので，放射線が身長に及ぼす遺伝的影響について一層広範な比較分析と評価が期待される．

INTRODUCTION

Mukai[1] has reported that in experimental animals that the genetic effects of radiation on the quantitative characters governed by polygenes are markedly greater than those governed by major genes. It is assumed that this also applies to man.

The recent advances in science and technology coupled with a greater peaceful utilization of atomic energy have increased the risk of human populations being exposed to radiation, and consequently the potential degeneration of man's genetic composition. These have made accurate estimation of the genetic effects of radiation on man an increasingly urgent and vital problem. As experiments cannot be made on man, little evidence is available on the genetic effects of radiation on man.

Thus far only Neel and Schull[2] have made an intensive investigation on the possible genetic damage in Hiroshima and Nagasaki. They investigated sex ratio, malformation, stillbirths, neonatal deaths, deaths within 9 months after birth, weight at birth, anthropometric and other values for 76,626 children born in Hiroshima and Nagasaki between 1948 and 1954. This study, made at great cost and on the greatest scale ever attempted for a study of its kind, did not demonstrate any significant differences in the observed variables between the offspring of exposed parents and their controls, but it was possible to estimate the maximum sensitivity of human genes. Ahuja et al[3] made a study of six quantitative dermatoglyphic traits, including total finger ridge count, in residents of Kerala district in India, where natural background radioactivity is high, and compared them with a control population. They observed that while the mean values did not necessarily show a definite tendency, the variance was smaller in the exposed group for all characters, and very careful consideration was given to this point.

緒　言

実験生物では，ポリジーンに支配される量的形質に対する放射線の遺伝的影響は主遺伝子に支配されるものに比べて著しく大きいことを Mukai[1] は報告している．人類においても同様であると考えられる．

最近の科学技術の進歩と相まった原子力の平和利用の拡大により人類の放射線被曝の機会が増大し，それに伴ってヒトの遺伝的構成が悪化するおそれも多くなってきた．このため，ヒトに対する放射線の遺伝的影響の正確な推定値を得ることは緊急かつ重要な問題である．しかし，ヒトの場合実験を行うことができないため，ヒトに対する放射線の遺伝的影響はほとんど解明されていない．

これまでに，広島と長崎において遺伝的障害に関する徹底的な調査を行ったのは Neel と Schull[2] だけである．彼らは1948年から1954年までの間に広島と長崎で生まれた76,626名について，性比，奇形，死産，新生児死亡，生後9か月以内の死亡，出生時体重，身体およびその他の測定値について調査した．この調査は，多大の費用を要しこの種の調査としては最大規模のものであったが，被爆両親の子とその対照者の子の間に有意な差を証明できなかった．しかし，人類遺伝子の感受性の最大限を推定することができた．Ahuja ら[3] は自然放射能が高いインドの Kerala 地方の住民について total finger ridge count など六つの quantitative dermatoglyphic trait を調査し，対照群と比較した．これによると，平均値は必ずしも一定の傾向を示していないが，分散値はいずれの形質においても被曝群の方が小さく，この点について非常に慎重な検討を行っている．

It is pointed out that in both of these studies 1) no clinical investigation was made on the parents, 2) the exposure doses were not accurately determined, and 3) the effect of parental age which is of particular importance to quantitative characters was not fully taken in account.

以上二つの調査では，1) 両親の臨床調査が行われていないこと，2) 被曝線量が明確でないこと，および3) 量的形質にとって特に重要な親の年齢効果が十分考慮されていないことが指摘される．

MATERIALS

The height, weight, chest circumference, and sitting height were measured in April 1965 for some 200,000 students of 199 public and private primary schools and junior and senior high schools in Hiroshima and Nagasaki. Further, through these school children questionnaires were sent to their parents, from whom detailed answers were obtained concerning the date, place and order of birth, and history of development of their children. For the parents the date and place of birth, date of death, occupation, date of marriage, consanguinity, height, and A-bomb exposure status were recorded; that is, place of exposure and distance from hypocenter if exposed, and date and place of entry into Hiroshima or Nagasaki if not exposed.

However, some information obtained by the questionnaires was incomplete, so efforts were made to improve the accuracy and completeness by referring to and making the maximum use of the data and koseki records available at various governmental offices including the City Office and the Prefectural Office.

Of paramount importance to the present study was identification of the exposure status of the parents and, if exposed, the accurate estimation of the individual exposure dose. For the latter, the tentative 1965 dose estimates of RERF were used.

Only the height of 15-17 year old children in Hiroshima was used in the present study and the subjects were confined to those who from birth to the time of the survey resided in Hiroshima City, excluding offspring of parents of consanguineous marriage, foreign nationals, twins, adopted children, and offspring of parents exposed in Nagasaki.

The stature measurements of the parents given in the questionnaire were found to be of very high reliability through a study of 679 subjects one or both of whose parents were Adult Health Study sample members.

資　料

1965年4月に，広島と長崎の199校の公立，私立の小学校，中学校，および高等学校に在学する児童生徒約20万人について，身長，体重，胸囲，および座高を測定した．また，これらの児童生徒を通じて両親に質問票を送り，子の生年月日，出生地，出生順位，および発育歴について詳細な回答を得た．両親についても，生年月日，出生地，死亡年月日，職業，結婚年月日，近親婚，身長，および原爆被爆状況，つまり被爆者の場合は被爆地点，爆心からの距離，非被爆者の場合は入市年月日と入市後の居所について回答を得た．

しかし，こうして得た情報にも不備な点があるので，市役所および県庁などの関係諸機関の資料や戸籍を最大限に利用参照して，資料の精度を高めるべく努力した．

本研究には，両親の被爆状態の同定と被曝線量の正確な推定が最も重要である．線量推定には，放影研の1965年暫定線量推定値を用いた．

本研究では広島の15歳から17歳までの子の身長の資料のみを用い，出生時から調査時点まで広島市内に居住していた者のみを対象として，親が近親婚，外国人，双生児，養子，ならびに親が長崎で被爆した者を除外した．

片親あるいは両親が成人健康調査対象者である者679名の比較調査から，質問票に記載された両親の身長測定値は非常に信頼性が高いことが分かった．

RESULTS

Mean Stature of Parents and Offspring, Variance, Covariance, and Correlation Coefficient by Age and Sex of Parents and Offspring

The mean parental stature tends to decrease gradually with age, which is natural, but within the same age the mean stature of children seems to be practically unrelated to parental age. However, according to some reports there is a significant relation between parental age and mean stature and correlation coefficient of parent and offspring for parental age by age and sex of the offspring.

The number of subjects in the present study was large and the reliability of the collected data is felt to be comparatively high. The regression coefficients of the mean paternal and maternal stature on paternal and maternal age for all sex and age classes of the offspring were all negative and almost all were statistically significant. However, hardly any of the regression coefficients of the mean stature of offspring of the same age classes on parental age were significant for either sex. This indicates that the stature of the offspring is not related to parental age at the time of their birth. Many of the regression coefficients of the Z transforms of the parent-offspring correlation of stature on parental age were negative, but few were statistically significant. A similar tendency was also observed in general when a similar examination was made by the average age of the nonexposed parents.

Analysis was made for the groups where both parents were exposed, the father only was exposed, and the mother only was exposed. The number of subjects in each of these groups was less than that of the nonexposed group, but the tendency seemed to be similar to that in the nonexposed group.

Mean Stature of Offspring, Variance, Covariance, and Correlation Coefficient by Parental Dose

In Case of Additive Parental Dose. Table 1 presents the estimates of mean stature, variance, covariance and correlation coefficient of stature by combined dose of both parents and by age and sex of offspring.

Test of Difference Between Offspring of Exposed Parents and Offspring of Nonexposed Parents. In this analysis, the exposed group should be compared with the nonexposed group by parental

結　果

親と子の年齢別・性別にみた親と子の平均身長と分散，および親子間の共分散と相関係数

親の平均身長は，当然のことながら年齢の増加に伴い漸減するが，同一年齢の子の平均身長は親の年齢にはほとんど関係がないと思われる．しかし，親の年齢と子の平均身長の間および親の年齢と親子の身長相関係数の間には子の性別・年齢別に有意な関係があるとする報告もある．

本研究の対象者数は多く，収集した資料の信頼性は比較的高いと思われる．子の性別・年齢別にみた父および母の平均身長への父および母の平均年齢に対する回帰係数はいずれも負で，そのほとんどが統計学的有意水準に達する．しかし，子の性別にみた同一年齢の子の平均身長への親の年齢に対する回帰係数は両性ともほとんど有意水準に達していない．このことは，子の身長は出生時の親の年齢に関係がないことを示している．親子間の身長相関をZ変換した値への親の年齢に対する回帰係数は負の符号を持つものが多いが，統計的有意水準に達するものは少ない．非被爆両親の平均年齢別に同様の検定を行った場合も同じような傾向がみられる．

両親被爆，父のみ被爆，および母のみ被爆の各群について分析を行った．この各群の対象者は非被爆群の対象者に比べて少ないが，傾向としては非被爆群と類似の傾向を示していると思われる．

親の被曝線量別にみた子の平均身長と分散，および親子間の共分散と相関係数

両親の相加線量の場合．両親の相加線量別にみた子の年齢別・性別の平均身長と分散，および親子間の共分散と相関係数の推定値を表1に示す．

被爆両親の子と非被爆両親の子の差の検定．この分析は，被爆群と非被爆群を両親の被曝線量別に比較すべきであるが，被爆群の資料が少ないため，ここ

dose, but because of the paucity of data for the exposed group, comparison with the nonexposed group was made here by dividing the exposed group into two groups by additive parental dose of 1 rad or more and less than 1 rad. The results are shown in Table 2.

First, comparison between the 1 rad or more group and the nonexposed group showed the mean value to be greater in the exposed group in every age class in both males and females, but the difference was statistically significant in only a very few instances. The differences in the variance, covariance and correlation showed no fixed tendency between the exposed group and the nonexposed group, and many of these variance ratios and differences of correlations were not statistically significant.

In the comparison between the less than 1 rad group and the nonexposed group, the mean was greater in the exposed group in all cases except for 16-year-old girls and was statistically significantly higher in 16- and 17-year-old boys and 17-year-old girls of the exposed group. The differences in the variance, covariance, and correlation showed no fixed tendency between the exposed group and the nonexposed group.

Weighted Regression Analysis for Additive Parental Dose. A weighted regression analysis was attempted for the combined dose of both parents by age and sex of the offspring. The analysis was made in two different ways, one using 0 rad as the dose for the nonexposed group and the other excluding the nonexposed group. Further, all subjects in the less than 1 rad group were excluded because the RERF dose estimates are treated as 0 rad for them. The results of analysis are shown in Table 3. The regression coefficients of mean, variance, covariance, and correlation coefficient for the combined dose of both parents did not show any specific trend, and very few were significant in the relationship on means and correlation coefficients. For 17-year-old boys, the regression coefficients fell short of a significant level, almost all being negative.

Test of Assortative Mating. Absolute assortative mating seldom occurs in man, but if it should occur to some extent, the estimates of covariance and correlation coefficient between parent and offspring and between sib-pairs obtained for such mating should be higher than the estimates

では，被爆群を両親の相加線量別に1 rad以上群と1 rad未満群に分けて非被爆群と比較した．その結果を表2に示す．

まず，1 rad以上群と非被爆群の比較では，男女ともすべての年齢群において被爆群の方が高い平均値を示したが，その差が統計的有意水準に達するものはごく少数であった．被爆群と非被爆群の間の分散，共分散，および相関の差は一定の傾向を示さず，分散比および相関の差が統計的有意水準に達するものはほとんどなかった．

1 rad未満群と非被爆群の比較では，16歳の女を除く全例において被爆群の方が高い平均を示し，16歳および17歳の男および17歳の女では被爆群の方が統計的に有意に高い．被爆群と非被爆群の間の分散，共分散，および相関の差は一定の傾向を示さなかった．

両親の相加線量による加重回帰分析．子の年齢別・性別に，両親の相加線量による加重回帰分析を試みた．分析は，非被爆群の被曝線量を0 radとした場合と非被爆群を除外した場合の二つの方法で行った．さらに，1 rad未満のものは，放影研の線量推定値が0 radとして扱われているので，これはすべて除外した．分析の結果を表3に示す．平均，分散，共分散，相関係数への両親の相加線量に対する回帰係数は特定の傾向を示さず，平均および相関係数に関しての有意水準に達したものは極めて少ない．17歳の男については，回帰係数は有意水準には達しないがほとんどが負の符号を示した．

選択結婚の検定．人類で絶対的選択結婚というのはほとんどないが，もしある程度選択結婚が行われるとすれば，親子間および同胞間の共分散および相関係数の推定値は，無選択結婚系の同じ遺伝

obtained with the same genetic structure for a lineage from random mating.

的構造で得られた値よりも高くなることが予想される.

Let the correlation of height between father and mother be r_{FM}, the covariance between the sum of both parents and the child, $W_{F+M\cdot O}$, the correlation coefficient, $r_{F+M\cdot O}$, variance of offspring, V_O, and variance of the sum of both parents, V_{F+M}. Then the formula to exclude the effect of correlation of height between father and mother can be expressed by:

父母間の身長相関を r_{FM}，両親の和と子の間の共分散を $W_{F+M\cdot O}$，相関係数を $r_{F+M\cdot O}$，子の分散を V_O，両親の和の分散を V_{F+M} とすると，父母間の身長相関の影響を除去する方式は：

$$r^*_{F+M\cdot O} = \frac{r_{F+M\cdot O}}{(1 + r_{FM})}$$

$$W^* = r^*_{F+M\cdot O} \cdot V_O \cdot V_{F+M}$$

$$W^{**} = \frac{W_{F+M\cdot O}}{(1 + r_{FM})}$$

Substitution of the estimates obtained from Table 1 and the correlation of height between father and mother in the above expression gave the results shown in Table 4.

で表わされる．表1で得られた推定値と父母間の身長相関を上式に代入して，表4に示した結果を得た.

Compared with the previous results where no modification was made (Table 1), there was a good resemblance of trend, though a small number of exceptions occur. However, the frequency of assortative mating seemed to be higher in the exposed group than in the non-exposed group.

