A CYTOGENETIC SURVEY OF DELINQUENT BOYS FOR THE XYY SYNDROME

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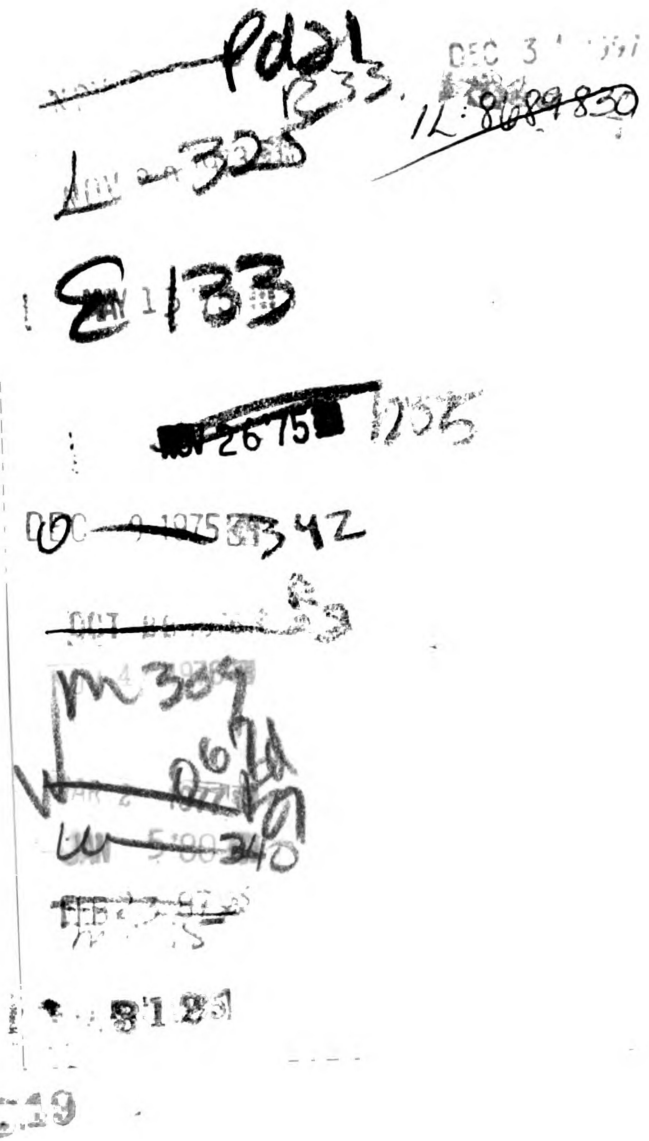

ABSTRACT

A CYTOGENETIC SURVEY OF DELINQUENT BOYS FOR THE XYY SYNDROME

by

Larry P. Yotti

In search of 47, XYY males among juvenile offenders, screens of Boys Training School in Lansing and Highfields Boys Camp in Onondaga were conducted. Based upon the literature which reported that the vast majority of XYY males were six feet or over, only those boys who were six feet tall or who were predicted to be that tall by the age of 16 years, 6 months were examined. No 47, XYY males were found among 75 boys examined although one 47, XXY Klinefelter male was found. In addition one suspected 46, XY/47, XXY male was found. The finding of no 47, XYY males among 75 male juvenile offenders is statistically significant when compared to the frequencies reported for similar institutions.

A CYTOGENETIC SURVEY OF DELINQUENT BOYS FOR THE XYY SYNDROME

by

Larry P. Yotti

A Thesis

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To my family

and

To Jovi

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION AND LITERATURE REVIEW

The 47, XYY chromosome complement was the last sex chromosome aneuploidy to be observed. The first XYY male reported in the literature was that of Sandberg et al. (1961), followed closely thereafter by a more detailed report of the same patient (Hauschka et al. 1962). The patient was seen by a physician because he was the father of a child with Downs Syndrome. He was a 44 year old white man with an unremarkable physical history.