補正を行わなかった前の結果（表1）と比較して，ごく一部の例外はあるが，よく似た傾向を示した．ただし，選択結婚の頻度は非被爆群よりも被爆群の方が高いようである.

Between Sib-Pairs. Siblings (brother-brother, brother-sister, sister-brother, sister-sister) were extracted from the exposed and nonexposed groups and their mean height, variance, covariance, and correlation coefficient were sought. Because the covariance and correlation coefficient between sib-pairs are affected by the correlation between parents, the following formula was used to exclude this effect and the results were as shown in Table 5.

同胞間について．両親が被爆者である者および非被爆者である者の中から同胞（兄弟，兄妹，姉弟，姉妹）を抽出し，その平均身長，分散，共分散，および相関係数を求めた．同胞間の共分散および相関係数は両親の間の相関の影響を受けるので，この影響を除去するために次の方式が用いられた．結果は表5に示したようになる.

$$r^*_{OO'} = \frac{r_{OO'}}{1 + r_{FM}}$$

$$W^*_{OO'} = \frac{W_{OO'}}{1 + r_{FM}}$$

The age combinations among siblings which can be obtained here are 17-16 years, 17-15 years, and 16-15 years, of which the greatest number of

ここで得られる同胞間の年齢組み合わせは，17—16歳，17—15歳，16—15歳であるが，このうち最も

cases are found in the combination 17-15 years. However, data for the exposed group are few, which presumably would pose a problem in making a comparative study. As a tendency, the covariance and correlation coefficient between sib-pairs show estimates which are smaller for brother-brother and brother-sister and larger for sister-brother and sister-sister in the exposed group as compared with the nonexposed group. In any case, nothing conclusive can be said because the number of cases is small.

例数の多いのは17—15歳の組み合わせである．しかし，被爆群の資料が少ないので，比較検討するのに問題もあろうかと思われる．傾向としては，同胞間の共分散および相関係数は，非被爆群に比べて被爆群の方が，兄弟および兄妹で小さく，姉弟および姉妹で大きい値を示している．いずれにしても，例数が少ないので決定的なことは言えない．

In Case One Parent was Exposed. Tables 6 and 7 show by age and sex of offspring the mean height and variance by exposure dose of one parent in case one was exposed and the other was not exposed. Also shown is the covariance and correlation coefficient between parent and offspring, the correlation between parents, and the covariance and correlation between parent and offspring modified by correlation between parents.

片親被爆の場合． 表6および表7は，片親のみが被爆の場合，その被曝線量別にみた子の平均身長と分散を子の年齢別・性別に示す．また，親子間の共分散と相関係数および両親間の相関によって補正した親子間の共分散と相関も示す．

Test of Difference Between Group with Either Father or Mother Exposed and Nonexposed Group. Again, because of the small number in the exposed group, the group with one parent exposed was divided into two groups according to dose, (1 rad or more and less than 1 rad) and a test was made of the differences with the nonexposed group (Tables 8-11).

片親被爆群と非被爆群の差の検定．この場合も，被爆群の資料が少ないので，片親被爆群を線量によって1 rad 以上群および1 rad 未満群の二つに分け，非被爆群との差を検定した(表8—11)．

Father only exposed: The mean stature of the offspring was lower in the exposed group than the nonexposed group for all ages and both sexes, but none of the differences were statistically significant. The variance ratio showed no specific tendency, but where the ratio was statistically significant, the variance was almost always larger in the exposed group, both the 1 rad or more and less than 1 rad groups, than in the nonexposed group. Although it was expected that the sign of the differences in the father-offspring (FO) covariance (W_{FO}, W^*_{FO}) between the exposed group and the nonexposed group would be negative, it was positive in many cases. The father-offspring correlation (r_{FO}, r^*_{FO}), like covariance, was also expected to be negative, but was more often positive and few differences of correlation coefficients were significant. The mother-offspring (MO) covariance (W_{MO}, W^*_{MO}) and correlation (r_{MO}, r^*_{MO}) showed the same tendency as between father and offspring.

父のみ被爆：子の平均身長は全年齢の男女ともに非被爆群よりも被爆群の方が低いが，その差が統計的有意水準に達するものはなかった．分散比は特定の傾向を示さなかったが，統計的に有意な場合は，被爆群の方が1 rad 以上群および1 rad 未満群とも非被爆群よりもほとんど大きい分散を示した．父子(FO)間の共分散(W_{FO}，W^*_{FO})の被爆群と非被爆群の差は負の符号を示すことが予想されたが，多くの場合正の符号を示した．父子相関(r_{FO}，r^*_{FO})も，共分散と同様に，負の符号を示すことが予想されたが，正の符号を示す方が多く，相関係数の差が統計的有意水準に達するものはほとんどなかった．母子(MO)間の共分散(W_{MO}，W^*_{MO})および相関(r_{MO}，r^*_{MO})も父子間の場合と同様の傾向を示した．

Mother only exposed: The mean stature in any age and either sex was almost always higher in the exposed group than in the nonexposed group, and only the difference between the less than 1 rad group and nonexposed group was statistically significant in 16- and 17-year-old boys and 15-year-old girls. No specific tendency was seen in the variance, and very few ratio values were statistically significant. The father-offspring covariance (W_{FO}, W^*_{FO}) and correlation (r_{FO}, r^*_{FO}) and the mother-offspring covariance (W_{MO}, W^*_{MO}) and correlation (r_{MO}, r^*_{MO}) showed almost the same tendency as in the case where only the father was exposed.

母のみ被爆：平均身長は全年齢の男女ともにほとんどの場合被爆群の方が非被爆群よりも高く，1 rad未満群と非被爆群の差のみが16歳と17歳の男および15歳の女において統計的有意水準に達した．分散には特定の傾向はみられず，その分散比が統計的有意水準に達するものは極めて少なかった．父子間の共分散(W_{FO}，W^*_{FO})と相関(r_{FO}，r^*_{FO})および母子間の共分散(W_{MO}，W^*_{MO})と相関(r_{MO}，r^*_{MO})は，父のみ被爆の場合とほぼ同じ傾向を示した．

Weighted Regression Analysis for Exposure Dose of One Parent by Combination of Exposed and Nonexposed Parents. A weighted regression analysis was attempted for the dose of one parent by combination of exposed parent and nonexposed parent (father exposed X mother not exposed; father not exposed X mother exposed) and by age and sex of the offspring. Here also, the analysis was made in two different ways, one using and the other excluding the dose (0 rad) of the nonexposed group. Further, all cases exposed to a dose less than 1 rad were excluded. The results show that few regression coefficients were significant (Tables 12-13). Among them, the regression slope of mean height of the child for parental dose had a negative sign, but the correlation coefficient had a positive sign in many cases. Further, it cannot be said that the respective regression coefficients necessarily showed a specific tendency according to the combination of parents (father exposed X mother not exposed; father not exposed X mother exposed).

両親の被爆および非被爆の組み合わせ別にみた，片親の被曝線量による加重回帰分析．両親の被爆および非被爆の組み合わせ(父被爆×母非被爆，父非被爆×母被爆)別，子の年齢別・性別に，片親の被曝線量による加重回帰分析を試みた．ここでも，分析は非被爆群の被曝線量(0 rad)を用いた場合と除外した場合の二通りの方法で行った．また，被曝線量1 rad未満のものはすべて除外した．この結果，回帰係数が有意水準に達するものはほとんどなかった(表12－13)．このうち，子の平均身長への親の被曝線量に対する回帰は負の符号を示したが，相関係数では正の符号を示すものが多い．また，両親の組み合わせ(父被爆×母非被爆，父非被爆×母被爆)によって，それぞれの回帰係数が必ずしも特定の傾向を示すとは言えない．

DISCUSSION

Numerous earlier reports have established that quantitative characters under the control of polygenes are readily influenced by environmental factors. While this can be expected for stature also, the heritability of stature as reported by Furusho[4] is $h^2 = 0.66 \sim 0.85$, which is markedly high for the heritability of a human quantitative character. Further, all studies since the report by Galton in 1886 have shown a high correlation between the stature of parents and their offspring, based upon measurements at maturity, which suggests that the genotype contributes largely to stature.

考　察

ポリジーンに支配される量的形質は環境要因の影響を受けやすいことは多くの報告で周知の通りである．身長の場合も同様であることが予測されるがFurusho[4]の報告した身長の遺伝力は $h^2 = 0.66 \sim 0.85$で，ヒトの量的形質の遺伝力としては著しく高い．また，1886年のGaltonの報告以来，あらゆる研究において，親の身長とその子の発育完了時の身長との間に高い相関が示されており，身長に遺伝子型の寄与が大きいことを示唆している．

Although the present study was made on stature which is regulated by polygenes, it is possible that such abnormalities as gigantism and dwarfism due to major genes or chromosome aberrations may be included at both extremities of the distribution of stature. Most of these abnormalities, however, are accompanied by mental retardation or physical deformities, and since the data used in the present study were obtained from ordinary senior high schools where such abnormalities are mostly excluded at time of the entrance examinations, almost all of the data probably pertain to stature as regulated by polygenes.

本研究はポリジーンに支配される身長を対象としているが，身長分布の両端には主遺伝子や染色体異常に因る巨人症や短人症などの異常が含まれる可能性もある．しかし，これらの異常は精神薄弱や肢体不自由を伴うことが多く，本研究で用いた資料は普通の高校から入手したもので，入試の際にこのような異常のあるものはほとんど除外されているので，本資料はほぼポリジーンに支配される身長の資料と思われる．

The data analyzed here were obtained on senior high school students between the ages of 15 to 17. The entrance examinations[5] to senior high schools introduce certain limitations on scholastic ability and socioeconomic status - the rate of advancement from junior high schools to senior high schools at the time of this survey was about 80%. In this sense, the data on senior high school students can be considered somewhat more uniform than those on pupils of primary and junior high schools as regards socioeconomic factors.

ここで分析した資料は15歳から17歳の高校生から入手したものである．高校入試[5]には学力および社会経済力にある限界がある．すなわち，調査時の高校進学率はおよそ80%であった．この意味で，高校生の資料は小学生や中学生の資料よりも社会経済要因に関してはより均一であると考えられる．

The possible presence of a dominant gene action upon the polygenic system governing stature should be taken into consideration because it may influence the results of the comparison of stature between the exposed and nonexposed groups. Furusho[4-8] reported that a comparison of the parent-offspring correlation (r_{PO}) and the sib-sib correlation ($r_{OO'}$) for stature had shown relation of $r_{PO} < r_{OO'}$, and that there seemed to be a dominant gene action upon the polygenic system which governs stature. Subsequently, Furusho[7-9] studied a large body of data collected from various areas and found that the parent-offspring correlation showed specific variations according to the age of the offspring. Further, Furusho[10,11] used data on 17-year-old males to obtain the parent-offspring correlation for stature by parental age, and found that the correlation tended to gradually decrease linearly with age of the parents. He therefore obtained the regression coefficient of the parent-offspring correlation for stature upon parental age. Using a given parental age of 20 or 25 and the stature at age 17, the parent-offspring correlation for stature was found to take an intermediate value between the correlations between dizygotic twins and between siblings. When the effect of

身長を支配するポリジーン系に優性効果が存在するか否かによって被爆群と非被爆群の身長の比較結果が左右されるので，この点について考慮すべきであろう．Furusho[4-8]は身長の親子相関（r_{PO}）と同胞相関（$r_{OO'}$）を比較したところ$r_{PO} < r_{OO'}$の関係がみられ，身長を支配するポリジーン系に優性効果が存在するらしいことを報告した．その後，Furusho[7-9]は各地から集めた多数の資料を調べ，子の年齢によって親子相関が特定の変動を示すことが分かった．また，Furusho[10,11]が17歳の男の資料を用いて親の年齢別に身長の親子相関を求めたところ，親の年齢増加に伴い身長の親子相関は直線的（一次的）漸減傾向を示した．そこで，身長の親子相関の親の年齢への回帰係数を求めた．親の年齢を20歳または25歳と仮定し，17歳時の身長を用いると，身長の親子相関は，2卵性双生児間相関と同胞相関の中間値を示し

parental age was eliminated, the parent-offspring correlation and sib-sib correlation for stature became almost equal so that the polygenic system governing stature probably has an additive gene action with hardly any dominant gene action.

た．親の年齢効果を除外すれば，身長の親子相関と同胞相関の値はほぼ等しいので，身長を支配するポリジーン系はほとんど優性効果のない相加的作用を有するであろう．

The correlation of stature between parent and offspring in the present study is shown in Table 7 and that between siblings in Table 5, but the comparisons here with the correlations between parent and offspring and between siblings in the nonexposed group were made after correction had been made for the correlation of stature between parents. Although the correlation between parents and offspring differs somewhat by the age and sex of the offspring, the range is small, the average being $\bar{r}_{PO}=0.240\sim0.322$ in the nonexposed group with both parents. The correlation between siblings was examined using cases with up to 2 years difference in age because of the small number of cases, and although the range was rather large depending upon the combination of siblings, the average was $\bar{r}_{OO'}=0.324\sim0.431$ in the combination 15-17 years. Comparison of $\bar{r}_{PO}$ and $\bar{r}_{OO'}$ clearly shows the relationship $\bar{r}_{OO'}>\bar{r}_{PO}$. This finding suggests that polygenes with dominance may be included in the polygenic system governing stature. However, the age difference between the parents and their offspring is at least 20 years and that between the siblings used here is 2 years in every case so that there is a difference of more than 10 times between the two. In view of this and the fact that the sign of the regression coefficient of the Z transform of the correlation of stature between parents and offspring was in almost every case negative, it is highly possible that $\bar{r}_{OO'}$ and $\bar{r}_{PO}$ would become almost equal if correction were made for parental age as in the report by Furusho.[10,11] Thus it seems almost certain that the stature used in this study is governed by a polygenic system having additive gene action with no dominant gene action.

本研究の親子間の身長相関は表7に，また同胞間の身長相関は表5に示すが，ここでは，父母間の身長相関について補正した非被爆群における親子相関と同胞相関を比較した．親子相関は子の年齢と性によって若干異なるが，その幅は小さく，非被爆群の両親との相関平均は $\bar{r}_{PO}=0.240\sim0.322$ であった．同胞相関は調査例数が少ないので年齢差2年までのものについてみると，同胞間の組み合わせによって幅はやや大きいが，15－17歳の組み合わせにおいて平均は $\bar{r}_{OO'}=0.324\sim0.431$ であった．$\bar{r}_{PO}$ と $\bar{r}_{OO'}$ を比較すると，明らかに $\bar{r}_{OO'}>\bar{r}_{PO}$ の関係がみられる．このことは，身長を支配するポリジーン系に優性作用を有するポリジーンが存在することを暗示している．しかし，親子間の年齢差は少なくとも20年以上であるが，ここに用いた同胞間の年齢差はすべて2年であるので，両者の差は約10倍以上である．この点を考慮するとともに親子間の身長相関をZ変換した値への親の年齢に対する回帰係数がほとんど負の符号を持つことから，Furusho[10,11]の報告のように親の年齢を補正すれば $\bar{r}_{OO'}$ と $\bar{r}_{PO}$ がほぼ等しくなることが十分考えられる．したがって，本研究で用いた身長も優性効果のない相加的作用を有するポリジーン系に支配されると考えてほぼ間違いないと思われる．

In the foregoing section the differences in mean stature, variance, and in the covariance and correlation between parents and offspring were examined for the both-parents-exposed group, father-only-exposed group and mother-only-exposed group in comparison with the nonexposed group. The nonexposed group presents no problem because of its large size, however, the exposed group is limited, thus variation in the data is highly possible. Experience shows

以上，両親被爆群，父のみ被爆群および母のみ被爆群について非被爆群と比較して，平均身長，分散，および親子間の共分散と相関の差を検討した．非被爆群は調査例数が多いので問題はないが，被爆群の調査例数は限られているので，資料に変動があるこ

that the variance will differ considerably according to the amount of data available. The means have comparatively the least variation.

とは十分予想される．分散は資料の量によって大きく異なることを経験している．比較的変動が少ないのは平均値である．

To recapitulate, the mean stature of offspring was higher in the groups with both parents exposed and mother alone exposed, as compared with the nonexposed group. However, the mean stature in the group with father alone exposed almost always showed a tendency to be lower as compared with the nonexposed group. Accordingly, the mean statures of offspring in 1) the group with father alone exposed (father exposed X mother not exposed) and 2) the group with mother alone exposed (father not exposed X mother exposed) show completely opposite results, with the difference from the nonexposed group in the former having a negative sign and that in the latter having a positive sign. If this were true, there is the possibility that X-linked genes may be involved in the polygenic system which controls stature. However, where only the father was exposed, almost all differences from the nonexposed group have a negative sign in both sexes. If X-linked genes were affected, the effect would be expected to appear only in female and not in male offspring, but studies to date indicate that the ratio of the length of autosomes to X-chromosomes is 20:1; that is lengthwise, the X-chromosome accounts for only 5% of all chromosomes so that effects would not appear in tests of differences unless a considerable number of polygenes are located on the X-chromosome. Further, if X-linked genes were involved in the polygenic system governing stature, the order of the correlation between parent and offspring by combination of parent and offspring (father-son: r_{FS}, father-daughter: r_{FD}, mother-son: r_{MS}, mother-daughter: r_{MD}) would be expected to be $r_{FS} < r_{MD} < r_{FD} = r_{MS}$, and the order of the correlation between sib-pairs by combination of siblings (brother-brother: r_{BB}, brother-sister: r_{BS}, sister-brother: r_{SB}, sister-sister: r_{SS}) would be $r_{BS} = r_{SB} < r_{BB} < r_{SS}$. However, the results of Tables 5 and 7 do not conform to the above hypothesis. In this connection, Furusho[10-14] has reported from studies of many cases in various areas that stature generally is regulated by an autosomal polygenic system. Thus, it is almost certain that practically all of the polygenic systems which regulate stature are located on autosomes.

要約すると，子の平均身長は両親被爆群および母のみ被爆群の方が非被爆群よりも高い．しかし，父のみ被爆群の平均身長は非被爆群に比べてほとんど低い傾向を示した．したがって，1) 父のみ被爆群（父被爆×母非被爆）と 2) 母のみ被爆群（父非被爆×母被爆）の子の平均身長は全く逆の結果を示し，非被爆群との差は前者が負の符号，後者が正の符号を持つ．もしこれが事実であれば，身長を支配するポリジーン系にX染色体関連遺伝子が関与している可能性がある．しかし，父のみ被爆群の場合，非被爆群との差のほとんどは男女ともに負の符号をもっている．もしX染色体関連遺伝子に影響を及ぼすのであれば，女のみに影響が現れ男には現れないことが期待されるが，これまでの研究によると，常染色体とX染色体の長さの比は20対1であり，長さではX染色体は全染色体の5％にすぎないので，X染色体上に相当数のポリジーンが座位していなければ差の検定に影響が現れないであろう．また，身長を支配するポリジーン系にX染色体関連遺伝子が関与していれば，親子の組み合わせ（父一息子：r_{FS}，父一娘：r_{FD}，母一息子：r_{MS}，母一娘：r_{MD}）によって親子相関の順位は $r_{FS} < r_{MD} < r_{FD} = r_{MS}$ となることが予想され，同胞の組み合わせ（兄一弟：r_{BB}，兄一妹：r_{BS}，姉一弟：r_{SB}，姉一妹：r_{SS}）によって同胞相関の順位は $r_{BS} = r_{SB} < r_{BB} < r_{SS}$ となることが予想される．しかし，表5および7は上記の仮説に適合しない．これについて，すでにFurusho[10-14]が各地の多数の調査から，身長はほぼ常染色体性ポリジーン系に支配されると報告している．このことから，身長を支配するポリジーン系のほとんどすべてが常染色体上に座位することはほぼ間違いない．

Then, why should the mean stature tend to be lower for offspring whose fathers only were

父のみ被爆群の子の方が両親とも非被爆群の子よりも平均身長が低いという傾向がなぜ生じたのだろう

exposed than in those whose parents were not exposed? Although this might be attributed to chance related to the small number in the exposed group, the evident contrary relation in the difference of mean stature between offspring whose fathers only were exposed (negative sign) and those whose mothers only were exposed (positive sign) perhaps can not be explained by chance alone. For example, in the Japanese family system when these offspring were young the father was clearly responsible for the socio-economic status of the family and his influence on family support was of a magnitude inconceivable at present. Needless to say, in the difficult postwar period, the family livelihood would have been greatly affected if the father had been sick to some degree as a result of A-bomb exposure. The Ministry of Education[15] reported that concerning consumer expenditures per family by prefecture the correlation of food expenses with stature (11-year-old boys) was markedly high, r = 0.92.

This supports a probable close relation between economic factors and stature which if true may well be one of the factors which would explain the negative sign for the difference in mean stature between offspring of one group and the positive sign for the others. However, offspring in the group with both parents exposed, which has comparatively a larger number of cases, tend to have a higher mean stature in almost all age classes and both sexes as compared with the nonexposed group. If this be considered, the above interpretation is not necessarily appropriate, but, on the other hand, since livelihood relief benefits, etc., differ between the one parent exposed group and both parents exposed group and since the present data were obtained on students of senior high schools where the entrance examinations introduce certain limitations on economic status as well as scholastic ability, this interpretation probably cannot be ignored altogether.

For comparison with the nonexposed group, the exposed group was further divided by exposure dose into two groups, the 1 rad or more group and less than 1 rad group. Although the mean dose of the 1 rad or more group was 59-64 rad, the actual doses ranged from less than 1 rad to over 300 rad so there may be problems in combining them into one group. For this reason, although the number of cases in the exposed group was small, weighted regression analysis

か．このことは被爆群の調査例数が少ないことによる偶然の結果であるとみなすこともできるが，父のみ被爆群の子(負の符号)と母のみ被爆群の子(正の符号)の平均身長の差に明らかに逆の関係があることは偶然の結果であるというだけでは説明できないであろう．例えば，この子らが幼少の時期，日本の家族制度では，家の社会経済的な地位を支えていたのは父であり，父の家を支える経済力は現在では考えられない程強かったのである．戦後の困難な時期に，父が原爆被爆のために病的状態になれば，その家族の生計に著しく影響したことは言うまでもない．文部省報告[15]によると，都道府県別の1世帯当たりの消費支出のうち食費と身長(11歳男)の相関はr＝0.92と著しく高い．

このことは経済要因と身長の間に密接な関係があることを示唆しており，これが事実とすれば，一方の平均身長の差が負の符号を持ち他方が正の符号を持つことを説明する要因の一つと考えられる．しかし，調査例数も比較的に多い両親被爆群の子は非被爆群の子と比較してほぼ全年齢および両性において平均身長が高い傾向を示している．このことを考慮すれば，上記の解釈は必ずしも適切ではないが，片親被爆群と両親被爆群では生活救済などが異なり，本調査の資料は高校生を対象に入手したもので，高校入試は学力だけでなく経済状態にも一定の限界があるので，この解釈も全く無視することはできないだろう．

非被爆群との比較のために，被爆群をさらにその被曝線量によって1 rad未満群と1 rad以上群に分けた．1 rad以上群の平均線量は59—64 radであるが，実際の線量は1 rad未満から300 rad以上にわたるためこれを一つの群にまとめることに問題があるかもしれない．このため，被爆群の例数は少ないが，

was made for parental dose using the mean stature, variance, and the covariance and correlation between the parents and offspring. Two analyses were made, one including the nonexposed group (0 dose) and the other using only the exposed group, excluding the nonexposed group which is the so-called control group here.

In selecting a control group, it is preferable that it be as homogeneous as possible with the exposed group, especially with regard to environmental conditions, etc. In the present data, consideration was given to selecting only offspring born and raised in Hiroshima City who preferably were living with their real parents and attending senior high school. Excluded were those accommodated in institutions or whose guardians were not blood relations. However, growth of man in the broad sense begins at time of fertilization. Therefore, some may even question the significance of any estimate obtained through the analysis of the relation between measurements of stature and detailed data concerning socioeconomic factors at the time of survey. The analysis should consider the developmental history based upon yearly investigations of stature, social and environmental factors, etc., from time of birth, but such a method is impractical in the case of man. If such details are to be taken into account, the exposed group and the nonexposed group used here are not necessarily a homogeneous population. To accomodate for this, weighted regression analysis was made in two ways, one including and the other excluding the nonexposed group.

It is evident that the sign of the regression coefficient differs depending on whether the nonexposed group was included or not in the weighted regression analysis for the 17-year-old boys of the both parents exposed group and the 16-year-old boys of the father only exposed group. In each case, the regression coefficients took the positive sign when the nonexposed group is included and took the negative sign when excluded. The sign remained the same whether the nonexposed group is included or not in all other groups. Thus for almost all groups no reversal of the positive and nagative sign occurred by the inclusion or exclusion of the nonexposed group, but on more careful examination of the regression coefficients many showed marked differences, but without specific trends, depending on whether the nonexposed group is included or not. Further, differing from the previously

子の平均身長，分散，および親子間の共分散と相関を用いて親の線量との加重回帰分析を行った．分析に当たって非被爆群（被曝線量＝0）を入れた場合と，非被爆群を除き被爆群のみを用いた場合の2通りの分析を行った．ここで，非被爆群はいわゆる対照群である．

対照群の抽出には，できるだけ被爆群と均質であること，特に環境条件などが均質であることが望ましい．本資料は，広島市で出生し成育した子で，なるべく実父母とともに生活しており，高校在学の者を抽出するよう考慮した．施設で成育した者あるいは保護者が血縁者でない者は除外した．しかし，人間の発育は広い意味では受精した瞬間から始まる．そこで，調査時点で身長を測定し，社会経済要因を詳しく調査して，両者間の関係を分析して得た推定値が有意かどうかという疑問が生ずるかもしれない．出生時から逐年的に身長測定や社会環境要因などの調査を行い，これに基づいた成長歴を考慮して分析を行うべきであるが，人間の場合このような方法は不可能である．このような詳細な点まで考慮すると，ここで用いた被爆群と非被爆群は必ずしも均質な集団ではない．この点を考慮して，非被爆群を入れた場合と除いた場合の2通りの方法で加重回帰分析を行った．

両親被爆群の17歳男および父のみ被爆群の16歳男では，加重回帰分析で非被爆群を入れた場合と除いた場合で回帰係数の符号が異なっている．いずれも非被爆群を入れた場合は正の回帰係数を示すが，非被爆群を除いた場合は負の回帰係数を示す．その他の群ではすべて，非被爆群を入れた場合も除いた場合も同じ符号をもつ．このようにほぼ全群とも，非被爆群を入れた場合と除いた場合で正負の符号が逆転することはないが，回帰係数を詳細に検討すると，特定の傾向はみられないまでも，非被爆群を入れた場合と除いた場合で著しく異なるものが多かった．

described results of comparison of the differences in mean stature of offspring between the exposed group and the nonexposed group, the results of weighted regression analysis (Table 3) indicate that 16 of the 36 regression coefficients have the negative sign. Moreover, of the 10 regression coefficients each for father only exposed group and mother only exposed group, more than half have the negative sign. This indicates that regardless of whether the regression coefficient has a positive or negative sign the mean stature has been influenced by parental exposure, as expected to some degree from the results of animal experiments using radiation.

また，すでに述べた被爆群と非被爆群の子の平均身長の差の比較結果とは異なり，加重回帰分析の結果(表3)は，36の回帰係数のうち16が負の符号を持つことを示している．さらに，父のみ被爆群および母のみ被爆群それぞれ10の回帰係数のうち，半数以上が負の符号を持つ．このことは，放射線を用いた動物実験の結果からある程度予想できたように，回帰係数の符号の正負にかかわらず，親の被曝線量が平均身長に影響を及ぼすことを示している．

The genetic effects of A-bomb radiation were discussed using the mean stature, etc., of offspring based upon differences between the exposed and nonexposed groups and weighted regression analyses upon parental exposure dose, but the differences and regression coefficients, as previously stated, are not all statistically significant. Although there may be problems in making conclusions using such estimates as these, the results of numerous animal experiments suggest that genetic effects of A-bomb radiation cannot be negated just because the results were not statistically significant. In particular, it should be kept in mind that the exposed group used in the present study had been exposed to instantaneous radiation of an average of 59-64 rad.