Within the next four years twelve cases of XYY males were reported in the literature (Court Brown 1968). The vast majority of these individuals were ascertained on the basis of physical and/or psychological abnormalities which caused them to seek the help of a physician. The most prevalent physical abnormality seen in these twelve XYY males was undescended testes of hypogonadism.

Frequency of 47, XYY Karyotype in Normal Newborn Populations

Based upon the assumption that the vast majority of aneuploid individuals arise as a result of non-disjunction during the first or second meiotic division, XYY males would be the least common of all sex chromosome abnormalities at conception as they can only result from a non-disjunctional error in the second meiotic division of spermatogenesis. Therefore, for example, one would expect the frequency of XYY males at birth to be lower than the frequency of XXY Klinefelter males at birth (approximately 0.2% of the newborn male population, Jacobs et al. 1968).

The number of reports of the frequency of 47, XYY males at birth is limited. Stewart et al. (1969) examined 2500 consecutive liveborns, 184 of whom were congenitally abnormal and, therefore, were karyotyped. No XYY males were observed among the 184 individuals. Walzer et al. (1969) chromosomally examined 2400 phenotypically normal newborn infants from October 1965 to April 1968. The procedure involved chromosomal analysis of the first five newborns on a given day. None of the infants proved to be 47, XYY males. Gerald and Walzer (1970) examined more than 2000 male newborns in Boston, most of whom were selected because of normal phenotype and found no XYY males. Sergovich et al. (1969), using umbilical cord blood leucocytes as a source of nuclei, examined 2159 consecutively born infants (born within one calendar year) in a London, Ontario hospital. Chromosome cultures were successful on 2081 of the infants. Out of 1066 males, four were 47, XYY karyotypes, a frequency of 0.38%. Ratcliffe et al. (1970) conducted chromosome studies on 3496 consecutive, liveborn males. Five 47, XYY males were discovered, a frequency of 0.14%. Lubs and Ruddle (1970) examined the chromosomes of 4366 infants, born consecutively over a one year period at the Yale-New Haven Hospital. Among 2184 newborn males, three had a 47, XYY karyotype (a frequency of 0.14%).

If the studies of consecutive newborns (Sergovich et al. 1969; Ratcliffe et al. 1970; and Lubs and Ruddle 1970) are pooled it can be seen that an XYY karyotype occurred with a frequency of 0.18% of liveborn male births. Although one should realize (as seen above) that the literature reports frequencies of XYY among newborn males as

low as 0% and as high as 0.38%, the figure of 0.18% based only upon those studies which reported consecutive male newborns will be used for comparison purposes later in this paper.

Frequency of 47, XYY in Specialized Populations

Casey et al. (1966a) conducted a sex chromatin survey of two British hospitals for the mentally subnormal (mentally retarded), Rampton and Moss Side. These two hospitals house patients who are only mentally subnormal, but who also require special security. Among 942 patients, 21 were found to be sex chromatin positive, a frequency of 2.2%. Of these 21 males, seven were found to be XXYY. Among sex chromatin positive males, it was a highly unusual situation to find, upon karyotypic analysis, fully one third to be XXYY. Motivated by this abnormally high frequency of XXYY males among sex chromatin positive males in a security hospital for the mentally subnormal, Jacobs et al. (1965) conducted a chromosome survey of the Carstairs State Hospital in Scotland. Carstairs is a hospital which provides detention for dangerous, violent, or criminal individuals. Out of 315 men examined, nine were shown to be XYY, a frequency of 2.9% (Jacobs et al. 1968). The frequency of 2.9% observed at Carstairs represented greater than an 18 fold increase over the frequency of XYY seen among newborn males (0.18%). Consequently it appeared that maximum security hospitals were likely to contain XYY males in numbers greater than those found in newborn male populations. As a result investigations were conducted in a number of institutions similar to Carstairs in an attempt to determine the frequency of

XYY males.