子の平均身長などを用い，被爆群と非被爆群の差および親の被曝線量への加重回帰分析に基づいて，原爆放射線による遺伝的影響を論じてきたが，既に述べたように，差や回帰係数はほとんど統計的有意水準に達しなかった．このような推定値から結論を導くことには問題があろうが，多くの動物実験の結果が示しているように，結果が統計的有意水準に達していないからといって原爆放射線による遺伝的影響を否定することはできない．特に，本調査で用いた被爆群は瞬間的に平均59－64 rad の放射線に被曝していることを考慮すべきである．

A study similar to the present one has been reported by Neel and Schull,[2] but the Furusho data used in the present study differed basically in nature from those of Neel and Schull. The Furusho data are for 15 to 17-year-old children who have nearly completed their growth, while the data of Neel and Schull were for children at 9 months of age. This is a very important point. The stature increases with age, following the growth curve from birth to time of completion of growth. Furusho[9] has used yearly measurements of stature of many Japanese subjects to make a study on the manifestation by genotypes responsible for stature. That is, the data used were those concerning yearly measurements of stature for the same individual during growth till completion of growth. It was reported that the correlation coefficient (r'_{ij}) between stature for the same individual at maturity (i) and at various ages during the growth period (j) becomes higher with decreasing difference in age, being very low during infancy and gradually increasing thereafter with age. However, because of a

本研究と同様な研究には Neel と Schull[2] によるものがあるが，本研究に用いた Furusho の資料は Neel と Schull の資料とは根本的に性質を異にする．Furusho の資料はほぼ発育完了期に近い15歳から17歳の子を対象としているが，Neel と Schull の資料は生後9か月の子を対象としている．これは非常に重要な点である．身長は，出生時から発育完了期までの発育曲線にしたがって，年齢とともに増加する．Furusho[9] は多数の日本人の身長を逐年的に測定して，身長を支配する遺伝子型の発現について検討した．すなわち，同一個人の発育期から発育完了期までの逐年身長測定資料を用いて，発育完了期(i)および発育過程の各年齢(j)の同一個人に対する身長の相関係数(r'_{ij})は年齢差の減少に伴って高くなり，幼年期には非常に低く，その後年齢に伴って漸増することを

temporary decrease in the correlation at the age corresponding to preadolescence the variation of the r'_{ij} curve is not linear but is a curve of the nth degree. In particular, the parent-offspring correlation of stature for children age 0-1 is low, being reported to be $r=-0.001 \sim 0.117$ by Yoshida[16] which is much lower than the parent-offspring correlation of stature at completion of growth.

報告した．しかし，前思春期に相当する年齢で一時的に相関が減じるため，r'_{ij} 曲線の変動は直線的ではなくn次曲線にしたがう．特に，0－1歳の子の身長の親子相関は低く，Yoshida[16] の報告によると $r=-0.001 \sim 0.117$ と発育完了期の身長の親子相関より著しく低い．

This indicates that environmental factors have greater effects than genetic factors upon the phenotype of stature measurements in 0 to 1-year-old children. Even if a difference of a significant level had been found between the exposed group and the nonexposed group in the data of Neel and Schull, it would seem, in consideration of these points, that it would be more appropriate to regard it as the effect of differences in socioeconomic environmental factors between the population whose parents were exposed and those whose parents were not exposed rather than the genetic effect of A-bomb radiation. On the other hand, the Furusho data are for 15 to 17-year-old offspring, and as reported by Furusho,[9-14] the correlation of stature between parent and offspring in the nonexposed group with both parents using stature measurements of offspring of this age range (15-17 years) is $r_{PO}=0.28$-0.39, which is markedly higher than the correlation between parent and offspring in children of ages 0-1 year, and the manifestation of genotypes is 70%-90% in 15 to 17-year-old offspring. Therefore, it is very likely that the difference seen between offspring of the exposed group and offspring of the nonexposed group in the Furusho data includes more genetic effects of A-bomb radiation than the data of Neel and Schull.

このことは，0－1歳の子の身長測定値という表現型に遺伝的要因よりも環境要因の方が強い影響を及ぼすことを示している．Neel と Schull の資料で被爆群と非被爆群の差が有意水準に達したとしても，これらの点を考慮すると，その差は原爆放射線による遺伝的影響というよりも親の被爆・非被爆による社会経済的環境要因のちがいによる影響とみなす方がより適切であると思われる．一方，Furusho の資料は15歳から17歳までの子を対象としており，Furusho[9-14] が報告したように，この年齢期(15－17歳)の子の身長測定値を用いた両親非被爆群の親子相関は $r_{PO}=0.28 \sim 0.39$ と0－1歳の子の親子相関よりも著しく高く，遺伝子型の発現は15歳から17歳の子で70%から90%である．したがって，Furusho の資料で得られた被爆群と非被爆群の子の差は Neel と Schull の資料から得た差よりも原爆放射線による遺伝的影響がより大きいことが十分考えられる．

However, in neither the Furusho data nor those of Neel and Schull are the differences between the exposed group and the nonexposed group, for the most part, of a significant level, and although definitive conclusions at the statistical level cannot be made with these data, it seems clear that the nature of the estimates of the differences obtained by the two studies are altogether different.

しかし，Furusho の資料および Neel と Schull の資料はいずれも，被爆群と非被爆群の差がおおむね有意水準に達せず，これらの資料を用いた統計的水準で結論を導くことはできないが，両研究で得られた差の推定値の性質が全く異なることは明らかであろう．

The peaceful uses of atomic energy, diagnostic X-ray irradiation, therapeutic X-ray exposures, injections of radioisotopes, radium therapy, and nuclear tests have rapidly increased the chances of exposure to radiation of man during

原子力の平和利用，医学的診断のためのX線照射，治療のためのX線照射，放射性同位元素の注射，ラジウム治療，あるいは核爆発実験によって人類が日常生活において放射線にさらされる機会が急激に

his daily life and have increased the possibility of deterioration of man's genetic components. Therefore, the accurate determination of the genetic effects of radiation in man is not only an urgent and important problem but also our obligation to posterity. The data used in the present study were obtained in an investigation of all primary schools, junior high schools, and senior high schools in an A-bomb exposed city and the data presented here are for all senior high schools in Hiroshima City. But in any case, it is impossible to collect more cases and consequently although the number of cases in the exposed group is insufficient, this comprehensive and methodical study, in which estimates of the parental exposure dose are available, may constitute the only study which will provide information on the genetic effects of radiation in man. Because analysis will also be made of the Nagasaki data in the future, with which a comparative study will have to be made, all of the estimates on which detailed analysis was attempted are shown in the tables.

増加するとともにその遺伝的構成要素が悪化するおそれが多くなった．それだけに，放射線がヒトに及ぼす遺伝的影響を正確に知ることは緊急かつ重要な問題であるばかりでなく子孫に対する我々の義務でもある．本研究に用いた資料は原爆被爆都市の全小学校，中学校，および高校を対象に調査して得たもので，ここでは広島市の全高校の資料を検討した．いずれにせよ調査例数をこれ以上増やすことは不可能であり，被爆群の調査例数が不十分ではあるが，この全体的組織的な調査では，親の被曝線量の推定値も入手されており，ヒトに対する放射線の遺伝的影響を知る唯一のものであろう．今後長崎の資料の分析も行い，これと比較検討を行うため，詳細な分析を試みた推定値をすべて表に示した．

TABLE 1 MEAN, VARIANCE, COVARIANCE, & CORRELATION COEFFICIENT BY PARENTAL RADIATION DOSE (FATHER + MOTHER)

表1 親の被曝線量別平均，分散，共分散，および相関係数（父＋母の線量）

Item	Non-exposed	Radiation Dose in rad							
		<1	1-9	10-19	20-39	40-99	100-199	200+	1+
Boys Aged 15 Years									
No. of offspring	3039	369	140	68	40	41	22	32	343
Mean dose ($\bar{D}$)	0	?	4.0	14.3	28.1	66.4	139.5	398.1	61.8
Mean (M_O)	163.70	163.96	164.10	163.43	165.31	163.16	162.90	164.59	163.96
Variance (V_O)	36.30	39.63	35.78	26.42	39.24	36.98	41.80	27.50	34.04
Covariance ($W_{F+M\cdot O}$)	20.22	17.13	28.44	10.93	20.52	15.16	39.01	25.40	23.01
Correlation coefficient ($r_{F+M\cdot O}$)	0.399	0.317	0.508	0.277	0.336	0.326	0.613	0.580	0.447
Boys Aged 16 Years									
No. of offspring	3388	420	173	91	42	59	29	30	424
Mean dose ($\bar{D}$)	0	?	4.1	14.8	27.9	64.9	134.1	484.1	60.1
Mean (M_O)	165.76	166.57	166.24	165.71	166.49	164.96	165.52	164.35	165.79
Variance (V_O)	30.76	32.39	26.40	38.79	28.24	38.66	42.31	29.69	32.25
Covariance ($W_{F+M\cdot O}$)	20.58	22.75	16.37	26.12	20.71	24.55	36.70	20.19	21.42
Correlation coefficient ($r_{F+M\cdot O}$)	0.426	0.442	0.400	0.491	0.457	0.488	0.708	0.471	0.463
Boys Aged 17 Years									
No. of offspring	3163	399	174	79	40	59	38	43	433
Mean dose ($\bar{D}$)	0	?	3.8	14.4	29.6	62.8	134.5	367.3	63.7
Mean (M_O)	166.80	167.44	167.38	167.64	167.71	167.42	166.02	167.29	167.34
Variance (V_O)	30.95	33.05	30.95	35.87	24.74	34.36	20.77	21.86	29.80
Covariance ($W_{F+M\cdot O}$)	19.16	18.09	23.41	24.55	14.74	25.98	12.28	14.89	21.23
Correlation coefficient ($r_{F+M\cdot O}$)	0.404	0.393	0.473	0.460	0.332	0.546	0.409	0.364	0.453
Girls Aged 15 Years									
No. of offspring	2862	436	146	64	45	52	35	32	374
Mean dose ($\bar{D}$)	0	?	3.8	14.5	29.1	64.2	138.5	407.3	64.2
Mean (M_O)	154.46	154.74	154.47	154.67	154.45	155.73	154.13	153.82	154.59
Variance (V_O)	24.39	23.55	21.86	18.31	23.94	18.79	19.35	24.52	21.05
Covariance ($W_{F+M\cdot O}$)	18.41	19.82	17.70	15.96	15.10	10.87	24.18	14.90	16.69
Correlation coefficient ($r_{F+M\cdot O}$)	0.462	0.457	0.435	0.444	0.380	0.346	0.620	0.416	0.439
Girls Aged 16 Years									
No. of offspring	3059	429	160	79	49	51	40	27	406
Mean dose ($\bar{D}$)	0	?	4.2	14.7	27.9	62.2	143.5	440.6	59.1
Mean (M_O)	154.89	154.86	155.11	154.63	155.99	155.88	154.73	157.13	155.32
Variance (V_O)	23.81	24.86	24.94	19.09	25.24	25.42	24.66	30.29	24.37
Covariance ($W_{F+M\cdot O}$)	19.07	16.44	21.51	19.39	24.48	21.58	18.78	16.08	20.78
Correlation coefficient ($r_{F+M\cdot O}$)	0.488	0.406	0.510	0.567	0.568	0.445	0.490	0.345	0.499
Girls Aged 17 Years									
No. of offspring	2884	441	154	70	46	59	37	30	396
Mean dose ($\bar{D}$)	0	?	3.8	14.4	28.5	69.9	128.7	418.0	61.5
Mean (M_O)	154.95	155.50	155.61	155.33	154.68	155.39	155.40	156.35	155.46
Variance (V_O)	24.79	27.65	28.21	21.15	18.50	19.24	44.04	28.12	25.78
Covariance ($W_{F+M\cdot O}$)	18.30	20.67	26.24	15.66	13.44	16.82	33.60	31.57	22.22
Correlation coefficient ($r_{F+M\cdot O}$)	0.464	0.507	0.573	0.423	0.488	0.444	0.592	0.608	0.524

TABLE 2 RELATION OF NONEXPOSED VS <1 RAD AND NONEXPOSED VS 1+ RAD

表 2 「非被爆群」と「1 rad 未満群」の比較および「非被爆群」と「1 rad 以上群」の比較

Item	Nonexposed vs <1 rad				Nonexposed vs 1+rad			
	Nonexposed	<1 rad	Test	P	Nonexposed	1+ rad	Test	P
Boys Aged 15 Years								
Mean	163.70	163.96	.753	NS	163.70	163.96	.780	NS
Variance	36.30	39.63	1.092	NS	36.30	34.04	1.066	NS
Covariance	20.22	17.13	-	-	20.22	23.01	-	-
Z-value	.40	.32	1.702	Sug	.40	.45	1.023	NS
$W^{*}_{F+M \cdot O}$	17.12	13.87	-	-	17.12	18.08	-	-
$Z^{*}_{F+M \cdot O}$	.35	.26	1.607	NS	.35	.37	.258	NS
Boys Aged 16 Years								
Mean	165.76	166.57	2.759	P<.01	165.76	165.79	.103	NS
Variance	30.76	32.39	1.053	NS	30.76	32.25	1.048	NS
Covariance	20.58	22.75	-	-	20.58	21.42	-	-
Z-value	.43	.44	.380	NS	.43	.46	.893	NS
$W^{*}_{F+M \cdot O}$	16.63	18.89	-	-	16.63	18.45	-	-
$Z^{*}_{F+M \cdot O}$	.36	.38	.485	NS	.36	.42	1.235	NS
Boys Aged 17 Years								
Mean	166.80	167.44	2.103	P<.05	166.80	167.34	1.926	Sug
Variance	30.95	33.05	1.068	NS	30.95	29.80	1.039	NS
Covariance	19.16	18.09	8.445	-	-	21.23	-	-
Z-value	.40	.39	.245	NS	.40	.45	1.168	NS
$W^{*}_{F+M \cdot O}$	16.16	15.62	4.262	-	-	17.81	-	-
$Z^{*}_{F+M \cdot O}$	.36	.35	.042	NS	.36	.40	.872	NS
Girls Aged 15 Years								
Mean	154.46	154.74	1.120	NS	154.46	154.59	.511	NS
Variance	24.39	23.55	1.036	NS	24.39	21.05	1.159	Sug
Covariance	18.41	19.82	-	-	18.41	16.69	-	-
Z-value	.46	.44	.123	NS	.46	.46	.523	NS
$W^{*}_{F+M \cdot O}$	16.07	14.99	-	-	16.07	13.47	-	-
$Z^{*}_{F+M \cdot O}$	.43	.36	1.286	NS	.43	.37	1.037	NS
Girls Aged 16 Years								
Mean	154.89	154.86	.117	NS	154.89	155.32	1.651	Sug
Variance	23.81	24.86	1.044	NS	23.81	24.37	1.024	NS
Covariance	19.07	16.44	-	-	19.07	20.78	-	-
Z-value	.49	.41	1.984	P<.05	.49	.50	.274	NS
$W^{*}_{F+M \cdot O}$	15.99	14.38	-	-	15.99	17.39	-	-
$Z^{*}_{F+M \cdot O}$	.43	.37	1.223	NS	.43	.44	.182	NS
Girls Aged 17 Years								
Mean	154.95	155.50	2.060	P<.05	154.95	155.46	1.879	Sug
Variance	24.79	27.65	1.115	P<.05	24.79	25.78	1.040	NS
Covariance	18.30	20.67	22.908	-	-	22.22	-	-
Z-value	.46	.51	1.098	NS	.46	.52	1.477	NS
$W^{*}_{F+M \cdot O}$	16.44	18.19	16.915	-	-	17.87	-	-
$Z^{*}_{F+M \cdot O}$	.44	.48	.695	NS	.44	.45	.090	NS