Jacobs et al. (1965) in the report on the Carstairs State Hospital study in Scotland examined the heights of the XYY males discovered in that study. The mean height of the XYY males was 71.3 inches, substantially greater than the mean height of the remainder of the males in the hospital (67.0 inches). As a result of the Carstairs data concerning the apparent increased height of XYY males almost all subsequent screens of institutions selected a tall group of men, simply because it was within that group that one would expect the highest probability of finding an XYY male.

Casey et al. (1966b) found four XYY males among 50 tall (six feet or greater) patients in a mentally ill group detained because of anti-social behavior. Welch et al. (1967) surveyed an institution containing "defective delinquents"; defective defined as either intellectually or emotionally defective and delinquent defined as either antisocially or criminally delinquent. Among the 464 inmates, 97 were 72 inches or taller and eleven of the 97 had intelligence quotients less than 75. No XYY males were discovered in the eleven members of the tall, dull group selected by Welch et al.; however one XYY male was found in the institution. Daly (1969b) examined 210 tall (six feet or greater) male patients in four maximum security hospitals and found ten XYY males. This represents a frequency of 4.8%. Nielsen et al. (1968) examined the chromosomes of 37 out of 155 patients in a Danish institution for psychologically abnormal criminals, all of whom were over 180 cm. in height. Among the tall

prisoners, two proved to be 47, XYY, a frequency of 5.4%.

It became evident that maximum security hospitals did contain XYY males in frequencies much higher than those found in the newborn male population. Consequently, the hypothesis that the bearer of an extra Y chromosome might be predisposed to antisocial or criminal behavior became very popular.

Prosons were the next institutions which were screened in search of XYY males. Goodman et al. (1967) conducted a chromosome survey at a maximum security penal institution in Ohio. Among 3000 male inmates, 100 tall (greater than 73 inches) volunteers were selected, two of whom proved to be 47, XYY. This represents a frequency of 2%. Bartlett et al. (1968) examined 204 inmates of a security prison for the psychiatric treatment of offenders. The 204 inmates were consecutive admissions and among them two were 47, XYY males (a frequency of less than 1%). Wiener et al. (1968) found three XYY males among 34 prisoners in a Melbourne, Australia prison, all 34 of whom were from 175 to 210 cm. tall. This is a frequency of 8.8% among the tall group selected. Telfer et al. (1968) examined 115 tall (71 inches or taller) men in three different institutions for the care of criminal males in Pennsylvania. Four XYY males were found, a frequency of 3.5%. Marinello et al. (1969) found two XYY males among 86 tall (six feet or greater) men in a state prison, a frequency of 2.3%. Knox and Nevin (1969) found no XYY males among 67 prisoners in HM Prison in Belfast, North Ireland, all of whom were 177.5cm. or greater in height. Griffiths et al. (1970) examined the chromosomes of 355

prisoners in HM Prison, Wandsworth, London, all of whom were 5 feet 11 inches tall and over. Nine XYY males, a frequency of 2.5% were found. As seen above, prisons as well as maximum security hospitals had increased frequencies of XYY males; further adding support to the hypothesis that those who are XYY may be predisposed to antisocial and/or criminal behavior.

Institutions housing juvenile delinquents were the next most likely place to search for XYY males. Telfer et al. (1968) found one XYY male among 14 tall (greater than 71 inches) youths in a juvenile detention center in Pennsylvania, a frequency of 7.1%. Hunter (1968) examined 1021 "approved-school" (delinquent) boys in Britain and selected 34 boys whose height was at or over the 90th percentile for their age according to the Tanner and Whitehouse (1966) growth chart. Chromosome studies were successfully completed on 29 boys, three of whom proved to be 47, XYY. This represents a frequency of 10.3%. Marinello et al. (1969) found one XYY among 57 male juvenile offenders, none of whom was selected because of height. This is a frequency of 1.8%. Probably most complete was a study by Hook and Kim (1970) who examined the chromosomes of all 337 boys in a home for non-psychotic, non-retarded juvenile delinquents. Four XYY males were discovered, a frequency of 1.2%. As in maximum security hospitals and prisons, therefore, it appeared that the frequency of XYY males in juvenile detention institutions was higher than the frequency in newborn male populations.