NS: Not significant Sub: .05<P≤.10

TABLE 3 REGRESSION COEFFICIENT OF MEAN, VARIANCE, COVARIANCE, & Z-VALUE OF CORRELATION COEFFICIENT

表3　平均，分散，共分散，および相関係数のZ値への回帰係数

Item	Regression for Nonexposed & Exposed Data				Regression for Exposed Data			
	Constant	Slope	T-value	(df=5)	Constant	Slope	T-value	(df=4)
Boys Aged 15 Years								
Mean (M_O)	163.7	.00172	.935	NS	163.9	.00121	.564	NS
Variance (V_O)	36.3	−.02217	-	-	33.7	−.01312	-	-
Covariance ($W_{F+M\cdot O}$)	20.2	.00509	-	-	20.6	.00320	-	-
Z-value ($Z_{F+M\cdot O}$)	.424	.00061	1.430	NS	.441	.00055	1.155	NS
$W^*_{F+M\cdot O}$	17.119	−.00213	-	-	16.6	.00044	-	-
$Z^*_{F+M\cdot O}$	.351	.00029	.992	NS	.338	.00033	1.037	NS
Boys Aged 16 Years								
Mean (M_O)	165.8	−.00300	2.094	Sug	166.1	−.00388	3.087	$P<.05$
Variance (V_O)	30.7	.00019	-	-	27.9	.00895	-	-
Covariance ($W_{F+M\cdot O}$)	20.6	.00344	-	-	18.1	.01187	-	-
Z-value ($Z_{F+M\cdot O}$)	.458	.00036	1.047	NS	.491	.00026	.698	NS
$W^*_{F+M\cdot O}$	16.6	.00765	-	-	15.2	.01242	-	-
$Z^*_{F+M\cdot O}$	.363	.00040	1.280	NS	.409	.00025	.810	NS
Boys Aged 17 Years								
Mean (M_O)	166.9	.00081	.434	NS	167.4	−.00118	.739	NS
Variance (V_O)	31.0	−.02598	-	-	31.3	−.02712	-	-
Covariance ($W_{F+M\cdot O}$)	19.2	−.01274	-	-	22.9	−.02684	-	-
Z-value ($Z_{F+M\cdot O}$)	.436	−.00003	.081	NS	.510	−.00033	1.310	NS
$W^*_{F+M\cdot O}$	16.2	−.00989	-	-	19.2	−.02136	-	-
$Z^*_{F+M\cdot O}$	.361	.00004	.130	NS	.415	−.00018	.672	NS
Girls Aged 15 Years								
Mean (M_O)	154.5	−.00082	.435	NS	154.7	−.00182	.967	NS
Variance (V_O)	24.4	−.02286	-	-	20.6	.00046	-	-
Covariance ($W_{F+M\cdot O}$)	18.4	−.01128	-	-	16.6	−.00253	-	-
Z-value ($Z_{F+M\cdot O}$)	.496	−.00003	.112	NS	.461	.00010	.314	NS
$W^*_{F+M\cdot O}$	16.1	−.01566	-	-	13.5	−.00291	-	-
$Z^*_{F+M\cdot O}$	.421	−.00018	.846	NS	.361	.00006	.504	NS
Girls Aged 16 Years								
Mean (M_O)	154.9	.00463	2.349	Sug	155.0	.00407	1.977	NS
Variance (V_O)	23.8	.01174	-	-	23.1	.01510	-	-
Covariance ($W_{F+M\cdot O}$)	19.1	.00015	-	-	21.1	−.01228	-	-
Z-value ($Z_{F+M\cdot O}$)	.539	−.00032	1.350	NS	.593	−.00053	2.855	$P<.05$
$W^*_{F+M\cdot O}$	16.0	.00425	-	-	17.7	−.00599	-	-
$Z^*_{F+M\cdot O}$	.439	−.00019	.782	NS	.480	−.00036	1.507	NS
Girls Aged 17 Years								
Mean (M_O)	155.0	.00344	2.400	Sug	155.3	.00218	1.673	NS
Variance (V_O)	24.8	.00047	-	-	24.9	.00096	-	-
Covariance ($W_{F+M\cdot O}$)	18.3	.02857	-	-	21.1	.01311	-	-
Z-value ($Z_{F+M\cdot O}$)	.508	.00052	1.479	NS	.566	.00029	.849	NS
$W^*_{F+M\cdot O}$	16.4	.00733	-	-	17.4	.00212	-	-
$Z^*_{F+M\cdot O}$	.445	−.00002	.070	NS	.454	−.00005	.203	NS

TABLE 4 COVARIANCE & CORRELATION COEFFICIENT OF STATURE BETWEEN PARENTS & OFFSPRING CORRECTED FOR CORRELATION BETWEEN PARENTS

表4　両親の相関で補正した親子の身長の共分散および相関係数

Item	Radiation Dose in rad								
	Nonexposed	<1	1-9	10-19	20-39	40-99	100-199	200+	1+
Boys Aged 15 Years									
No. of offspring	3039	369	140	68	40	41	22	32	343
Mean Dose ($\bar{D}$)	0	?	4.0	14.3	28.1	66.4	139.5	398.1	61.8
Variance (V_O)	36.30	39.63	35.78	26.42	39.24	36.98	41.80	27.50	34.04
	(6.03)	(6.30)	(5.98)	(5.14)	(6.26)	(6.08)	(6.47)	(5.24)	(5.84)
Variance (V_{F+M})	70.64	73.63	87.52	58.85	94.83	58.55	97.03	69.63	78.02
	(8.41)	(8.58)	(9.36)	(7.67)	(9.74)	(7.65)	(9.85)	(8.34)	(8.83)
Covariance ($W_{F+M \cdot O}$)	20.22	17.13	28.44	10.93	20.52	15.16	39.01	25.40	23.01
Correlation coefficient ($r_{F+M \cdot O}$)	0.399	0.317	0.508	0.277	0.336	0.326	0.613	0.580	0.447
Correlation coefficient (r_{FM})	0.182	0.235	0.252	0.124	0.398	0.295	0.611	0.249	0.274
$r^*_{F+M \cdot O}$	0.338	0.257	0.406	0.246	0.240	0.252	0.381	0.464	0.351
W^*	17.12	13.87	22.71	9.72	14.65	11.71	24.25	20.29	18.09
W^{**}	17.11	13.87	22.72	9.72	14.68	11.71	24.21	20.34	18.06
$\bar{W}^*$	17.12	13.87	22.72	9.72	14.67	11.71	24.23	20.32	18.08
Boys Aged 16 Years									
No. of offspring	3388	420	173	91	42	59	29	30	424
Mean Dose ($\bar{D}$)	0	?	4.1	14.8	27.9	64.9	134.1	484.1	60.1
Variance (V_O)	30.76	32.39	26.40	38.79	28.24	38.66	42.31	29.69	32.25
	(5.55)	(5.69)	(5.14)	(6.23)	(5.31)	(6.22)	(6.51)	(5.45)	(5.68)
Variance (V_{F+M})	75.81	81.81	63.46	73.08	72.79	65.52	63.44	61.87	66.27
	(8.71)	(9.05)	(7.97)	(8.55)	(8.53)	(8.09)	(7.97)	(7.87)	(8.14)
Covariance ($W_{F+M \cdot O}$)	20.58	22.75	16.37	26.12	20.71	24.55	36.70	20.19	21.42
Correlation coefficient ($r_{F+M \cdot O}$)	0.426	0.442	0.400	0.491	0.457	0.488	0.708	0.471	0.463
Correlation coefficient (r_{FM})	0.238	0.205	0.197	0.221	0.071	0.106	0.125	0.144	0.161
$r^*_{F+M \cdot O}$	0.344	0.366	0.334	0.402	0.427	0.441	0.629	0.412	0.399
W^*	16.63	18.89	13.69	21.42	19.33	22.20	32.65	17.66	18.44
W^{**}	16.62	18.88	13.68	21.39	19.34	22.20	32.62	17.65	18.45
$\bar{W}^*$	16.63	18.89	13.69	21.41	19.34	22.20	32.64	17.66	18.45
Boys Aged 17 Years									
No. of offspring	3163	399	174	79	40	59	38	43	433
Mean Dose ($\bar{D}$)	0	?	3.8	14.4	29.6	62.8	134.5	367.3	63.7
Variance (V_O)	30.95	33.05	30.95	35.87	24.74	34.36	20.77	21.86	29.80
	(5.56)	(5.75)	(5.56)	(5.99)	(4.97)	(5.86)	(4.56)	(4.68)	(5.46)
Variance (V_{F+M})	72.76	64.00	79.09	79.56	79.63	65.93	43.34	76.51	73.76
	(8.53)	(8.00)	(8.89)	(8.92)	(8.92)	(8.12)	(6.58)	(8.75)	(8.59)
Covariance ($W_{F+M \cdot O}$)	19.16	18.09	23.41	24.55	14.74	25.98	12.28	14.89	21.23
Correlation coefficient ($r_{F+M \cdot O}$)	0.404	0.393	0.473	0.460	0.332	0.546	0.409	0.364	0.453
Correlation coefficient (r_{FM})	0.186	0.158	0.208	0.386	0.099	0.132	−0.125	0.278	0.193
$r^*_{F+M \cdot O}$	0.341	0.339	0.392	0.332	0.302	0.482	0.364	0.285	0.380
W^*	16.16	15.61	19.35	17.73	13.39	22.95	10.91	11.66	17.81
W^{**}	16.16	15.62	19.38	17.72	13.41	22.95	10.92	11.65	17.80
$\bar{W}^*$	16.16	15.62	19.37	17.73	13.40	22.95	10.92	11.66	17.81

$r^*_{F+M \cdot O} = \frac{r_{F+M \cdot O}}{(1 + r_{FM})}$, $W^* = r^*_{F+M \cdot O} \cdot V_O \cdot V_{F+M}$, $W^{**} = \frac{W_{F+M \cdot O}}{(1 + r_{FM})}$ and $\bar{W}^* = (W^* + W^{**})/2$ →

TABLE 4 Continued 表4続き

Item	Radiation Dose in rad								
	Nonexposed	<1	1-9	10-19	20-39	40-99	100-199	200+	1+
Girls Aged 15 Years									
No. of offspring	2862	436	146	64	45	52	35	32	374
Mean Dose ($\bar{D}$)	0	?	3.8	14.5	29.1	64.2	138.5	407.3	64.2
Variance (V_O)	24.39	23.55	21.86	18.31	23.94	18.79	19.35	24.52	21.05
	(4.94)	(4.85)	(4.68)	(4.28)	(4.89)	(4.34)	(5.40)	(4.95)	(4.59)
Variance (V_{F+M})	65.14	79.74	75.58	70.56	66.00	52.70	78.63	52.19	68.75
	(8.07)	(8.93)	(8.69)	(8.40)	(8.12)	(7.26)	(8.87)	(7.23)	(8.29)
Covariance ($W_{F+M \cdot O}$)	18.41	19.82	17.70	15.96	15.10	10.87	24.18	14.90	16.69
Correlation coefficient ($r_{F+M \cdot O}$)	0.462	0.457	0.435	0.444	0.380	0.346	0.620	0.416	0.439
Correlation coefficient (r_{FM})	0.146	0.321	0.215	0.357	0.174	0.077	0.469	0.185	0.240
$r^*_{F+M \cdot O}$	0.403	0.346	0.358	0.327	0.324	0.321	0.422	0.351	0.354
W*	16.07	14.98	14.56	11.76	12.85	10.12	16.47	12.56	13.47
W**	16.06	15.00	14.57	11.76	12.86	10.09	16.46	12.57	13.46
$\bar{W}$*	16.07	14.99	14.57	11.76	12.86	10.11	16.47	12.57	13.47
Girls Aged 16 Years									
No. of offspring	3059	429	160	79	49	51	40	27	406
Mean Dose ($\bar{D}$)	0	?	4.2	14.7	27.9	62.2	143.5	440.6	59.1
Variance (V_O)	23.81	24.86	24.94	19.09	25.24	25.42	24.66	30.29	24.37
	(4.88)	(4.99)	(4.99)	(4.37)	(5.02)	(5.04)	(4.97)	(5.50)	(4.94)
Variance (V_{F+M})	64.21	65.85	71.25	61.16	73.60	92.68	59.67	71.54	71.04
	(8.01)	(8.12)	(8.44)	(7.82)	(8.58)	(9.63)	(7.73)	(8.46)	(8.43)
Covariance ($W_{F+M \cdot O}$)	19.07	16.44	21.51	19.39	24.48	21.58	18.78	16.08	20.78
Correlation coefficient ($r_{F+M \cdot O}$)	0.488	0.406	0.510	0.567	0.568	0.445	0.490	0.345	0.499
Correlation coefficient (r_{FM})	0.193	0.144	0.236	0.087	0.286	0.220	0.087	0.158	0.195
$r^*_{F+M \cdot O}$	0.409	0.355	0.413	0.522	0.442	0.364	0.451	0.298	0.417
W*	15.99	14.38	17.38	17.83	19.02	17.70	17.32	13.86	17.39
W**	15.98	14.38	17.40	17.84	19.04	17.69	17.28	13.89	17.39
$\bar{W}$*	15.99	14.38	17.39	17.84	19.03	17.70	17.30	13.88	17.39
Girls Aged 17 Years									
No. of offspring	2884	441	154	70	46	59	37	30	396
Mean Dose ($\bar{D}$)	0	?	3.8	14.4	28.5	69.9	128.7	418.0	61.5
Variance (V_O)	24.79	27.65	28.21	21.15	18.50	19.24	44.04	28.12	25.78
	(4.98)	(5.26)	(5.31)	(4.60)	(4.30)	(4.39)	(6.64)	(5.30)	(5.08)
Variance (V_{F+M})	62.89	60.22	74.33	64.81	40.93	74.66	73.08	96.03	69.79
	(7.93)	(7.76)	(8.62)	(8.05)	(6.40)	(8.64)	(8.55)	(9.80)	(8.35)
Covariance ($W_{F+M \cdot O}$)	18.30	20.67	26.24	15.66	13.44	16.82	33.60	31.57	22.22
Correlation coefficient ($r_{F+M \cdot O}$)	0.464	0.507	0.573	0.423	0.488	0.444	0.592	0.608	0.524
Correlation coefficient (r_{FM})	0.114	0.137	0.249	0.305	0.008	0.209	0.270	0.495	0.244
$r^*_{F+M \cdot O}$	0.417	0.446	0.459	0.324	0.484	0.367	0.466	0.407	0.421
W*	16.45	18.20	21.00	12.00	13.32	13.93	26.46	21.12	17.87
W**	16.43	18.18	21.01	12.00	13.33	13.91	26.46	21.12	17.86
$\bar{W}$*	16.44	18.19	21.01	12.00	13.33	13.92	26.46	21.12	17.87

TABLE 5 MEAN, VARIANCE, COVARIANCE, & CORRELATION COEFFICIENT BY PARENTAL DOSE & AGE BETWEEN SIB-PAIRS

表 5　親の被曝線量別・年齢別，同胞間の平均，分散，共分散および相関係数

Item	Age in Years											
	Brother-Brother			Brother-Sister			Sister-Brother			Sister-Sister		
Elder (O)	17	17	16	17	17	16	17	17	16	17	17	16
~Younger (O')...	16	15	15	16	15	15	16	15	15	16	15	15
Nonexposed Parents												
No. of sib-pairs	28	185	25	30	178	27	38	197	39	32	224	30
Parent's mean dose in rad		0			0			0			0	
Elder: Mean (O)	166.17	167.33	165.21	167.85	166.92	165.69	154.27	154.71	154.55	154.10	154.87	154.19
: Variance (O)	40.52	32.57	21.79	25.86	30.10	56.59	23.37	22.89	32.53	29.65	22.91	22.91
Younger: Mean (O')	165.63	163.75	164.22	155.11	154.01	155.29	166.06	163.29	162.73	155.79	154.52	153.50
: Variance (O')	31.56	34.52	39.79	15.91	21.46	36.23	30.56	36.99	33.56	17.97	24.44	30.36
Covariance (OO')	24.93	13.16	0.99	8.40	12.60	12.37	11.29	11.34	16.35	12.68	9.96	15.19
$r_{OO'}$	0.697	0.393	0.034	0.414	0.496	0.273	0.423	0.390	0.495	0.549	0.421	0.576
r^*_{FM}	0.295	0.214	−0.005	0.074	0.152	0.062	0.203	0.056	−0.046	0.150	0.160	0.245
$r^*_{OO'}$	0.538	0.324	0.034	0.386	0.431	0.257	0.352	0.369	0.473	0.477	0.363	0.463
$W_{OO'}$	19.25	10.84	0.99	7.82	10.94	11.65	9.83	11.74	15.63	11.03	8.59	12.20
Exposed Parents (1 rad or more)												
No. of sib-pairs	3	32	2	8	38	5	7	33	4	9	41	4
Parent's mean dose in rad	3.33	66.8	8.5	20.0	89.50	9.0	16.6	41.8	34.8	15.1	54.4	106.5
Elder: Mean (O)	166.17	165.70	168.25	165.51	168.31	165.40	152.03	155.90	156.78	156.60	155.60	154.70
: Variance (O)	8.49	26.66	55.13	12.99	27.07	44.06	6.48	41.20	15.43	32.59	17.61	3.10
Younger: Mean (O')	168.30	164.25	161.30	155.00	155.32	153.04	163.44	164.02	161.45	155.53	154.69	154.03
: Variance (O')	19.83	43.49	100.82	13.77	19.36	10.75	21.59	41.24	26.91	32.97	23.86	7.82
Covariance (OO')	12.34	7.44	74.55	8.68	11.88	16.61	8.96	23.17	−8.80	19.79	12.92	0.05
$r_{OO'}$	0.951	0.218	1.000	0.649	0.519	0.763	0.758	0.562	−0.432	0.604	0.630	0.009
r^*_{FM}	−0.990	0.383	1.000	−0.002	0.313	0.702	0.262	0.349	−0.561	0.774	0.248	−0.440
$r^*_{OO'}$	0.478	0.158	0.500	0.648	0.395	0.448	0.601	0.417	0.277	0.341	0.505	0.006
$W_{OO'}$	6.20	5.38	37.28	8.66	9.05	9.76	7.10	17.18	5.64	11.16	10.35	0.035

TABLE 6 MEAN & VARIANCE OF OFFSPRING STATURE BY PARENTAL EXPOSURE STATUS

表6　親の被爆状態別，子の身長の平均と分散

Exposure Status		No. of Offspring	Mean Dose	Stature of Offspring	
Father	Mother			Mean	Variance
		Boys Aged 15 Years			
Nonexposed	Nonexposed	3039	0	163.70	36.30
Nonexposed	<1 rad	234	?	163.96	40.99
Nonexposed	1-9	86	3.8	164.63	31.46
Nonexposed	10-19	35	15.2	162.80	18.43
Nonexposed	20-99	49	49.2	163.78	32.44
Nonexposed	100+	21	348.9	164.85	26.11
Nonexposed	1+	191	55.5	164.10	28.84
<1 rad	Nonexposed	60	?	163.98	36.34
1-9	Nonexposed	28	3.7	162.52	48.64
10-19	Nonexposed	13	13.5	162.09	9.43
20-99	Nonexposed	8	35.3	163.36	28.91
100+	Nonexposed	6	307.3	160.90	59.03
1+	Nonexposed	55	43.7	162.36	36.05
Nonexposed 1+ rad	1+ rad Nonexposed	246	52.8	163.71	30.84
		Boys Aged 16 Years			
Nonexposed	Nonexposed	3383	0	165.76	30.76
Nonexposed	<1 rad	235	?	166.92	33.62
Nonexposed	1-9	98	3.8	166.66	25.62
Nonexposed	10-19	56	15.1	166.14	40.94
Nonexposed	20-99	46	51.4	166.11	32.58
Nonexposed	100+	25	339.2	163.51	21.58
Nonexposed	1+	225	53.6	166.07	30.89
<1 rad	Nonexposed	76	?	166.61	29.08
1-9	Nonexposed	37	3.8	166.46	22.74
10-19	Nonexposed	13	14.1	163.85	42.91
20-99	Nonexposed	11	46.1	164.86	85.81
100+	Nonexposed	14	370.6	165.94	50.84
1+	Nonexposed	75	80.3	165.68	39.55
Nonexposed 1+	1+ Nonexposed	300	60.3	165.97	32.96
		Boys Aged 17 Years			
Nonexposed	Nonexposed	3163	0	166.80	30.95
Nonexposed	<1 rad	227	?	167.94	34.24
Nonexposed	1-9	84	3.7	167.17	33.73
Nonexposed	10-19	34	14.2	167.21	46.87
Nonexposed	20-99	41	48.4	167.67	23.23
Nonexposed	100+	28	244.7	166.03	16.47
Nonexposed	1+	187	51.5	167.11	31.00
<1 rad	Nonexposed	63	?	166.67	30.38
1-9	Nonexposed	37	3.3	167.15	24.72
10-19	Nonexposed	12	15.0	168.95	35.55
20-99	Nonexposed	10	48.7	162.80	15.53
100+	Nonexposed	18	323.4	166.54	20.69
1+	Nonexposed	77	85.8	166.72	26.23
Nonexposed 1+	1+ Nonexposed	264	61.5	167.00	29.53

→

TABLE 6 Continued 表6続き

Exposure Status		No. of Offspring	Mean Dose	Stature of Offspring	
Father	Mother			Mean	Variance
		Girls Aged 15 Years			
Nonexposed	Nonexposed	2862	0	154.46	24.39
Nonexposed	<1 rad	290	?	155.25	21.34
Nonexposed	1-9	87	3.9	154.35	23.51
Nonexposed	10-19	37	14.5	155.30	19.37
Nonexposed	20-99	48	49.0	154.02	19.99
Nonexposed	100+	29	231.8	153.70	21.48
Nonexposed	1+	201	49.5	154.35	21.55
<1 rad	Nonexposed	60	?	153.77	20.51
1-9	Nonexposed	30	3.0	153.73	23.37
10-19	Nonexposed	8	14.6	154.11	19.86
20-99	Nonexposed	11	31.4	156.06	21.94
100+	Nonexposed	10	220.4	153.09	19.82
1+	Nonexposed	59	46.7	154.11	21.92
Nonexposed 1+	1+ Nonexposed	260	48.9	154.30	21.56
		Girls Aged 16 Years			
Nonexposed	Nonexposed	3059	0	154.89	23.81
Nonexposed	<1 rad	253	?	155.26	22.91
Nonexposed	1-9	85	3.9	155.00	30.25
Nonexposed	10-19	48	14.8	154.65	17.99
Nonexposed	20-99	59	41.3	155.73	20.98
Nonexposed	100+	32	250.7	156.30	27.78
Nonexposed	1+	224	51.4	155.30	24.82
<1 rad	Nonexposed	68	?	153.97	24.39
1-9	Nonexposed	22	3.6	156.14	12.34
10-19	Nonexposed	12	14.8	152.51	17.09
20-99	Nonexposed	14	42.1	155.64	31.41
100+	Nonexposed	12	221.9	153.88	29.93
1+	Nonexposed	60	58.5	154.85	22.15
Nonexposed 1+	1+ Nonexposed	284	52.9	155.21	24.21
		Girls Aged 17 Years			
Nonexposed	Nonexposed	2884	0	154.95	24.79
Nonexposed	<1 rad	232	?	155.60	25.17
Nonexposed	1-9	93	3.5	155.23	25.60
Nonexposed	10-19	38	14.2	154.63	16.38
Nonexposed	20-99	55	48.4	154.31	17.63
Nonexposed	100+	19	217.1	156.88	29.78
Nonexposed	1+	205	37.3	155.03	22.32
<1 rad	Nonexposed	71	?	154.93	34.07
1-9	Nonexposed	18	3.6	155.61	30.36
10-19	Nonexposed	5	14.0	155.94	23.89
20-99	Nonexposed	10	44.8	156.52	28.85
100+	Nonexposed	7	282.0	156.04	63.17
1+	Nonexposed	40	63.9	155.95	32.20
Nonexposed 1+	1+ Nonexposed	245	41.7	155.18	23.92