The next group of people to receive attention in the search for

XYY males was the mentally ill, non-criminal population. Casey et al. (1966b) examined 30 mentally ill patients, none of whom was anti-social, and found no XYY males. Akesson et al. (1968) screened two Swedish mental hospitals and selected 96 men of 183 cm. or more. Among them three were XYY, a frequency of 3.1%. Anders et al. (1968) examined 529 male schizophrenic patients in a British mental hospital. None of the patients was selected on the basis of height and no one of them proved to be an XYY male.

One report (Casey et al. 1966b) described twelve XYY males among 50 tall (over six feet) patients (a frequency of 24%) in a mentally subnormal group detained because of antisocial behavior. No other investigation which screened institutions for the mentally subnormal who are also criminals appears in the literature.

Those who are mentally retarded but not criminal or antisocial have also been screened for XYY. Wiener et al. (1968) examined 30 mentally retarded men without criminal record who were 72 inches and taller and found no XYY males. In addition, they examined 300 retarded boys without height selection and again found no XYY karyotypes. Shapiro (1970a) screened mentally retarded patients at Letchworth Village in N. Y. Among 4000 patients, 55 were 5 feet 9 inches or taller, and among the tall patients one was an XYY, a frequency of 1.8%. Close et al. (1968) surveyed Darenth Park Hospital in Kent, a large psychiatric hospital for the mentally subnormal. There were 917 adult males in the hospital, 19 of whom were over six feet in height. Two of the 19 tall men were XYY, a frequency of 10.5%.

Groups of normal men have received very little attention in investigations designed to reveal XYY males. Court Brown (1968) examined 207 adult males from the ordinary adult population in Edinburgh and found no XYY males. Casey et al. (1966b) found no XYY males among 30 normal adult men. Goodman et al. (1968) chromosomally examined 36 college basketball players whose average height was 193 cm. (76 inches). No XYY males were seen.

The frequency of the XYY karyotype, as seen above, is highly variable depending upon the population under investigation. Table 1 summarizes the frequencies which have appeared in the literature.

Table 1. Previous Cytogenetic Surveys

	No. studied	XYY found	Per cent XYY
Prisons*			
unselected	598	7	1.2
tall	824	26	3.2
Maximum Security Institutions			
unselected	315	9	2.9
tall	308	16	5.2
Mental Illness Hospitals (non-criminal)			
unselected	559	0	0
tall	222	5	2.3
Mental Subnormality Hospitals (definite criminal tendencies)			
tall	50	12	24.0
Mental Retardation Hospitals (non-criminal)			
unselected	300	0	0
tall	104	3	2.8
Normal Adult Male Population			
unselected	237	0	0
tall	36	0	0
Newborn Male Population	6747	12	0.18

* Including Juvenile Deliquents

Height of 47, XYY Males

All of those XYY males reported in screens of institutions such as maximum security hospitals, prisons, juvenile detention centers, and mental retardation hospitals (with the exception of those screens which examined an entire institution regardless of height) were at or over the height designated in the specific report as tall (usually six feet or 183 cm.).

Those screens which have examined an institution without selecting a tall group in which to concentrate have found 47, XYY males who were not "tall". Price et al. (1966) reported that three of the nine XYY males found in the original Carstairs study were less than six feet tall Bartlett et al. (1968) found a 22 year old adult male in a screen of 204 inmates in a security prison for the psychiatric treatment of offenders who was only 70 inches tall. Wiener et al. (1968) found three XYY males in a survey of a Melbourne prison, one of whom was only 178 cm. in height.

Simply due to the fact that almost all the chromosome surveys of institutions selected a tall group in which to investigate, the vast majority of 47, XYY males discovered in these surveys were tall. However, the situation is very similar in those XYY males ascertained not on the basis of tallness or institutionalization, but rather fortuitously. Hauschka et al. (1962); Richards and Stewart (1966); Forssman (1967); Persson (1967); Thorburn et al. (1968); Forssman (1968); Lisker et al. (1968); Matthews and Brooks (1968); Stenchever and Macintyre (1969); and Rainer et al. (1969) have all

described 47, XYY males who were 183 cm. or greater in height. All of these XYY males were either normal or were ascertained on some basis other than tallness or institutionalization. On the other hand, however, the number of non-institutionalized 47, XYY males who are not "tall" is limited. Kelly et al. (1967) described a 24 year old XYY male who was of "average height". Wiener and Sutherland (1968) found a 41 year old normal man who was 182 cm. tall. Berghe et al. (1968) described a fifteen year old boy of average height and finally Lehrnbecher and Lucas (1969) reported finding a 67 year old, 5 feet 2 inch XYY male.

It would appear, therefore, that 47, XYY males are very likely to be six feet tall or greater and that increased height is likely to be a relatively consistent phenotypic characteristic of the XYY syndrome.

Mental Status of 47, XYY Males

The first 47, XYY male reported in the literature was of normal intelligence (Hauschka et al. 1962). The intelligence quotients of those XYY males randomly ascertained between 1962 and 1965 were very often not reported. However, the importance of testing the intelligence levels of XYY males became apparent following the report that eight of the nine XYY males in the Carstairs Hospital study were classified as high grade mental defectives or as "below average" in intelligence (Price et al. 1966). Subsequent to the Carstairs study the intelligence quotients (usually measured by the Wechsler Adult Intelligence Scale

or the Wechsler Intelligence Scale for Children) were generally reported for any XYY males found.

The following investigations reported XYY males who were below average in intelligence (IQ values less than 90): Casey et al. (1966b); Forssman (1967);Persson (1967); Kelly et al. (1967); Welch et al. (1967); Close et al. (1968); Hunter (1968); Berghe (1968); Marinello et al. (1969); Rainer et al. (1969); Cleveland et al. (1969); Daly (1969a); and Shapiro (1970a). XYY males of normal intelligence have also been reported in the literature (Hauschka et al. 1962; Goodman et al. 1967; Wiener and Sutherland 1968; Cowie and Kahn 1968; Bartlett et al. 1968; Wiener et al. 1968; Hunter 1968; Marinello et al. 1969; Daly 1969a; Elbualy 1969; Hook and Kim 1970; and Griffiths et al. 1970). There have even been reports of XYY males who were above average (greater than 110 IQ) in intelligence. Forssman et al. (1968) discovered a 16 year old XYY male who had an IQ value of 116. Leff and Scott (1968) reported the discovery of an XYY male within a normal population who had an IQ value of 118. Table 2 gives a breakdown of the IQ values of those XYY males reported in the literature who were not ascertained specifically in institutions for the mentally subnormal. Such individuals would introduce a bias into the data because they were selected for institutionalization on the basis of diminished intelligence. Also Table 2 does not include those XYY males who had no specific IQ values reported; but instead were described as "average", "below average", or "above average" in intelligence.

As can be seen from Table 2, XYY males tend to be either low average or below average in intelligence. However, one must be aware

Table 2. Intelligence of XYY males who have been reported in the literature.

Intelligence Quotient	No. of 47, XYY Males
Below Average	
($\leq$ 90)	17
Average	
(91-100)	14
(101-109)	2
Above Average	
($\geq$ 110)	3

NOTE: Average I.Q. of 47, XYY Male is 86.8 (Range 57-118).

that Table 2 includes non-institutionalized as well as males confined to institutions, i.e. maximum security hospitals, prisons, etc. The majority of values reported in Table 2 are for institutionalized males and intelligence levels of institutionalized males in general are likely to be lower. As a result intelligence levels of XYY males within institutions probably cannot be stated to be relatively low.