TABLE 7 COVARIANCE & CORRELATION COEFFICIENT MODIFIED BY CORRELATION BETWEEN PARENTS

表7　両親の相関で補正した共分散および相関係数

Exposure Status		Correlation Coefficient		Relation of Father (F) and Offspring (O)				Relation of Mother (M) and Offspring (O)			
Father	Mother	No. of cases	r_{FM}	W_{FO}	r_{FO}	W^*_{FO}	r^*_{FO}	W_{MO}	r_{MO}	W^*_{MO}	r^*_{MO}
				Boys Aged 15 Years							
Nonexposed	Nonexposed	3039	.182	10.68	.299	9.04	.253	9.54	.319	8.07	.270
Nonexposed	<1 rad	221	.168	6.61	.190	5.66	.163	5.62	.178	4.81	.152
Nonexposed	1-9	83	.220	20.53	.549	16.83	.450	10.01	.329	8.21	.270
Nonexposed	10-19	33	.067	1.80	.081	1.69	.076	−2.87	−.152	−2.69	−.143
Nonexposed	20-99	49	.327	8.09	.272	6.10	.205	14.24	.494	10.73	.372
Nonexposed	100+	21	.409	16.16	.490	11.47	.348	8.75	.468	6.21	.332
Nonexposed	1+	186	.242	13.09	.406	10.54	.327	8.71	.328	7.01	.264
<1 rad	Nonexposed	58	.347	12.41	.312	9.21	.232	12.82	.359	9.52	.267
1-9	Nonexposed	23	.218	20.20	.432	16.59	.355	7.56	.318	6.21	.261
10-19	Nonexposed	11	.101	13.00	.591	11.81	.537	−2.93	−.171	−2.66	−.155
20-99	Nonexposed	8	.310	14.08	.498	10.75	.380	3.45	.140	2.63	.107
100+	Nonexposed	6	.363	44.64	.868	32.75	.637	1.46	.036	1.07	.026
1+	Nonexposed	48	.223	18.97	.488	15.51	.399	4.36	.171	3.56	.140
Nonexposed 1+	1+ Nonexposed	234	.241	14.82	.435	11.94	.351	7.96	.299	6.41	.241
				Boys Aged 16 Years							
Nonexposed	Nonexposed	3388	238	10.90	.332	8.80	.268	9.68	.340	7.82	.275
Nonexposed	<1 rad	226	.207	11.01	.312	9.12	.259	8.61	.276	7.13	.229
Nonexposed	1-9	97	.297	7.61	.292	5.87	.225	8.19	.370	6.32	.285
Nonexposed	10-19	56	.160	14.35	.341	12.37	.294	8.56	.287	7.38	.247
Nonexposed	20-99	45	−.038	16.49	.420	15.90	.405	2.59	.101	2.50	.097
Nonexposed	100+	22	.010	10.85	.499	10.74	.494	6.71	.325	6.64	.322
Nonexposed	1+	220	.130	11.33	.348	10.03	.308	7.16	.286	6.34	.253
<1 rad	Nonexposed	74	.120	10.27	.367	9.17	.328	9.82	.280	8.77	.250
1-9	Nonexposed	36	.095	1.43	.053	1.31	.048	9.18	.461	8.38	.421
10-19	Nonexposed	13	.511	29.32	.639	19.40	.423	13.42	.714	8.88	.473
20-99	Nonexposed	10	.203	21.54	.447	17.91	.372	15.12	.442	12.57	.367
100+	Nonexposed	14	.297	26.16	.502	20.17	.387	14.71	.433	11.34	.334
1+	Nonexposed	73	.209	13.03	.339	10.78	.280	11.78	.475	9.74	.393
Nonexposed 1+	1+ Nonexposed	293	.151	11.74	.346	10.20	.301	8.32	.332	7.23	.288
				Boys Aged 17 Years							
Nonexposed	Nonexposed	3163	.186	10.83	.334	9.13	.282	8.33	.285	7.02	.240
Nonexposed	<1 rad	218	.202	11.26	.317	9.37	.264	10.93	.384	9.09	.320
Nonexposed	1-9	83	.233	12.00	.403	9.73	.327	14.20	.436	11.52	.354
Nonexposed	10-19	32	.543	21.65	.544	14.03	.353	16.82	.581	10.90	.377
Nonexposed	20-99	40	.090	10.75	.408	9.86	.374	12.05	.439	11.06	.403
Nonexposed	100+	28	.127	4.24	.208	3.76	.185	7.60	.385	6.74	.342
Nonexposed	1+	183	.213	12.31	.415	10.15	.342	13.30	.448	10.96	.369
<1 rad	Nonexposed	63	.070	.87	.028	.81	.026	5.74	.250	5.36	.234
1-9	Nonexposed	36	.252	5.40	.203	4.31	.162	9.94	.391	7.94	.312
10-19	Nonexposed	11	.668	23.06	.446	13.83	.267	15.71	.398	9.42	.239
20-99	Nonexposed	10	.309	10.06	.382	7.68	.292	5.35	.221	4.09	.169
100+	Nonexposed	17	.172	7.05	.276	6.02	.236	4.00	.186	3.41	.159
1+	Nonexposed	74	.351	9.05	.289	6.70	.214	9.85	.350	7.29	.259
Nonexposed 1+	1+ Nonexposed	257	.258	11.36	.376	9.03	.299	12.29	.421	9.77	.335

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TABLE 7 Continued 表7続き

Exposure Status		Correlation Coefficient		Relation of Father (F) and Offspring (O)				Relation of Mother (M) and Offspring (O)			
Father	Mother	No. of cases*	r_{FM}	W_{FO}	r_{FO}	W^*_{FO}	r^*_{FO}	W_{MO}	r_{MO}	W^*_{MO}	r^*_{MO}
				Girls Aged 15 Years							
Nonexposed	Nonexposed	2862	.146	9.61	.336	8.39	.293	8.80	.368	7.68	.321
Nonexposed	<1 rad	281	.178	9.91	.386	8.41	.328	5.66	.281	4.80	.239
Nonexposed	1-9	87	.209	9.93	.356	8.21	.295	8.51	.327	7.04	.271
Nonexposed	10-19	33	.337	7.66	.306	5.73	.229	8.43	.478	6.30	.358
Nonexposed	20-99	48	.333	9.55	.366	7.17	.275	10.63	.523	7.97	.392
Nonexposed	100+	29	.477	12.30	.490	8.33	.332	9.92	.508	6.72	.344
Nonexposed	1+	197	.292	10.00	.376	7.74	.291	9.19	.417	7.11	.323
<1 rad	Nonexposed	54	.607	15.30	.421	9.52	.262	17.05	.481	10.61	.299
1-9	Nonexposed	28	.139	19.55	.662	17.16	.546	9.75	.351	8.56	.308
10-19	Nonexposed	8	.601	15.50	.548	9.68	.342	4.29	.314	2.68	.196
20-99	Nonexposed	11	.009	19.25	.597	19.08	.592	7.98	.359	7.91	.356
100+	Nonexposed	10	−.067	8.34	.350	7.82	.328	12.68	.730	11.88	.684
1+	Nonexposed	57	.126	15.86	.523	14.09	.465	9.71	.416	8.62	.369
Nonexposed 1+	1+ Nonexposed	254	.256	11.31	.413	9.00	.329	9.31	.415	7.41	.330
				Girls Aged 16 Years							
Nonexposed	Nonexposed	3059	.193	10.49	.374	8.79	.314	8.58	.384	7.19	.322
Nonexposed	<1 rad	244	.097	7.39	.265	6.74	.242	6.09	.271	5.55	.247
Nonexposed	1-9	80	.200	16.03	.509	13.36	.424	9.46	.356	7.88	.297
Nonexposed	10-19	45	.130	7.47	.328	6.61	.290	8.74	.500	7.73	.443
Nonexposed	20-99	57	.203	8.59	.376	7.14	.313	8.69	.390	7.22	.324
Nonexposed	100+	30	.395	17.08	.660	12.24	.473	14.22	.488	10.19	.350
Nonexposed	1+	212	.220	12.25	.461	10.04	.378	9.64	.404	7.90	.331
<1 rad	Nonexposed	66	.258	11.46	.392	9.11	.312	10.99	.446	8.74	.355
1-9	Nonexposed	22	.197	3.36	.217	2.81	.181	10.18	.668	8.51	.558
10-19	Nonexposed	11	−.212	23.82	.671	19.65	.554	−8.17	−.359	−6.74	−.296
20-99	Nonexposed	12	.638	10.44	.344	6.37	.210	5.72	.141	3.49	.086
100+	Nonexposed	11	−.679	−10.05	−.331	−5.99	−.197	8.24	.480	4.91	.286
1+	Nonexposed	56	.048	7.64	.256	7.29	.244	5.06	.213	4.83	.203
Nonexposed 1+	1+ Nonexposed	268	.177	11.28	.413	9.58	.351	8.69	.364	7.38	.309
				Girls Aged 17 Years							
Nonexposed	Nonexposed	2884	.114	9.80	.339	8.80	.304	8.50	.357	7.63	.321
Nonexposed	<1 rad	228	.084	9.76	.345	9.00	.318	9.17	.408	8.46	.376
Nonexposed	1-9	92	.158	14.27	.471	12.32	.407	12.90	.538	11.14	.465
Nonexposed	10-19	38	.335	13.45	.618	10.07	.463	7.73	.417	5.79	.312
Nonexposed	20-99	52	.025	6.30	.307	6.15	.300	2.44	.145	2.38	.142
Nonexposed	100+	18	.520	11.97	.339	7.87	.223	14.03	.499	9.23	.328
Nonexposed	1+	200	.198	11.40	.430	9.52	.359	9.22	.428	7.70	.357
<1 rad	Nonexposed	66	.141	14.17	.427	12.42	.374	13.34	.468	11.69	.410
1-9	Nonexposed	17	.193	9.72	.249	8.15	.209	6.22	.263	5.21	.221
10-19	Nonexposed	5	.969	14.74	.516	7.49	.262	11.03	.578	5.60	.294
20-99	Nonexposed	10	.062	14.95	.425	14.08	.400	14.17	.449	13.34	.423
100+	Nonexposed	6	.601	48.83	.897	30.50	.560	15.65	.636	9.78	.397
1+	Nonexposed	38	.247	16.59	.447	13.31	.359	9.55	.372	7.66	.298
Nonexposed 1+	1+ Nonexposed	238	.206	12.18	.432	10.10	.358	9.20	.414	7.63	.343

TABLE 8 COMPARISON OF ESTIMATED VALUES BETWEEN OFFSPRING & AN EXPOSED FATHER & NONEXPOSED MOTHER - BOYS

表8　父被爆・母非被爆と子(男)の間の推定値の比較

Item	Father.... Nonexposed Mother.... Nonexposed (1)	<1 rad Nonexposed (2)	Test (1):(2) P		1+ rad Nonexposed (3)	Test (1):(3) P		1+ Nonexposed Nonexposed 1+ (4)	Test (1):(4) P	
					Boys Aged 15 Years					
Mean	163.70	163.98	.356	NS	162.36	1.640	NS	163.71	.027	NS
Variance	36.30	36.34	1.00	NS	36.05	1.01	NS	30.84	1.18	Sug
Covariance (W_{FO})	10.68	12.41	-	-	18.97	-	-	14.82	-	-
Covariance (W_{MO})	9.54	12.82	-	-	4.36	-	-	7.96	-	-
Z-value (Z_{FO})	.308	.323	.107	NS	.533	1.609	NS	.466	2.364	$P<.02$
Z-value (Z_{MO})	.331	.376	.335	NS	.173	1.074	NS	.308	.327	NS
W^*_{FO}	9.04	9.21	-	-	15.51	-	-	11.94	-	-
W^*_{MO}	8.07	9.52	-	-	3.56	-	-	6.41	-	-
Z^*_{FO}	.259	.236	.167	NS	.422	1.172	NS	.367	1.619	NS
Z^*_{MO}	.277	.274	.024	NS	.141	.925	NS	.246	.459	NS
					Boys Aged 16 Years					
Mean	165.76	166.61	1.358	NS	165.68	.109	NS	165.97	.609	NS
Variance	30.76	29.08	1.06	NS	39.55	1.94	$P<.01$	32.96	1.07	NS
Covariance (W_{FO})	10.90	10.27	-	-	13.03	-	-	11.74	-	-
Covariance (W_{MO})	9.68	9.82	-	-	11.78	-	-	8.32	-	-
Z-value (Z_{FO})	.345	.385	.337	NS	.353	.066	NS	.361	.261	NS
Z-value (Z_{MO})	.354	.288	.558	NS	.517	1.382	NS	.345	.150	NS
W^*_{FO}	8.80	9.17	-	-	10.78	-	-	10.20	-	-
W^*_{MO}	7.82	8.77	-	-	9.74	-	-	7.23	-	-
Z^*_{FO}	.275	.341	.557	NS	.288	.109	NS	.311	.593	NS
Z^*_{MO}	.282	.255	.225	NS	.415	1.132	NS	.296	.235	NS
					Boys Aged 17 Years					
Mean	166.80	166.67	.185	NS	166.72	.135	NS	167.00	.573	NS
Variance	30.95	30.38	1.02	NS	26.23	1.18	Sug	29.53	1.05	NS
Covariance (W_{FO})	10.83	.87	-	-	9.05	-	-	11.36	-	-
Covariance (W_{MO})	8.33	5.74	-	-	9.85	-	-	12.29	-	-
Z-value (Z_{FO})	.347	.028	2.450	$P<.02$	.297	.424	NS	.395	.746	NS
Z-value (Z_{MO})	.293	.255	.299	NS	.365	.611	NS	.449	2.423	$P<.02$
W^*_{FO}	9.13	.81	-	-	6.70	-	-	9.03	-	-
W^*_{MO}	7.02	5.36	-	-	7.29	-	-	9.77	-	-
Z^*_{FO}	.290	.026	2.025	$P<.05$	.219	.616	NS	.308	.288	NS
Z^*_{MO}	.245	.238	.050	NS	.265	.171	NS	.348	1.613	NS

TABLE 9 COMPARISON OF ESTIMATED VALUES BETWEEN OFFSPRING & A NONEXPOSED FATHER & EXPOSED MOTHER - BOYS

表9　父非被爆・母被爆と子(男)の間の推定値の比較

Item	Father .... Nonexposed Mother.... Nonexposed (1)	Nonexposed <1 rad (2)	Test (1):(2) P		Nonexposed 1+ rad (3)	Test (1):(3) P		1+ Nonexposed Nonexposed 1+ (4)	Test (1):(4) P	
Boys Aged 15 Years										
Mean	163.70	163.96	.601	NS	164.10	.991	NS	163.71	.027	NS
Variance	36.30	40.99	1.13	NS	28.84	1.26	Sug	30.84	1.18	P<.10
Covariance (W_{FO})	10.68	6.61	-	-	13.09	-	-	14.82	-	-
Covariance (W_{MO})	9.54	5.62	-	-	8.71	-	-	7.96	-	-
Z-value (Z_{FO})	.308	.192	1.701	P<.10	.431	1.628	NS	.466	2.364	P<.02
Z-value (Z_{MO})	.331	.180	2.189	P<.05	.341	.133	NS	.308	.327	NS
W^*_{FO}	9.04	5.66	-	-	10.54	-	-	11.94	-	-
W^*_{MO}	8.07	4.81	-	-	7.01	-	-	6.41	-	-
Z^*_{FO}	.259	.164	1.379	NS	.339	1.076	NS	.367	1.619	NS
Z^*_{MO}	.277	.153	1.797	P<.10	.270	.086	NS	.246	.459	NS
Boys Aged 16 Years										
Mean	165.76	166.92	2.974	P<.01	166.07	.810	NS	165.97	.609	NS
Variance	30.76	33.62	1.09	NS	30.89	1.00	NS	32.96	1.07	NS
Covariance (W_{FO})	10.90	11.01	-	-	11.33	-	-	11.74	-	-
Covariance (W_{MO})	9.68	8.61	-	-	7.16	-	-	8.32	-	-
Z-value (Z_{FO})	.345	.323	.329	NS	.363	.261	NS	.361	.261	NS
Z-value (Z_{MO})	.354	.283	1.030	NS	.294	.868	NS	.345	.150	NS
W^*_{FO}	8.80	9.12	-	-	10.03	-	-	10.20	-	-
W^*_{MO}	7.82	7.13	-	-	6.34	-	-	7.23	-	-
Z^*_{FO}	.275	.265	.143	NS	.318	.630	NS	.311	.593	NS
Z^*_{MO}	.282	.233	.715	NS	.259	.343	NS	.296	.235	NS
Boys Aged 17 Years										
Mean	166.80	167.94	2.844	P<.01	167.11	.740	NS	167.00	.573	NS
Variance	30.95	34.24	1.11	NS	31.00	1.00	NS	29.53	1.05	NS
Covariance (W_{FO})	10.83	11.26	-	-	12.31	-	-	11.36	-	-
Covariance (W_{MO})	8.33	10.93	-	-	13.30	-	-	12.29	-	-
Z-value (Z_{FO})	.347	.328	.275	NS	.442	1.244	NS	.395	.746	NS
Z-value (Z_{MO})	.293	.405	1.601	NS	.482	2.506	P<.02	.449	2.423	P<.02
W^*_{FO}	9.13	9.37	-	-	10.15	-	-	9.03	-	-
W^*_{MO}	7.02	9.09	-	-	10.96	-	-	9.77	-	-
Z^*_{FO}	.290	.270	.281	NS	.356	.877	NS	.308	.228	NS
Z^*_{MO}	.245	.332	1.246	NS	.387	1.889	P<.10	.348	1.613	NS

TABLE 10 COMPARISON OF ESTIMATED VALUES BETWEEN OFFSPRING & AN EXPOSED FATHER & NONEXPOSED MOTHER - GIRLS

表10　父被爆・母非被爆と子(女)の間の推定値の比較

Item	Father .... Nonexposed Mother.... Nonexposed (1)	<1 rad Nonexposed (2)	Test (1):(2) P	1+ rad Nonexposed (3)	Test (1):(3) P	1+ Nonexposed Nonexposed 1+ (4)	Test (1):(4) P
			Girls Aged 15 Years				
Mean	154.46	153.77	.811 NS	154.11	.227 NS	154.30	.055 NS
Variance	24.39	20.51	1.19 Sug	21.92	1.11 NS	21.56	1.13 NS
Covariance (W_{FO})	9.61	15.30	- -	15.86	- -	11.31	- -
Covariance (W_{MO})	8.80	17.05	- -	9.71	- -	9.31	- -
Z-value (Z_{FO})	.350	.449	.743 NS	.580	1.711 P<.10	.439	1.377 NS
Z-value (Z_{MO})	.386	.524	.997 NS	.443	.420 NS	.442	.853 NS
W^*_{FO}	8.39	9.52	- -	14.09	- -	9.00	- -
W^*_{MO}	7.68	10.61	- -	8.62	- -	7.41	- -
Z^*_{FO}	.302	.268	.251 NS	.504	1.496 NS	.342	.612 NS
Z^*_{MO}	.333	.308	.176 NS	.387	.404 NS	.343	.155 NS
			Girls Aged 16 Years				
Mean	154.89	153.97	1.513 NS	155.85	1.557 NS	155.21	1.031 NS
Variance	23.81	24.39	1.38 P<.01	22.15	1.52 P<.01	24.21	1.39 P<.01
Covariance (W_{FO})	10.49	11.46	- -	7.64	- -	11.28	- -
Covariance (W_{MO})	8.58	10.99	- -	5.06	- -	8.69	- -
Z-value (Z_{FO})	.393	.414	.168 NS	.262	.982 NS	.439	.740 NS
Z-value (Z_{MO})	.405	.480	.593 NS	.216	1.385 NS	.381	.364 NS
W^*_{FO}	8.79	9.11	- -	7.29	- -	9.58	- -
W^*_{MO}	7.19	8.74	- -	4.83	- -	7.38	- -
Z^*_{FO}	.325	.323	.018 NS	.249	.568 NS	.367	.667 NS
Z^*_{MO}	.334	.371	.295 NS	.206	.941 NS	.319	.226 NS
			Girls Aged 17 Years				
Mean	154.95	154.93	.029 NS	155.95	1.109 NS	155.18	.706 NS
Variance	24.79	34.07	1.37 P<.05	32.20	1.30 P<.05	23.92	1.04 NS
Covariance (W_{FO})	9.80	14.17	- -	16.59	- -	12.18	- -
Covariance (W_{MO})	8.50	13.34	- -	9.55	- -	9.20	- -
Z-value (Z_{FO})	.353	.456	.842 NS	.481	.774 NS	.462	1.634 NS
Z-value (Z_{MO})	.373	.508	1.069 NS	.391	.102 NS	.440	.997 NS
W^*_{FO}	8.80	12.42	- -	13.31	- -	10.10	- -
W^*_{MO}	7.63	11.69	- -	7.66	- -	7.63	- -
Z^*_{FO}	.314	.393	.645 NS	.376	.374 NS	.374	.906 NS
Z^*_{MO}	.333	.436	.820 NS	.307	.150 NS	.357	.368 NS

TABLE 11 COMPARISON OF ESTIMATED VALUES BETWEEN OFFSPRING & A NONEXPOSED FATHER & EXPOSED MOTHER - GIRLS

表11　父非被爆・母被爆と子(女)の間の推定値の比較

Item	Father .... Nonexposed Mother.... Nonexposed (1)	Nonexposed <1 rad (2)	Test (1):(2) P	Nonexposed 1+ rad (3)	Test (1):(3) P	1+ Nonexposed Nonexposed 1+ (4)	Test (1):(4) P
Girls Aged 15 Years							
Mean	154.46	155.25	2.757 P<.01	154.35	.323 NS	154.30	.529 NS
Variance	24.39	21.34	1.14 P≒.10	21.55	1.13 NS	21.56	1.13 NS
Covariance (W_{FO})	9.61	9.91	- -	10.00	- -	11.31	- -
Covariance (W_{MO})	8.80	5.66	- -	9.19	- -	9.31	- -
Z-value (Z_{FO})	.350	.407	.929 NS	.395	.623 NS	.439	1.377 NS
Z-value (Z_{MO})	.386	.289	1.567 NS	.444	.789 NS	.442	.853 NS
W^*_{FO}	8.39	8.41	- -	7.74	- -	9.00	- -
W^*_{MO}	7.68	4.80	- -	7.11	- -	7.41	- -
Z^*_{FO}	.302	.341	.626 NS	.300	.030 NS	.342	.612 NS
Z^*_{MO}	.333	.244	1.434 NS	.335	.030 NS	.343	.155 NS
Girls Aged 16 Years							
Mean	154.89	155.26	1.161 NS	155.30	1.175 NS	155.21	1.031 NS
Variance	23.81	22.91	1.04 NS	24.82	1.04 NS	24.21	1.02 NS
Covariance (W_{FO})	10.49	7.39	- -	12.25	- -	11.28	- -
Covariance (W_{MO})	8.58	6.09	- -	9.64	- -	8.69	- -
Z-value (Z_{FO})	.393	.271	1.848 P<.01	.499	1.515 NS	.439	.740 NS
Z-value (Z_{MO})	.405	.278	1.913 P<.10	.428	.331 NS	.381	.364 NS
W^*_{FO}	8.79	6.74	- -	10.04	- -	9.58	- -
W^*_{MO}	7.19	5.55	- -	7.90	- -	7.38	- -
Z^*_{FO}	.325	.247	1.187 NS	.398	1.044 NS	.367	.667 NS
Z^*_{MO}	.334	.252	1.232 NS	.344	.141 NS	.319	.226 NS
Girls Aged 17 Years							
Mean	154.95	155.60	1.900 Sug	155.03	.233 NS	155.18	.706 NS
Variance	24.79	25.17	1.02 NS	22.32	1.11 NS	23.92	1.04 NS
Covariance (W_{FO})	9.80	9.76	- -	11.40	- -	12.18	- -
Covariance (W_{MO})	8.50	9.17	- -	9.22	- -	9.20	- -
Z-value (Z_{FO})	.353	.360	.099 NS	.460	1.469 NS	.462	1.634 NS
Z-value (Z_{MO})	.373	.433	.870 NS	.457	1.154 NS	.440	.997 NS
W^*_{FO}	8.80	9.00	- -	9.52	- -	10.10	- -
W^*_{MO}	7.63	8.46	- -	7.70	- -	7.63	- -
Z^*_{FO}	.314	.329	.226 NS	.376	.849 NS	.375	.906 NS
Z^*_{MO}	.333	.395	.912 NS	.373	.559 NS	.357	.368 NS

TABLE 12 REGRESSION COEFFICIENT FOR THE RELATION BETWEEN EXPOSED FATHER & NONEXPOSED MOTHER

表12 父被爆群と母非被爆群間の関連した回帰係数

Item	Nonexposed & Exposed Father & Nonexposed Mother				Exposed Father & Nonexposed Mother			
	Constant	Slope	T-value (df=3)		Constant	Slope	T-value (df=2)	
Boys Aged 15 Years								
Mean	163.67	−.01190	1.271	NS	162.41	−.00426	1.185	NS
Variance	36.29	−.37051	-	-	13.75	.08607	-	-
Covariance (W_{FO})	10.68	.12483	-	-	17.19	.06441	-	-
Covariance (W_{MO})	9.53	−.03947	-	-	3.88	−.01135	-	-
Z-value (Z_{FO})	.31	.00357	3.041	P<.10	.50	.00271	5.201	P<.05
Z-value (Z_{MO})	.33	−.00123	.930	NS	.20	−.00065	.534	NS
W^*_{FO}	9.04	.08910	-	-	14.43	.03910	-	-
W^*_{MO}	8.07	−.03433	-	-	3.08	−.00955	-	-
Z^*_{FO}	.26	.00183	1.726	NS	.42	.00111	1.849	NS
Z^*_{MO}	.28	−.00105	.925	NS	.16	−.00052	−.513	NS
Boys Aged 16 Years								
Mean	165.76	.00023	.062	NS	166.00	−.00049	.128	NS
Variance	30.76	.05381	-	-	23.52	.07726	-	-
Covariance (W_{FO})	10.90	.03894	-	-	2.40	.06963	-	-
Covariance (W_{MO})	9.68	.01569	-	-	10.04	.01439	-	-
Z-value (Z_{FO})	.34	.00060	.689	NS	.24	.00093	1.000	NS
Z-value (Z_{MO})	.36	.00037	.466	NS	.58	−.00031	.561	NS
W^*_{FO}	8.80	.02890	-	-	2.01	.05342	-	-
W^*_{MO}	7.82	.01101	-	-	8.54	.00836	-	-
Z^*_{FO}	.273	.00039	.652	NS	.16	.00072	1.255	NS
Z^*_{MO}	.28	.00023	.439	NS	.46	−.00031	2.576	NS
Boys Aged 17 Years								
Mean	166.79	−.00198	.350	NS	166.39	−.00059	.087	NS
Variance	30.95	−.03471	-	-	25.06	−.01447	-	-
Covariance (W_{FO})	10.83	−.01206	-	-	6.02	.00364	-	-
Covariance (W_{MO})	8.33	−.01515	-	-	9.92	−.02101	-	-
Z-value (Z_{FO})	.35	−.00018	.484	NS	.28	.00005	.143	NS
Z-value (Z_{MO})	.29	−.00036	1.015	NS	.40	−.00077	3.491	P<.10
W^*_{FO}	9.13	−.01008	-	-	4.68	.00447	-	-
W^*_{MO}	7.02	−.01276	-	-	7.82	−.01571	-	-
Z^*_{FO}	.29	−.00015	.528	NS	.20	.00015	.839	NS
Z^*_{MO}	.25	−.00031	1.430	NS	.29	−.00050	2.657	NS

TABLE 13 REGRESSION COEFFICIENT FOR THE RELATION BETWEEN NONEXPOSED FATHER & EXPOSED MOTHER

表13 父非被爆群と母被爆群間の関連した回帰係数

Item	Nonexposed Father & Nonexposed & Exposed Mother				Nonexposed Father & Exposed Mother			
	Constant	Slope	T-value (df=3)		Constant	Slope	T-value (df=2)	
Boys Aged 15 Years								
Mean	163.71	.00303	1.023	NS	163.82	.00258	.734	NS
Variance	36.28	−.03929	-	-	29.08	−.00600	-	-
Covariance (W_{FO})	10.68	−.00955	-	-	9.14	.00346	-	-
Covariance (W_{MO})	9.54	.00107	-	-	8.42	.00640	-	-
Z-value (Z_{FO})	.31	.00056	.549	NS	.42	.00014	.130	NS
Z-value (Z_{MO})	.33	.00060	.603	NS	.28	.00081	.731	NS
W^*_{FO}	9.04	−.01638	-	-	7.52	−.00352	-	-
W^*_{MO}	8.07	−.00444	-	-	6.64	.00233	-	-
Z^*_{FO}	.26	.00021	.276	NS	.33	−.00007	.086	NS
Z^*_{MO}	.27	.00022	.272	NS	.21	.00048	.540	NS
Boys Aged 16 Years								
Mean	165.80	−.00625	2.129	NS	166.59	−.00911	14.596	$P<.01$
Variance	30.75	−.02586	-	-	27.67	−.01439	-	-
Covariance (W_{FO})	10.89	.00073	-	-	8.69	.00833	-	-
Covariance (W_{MO})	9.67	−.01080	-	-	7.97	−.00534	-	-
Z-value (Z_{FO})	.34	.00065	3.272	$P<.05$	.33	.00070	3.198	$P<.10$
Z-value (Z_{MO})	.35	−.00026	.509	NS	.31	−.00008	.145	NS
W^*_{FO}	8.79	.00694	-	-	6.95	.01329	-	-
W^*_{MO}	7.81	−.00576	-	-	6.26	.00014	-	-
Z^*_{FO}	.27	.00088	3.225	$P<.05$	.28	.00088	2.879	NS
Z^*_{MO}	.28	.000005	.012	NS	.24	.00016	.408	NS
Boys Aged 17 Years								
Mean	166.82	−.00237	1.062	NS	167.43	−.00536	3.533	Sug
Variance	30.95	−.06074	-	-	32.71	−.06870	-	-
Covariance (W_{FO})	10.83	−.02552	-	-	12.56	−.03379	-	-
Covariance (W_{MO})	8.34	.00051	-	-	14.22	−.02788	-	-
Z-value (Z_{FO})	.35	−.00037	.518	NS	.48	−.00108	2.534	NS
Z-value (Z_{MO})	.30	.00073	.702	NS	.51	−.00044	1.001	NS
W^*_{FO}	9.13	−.02055	-	-	10.19	−.02564	-	-
W^*_{MO}	7.03	.00223	-	-	11.69	−.02027	-	-
Z^*_{FO}	.29	−.00026	.675	NS	.37	−.00067	3.301	Sug
Z^*_{MO}	.25	.00068	1.054	NS	.39	−.00009	.568	NS

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