The psychological makeup of the 47, XYY male has been investigated to a very slight extent. Hope et al. (1967) could demonstrate no difference between XYY males and matched controls in intelligence or tested hostility. In contrast, they were able to demonstrate a marked difference between XYY males and a matched group of fellow patients in a state mental hospital in the effect of response set (defensiveness) on replies to questionnaires (Philip et al. 1967). They also observed a difference in the structure of aggression or hostility.

Neurologically 47, XYY males have received some attention. Daly (1969b) discovered ten XYY males in four maximum security hospitals and one XYY in two hospitals for the mentally subnormal. Of the eleven XYY males, ten were found to have abnormal neurological findings as measured by electroencephalography. Wiener et al. (1968); Cowie and Kahn (1968); Wiener and Sutherland (1968); Daly (1969c); Lehrnbecher and Lucas (1969); and Elbualy (1969) all describe XYY males with abnormal EEG readings. Forssman (1967) described a ten year old boy who suffered from grand mal epileptic seizures and a grossly abnormal EEG. Similarly, Welch et al. (1967) observed an XYY male who also had a history of grand mal seizures and abnormal EEG

readings. Petit mal seizures were characteristic of an XYY male described by Rainer et al. (1969). Baughman (1971) found five XYY males, two of whom suffered from "essential tremors" of the hands and three of whom had definitely abnormal EEG readings.

Hormone Levels of 47, XYY Males

Hormone levels of XYY males have probably been investigated more thoroughly than any other aspect of the syndrome. Since this syndrome is a sex chromosome aneuploidy it was logical that hormonal levels be examined. The investigations into the hormonal constitution of 47, XYY males have not revealed and unusual pattern with which the syndrome could be characterized. Nielsen et al. (1966) reported normal androgen excretion associated with an XYY male. Hudson et al. (1969) described three XYY males each of whom had levels of plasma testosterone and plasma luteinizing hormone (L.H.) within the normal range. Goodman et al. (1967) also reported normal plasma testosterone levels in two XYY males in an Ohio prison. Santen et al. (1970) examined seven XYY males who were detected by screening prison inmates and patients attending a dermatology clinic with severe pustular acne. All seven patients had normal levels of plasma testosterone and six/seven had normal follicle stimulating hormone (F.S.H.) and luteinizing hormone levels. Santen et al. stated that, "apparently most patients with the XYY syndrome have normal levels of serum L.H., F.S.H., and testosterone when measured by specific methods and compared with suitable controls". Only one case in the literature

(Welch et al. 1967) has reported an increased level of plasma testosterone in an XYY male. Three separate reports (Ismail et al., 1968; Rudd et al., 1968; and Price and Van Der Molen, 1970), however, have described a mean urinary output and plasma testosterone level for 47, XYY males which was significantly higher than in normal ambulant males, but was not significantly different from that in 46, XY inpatient controls who were confined to the same institution. It would appear, therefore, that those individuals under detention, regardless of their sex chromosome constitution are likely to have testosterone levels significantly above those who are not detained. This difference is as yet unexplained, however the fact remains that no studies carried out so far have demonstrated significant differences in testosterone levels in either serum or urine between XYY males and selected XY controls. The pattern of L.H. and F.S.H. excretion in XYY males is not quite as clear cut. Papanicolaou et al. (1968) conducted serial assays of F.S.H. and L.H. in urine of three XYY males. The F.S.H. levels were within the normal range for male subjects while the majority of L.H. readings were elevated, being within the range usually seen in menopausal or post-menopausal women. Papanicolaou et al. postulated that the Leydig cells of the testes of XYY men are relatively insensitive to stimulation by pituitary L.H. and, as a result, the anterior pituitary is required to produce abnormally large amounts of L.H. in order to overcome this insensitivity. Parker (1969) examined the L.H. level in seven XYY males all of whom were institutionalized, six feet tall, and aggressive. He found significantly higher L.H. levels in XYY males than in comparable XY controls.

And finally Shapiro (1970a) examined the serum L.H. and F.S.H. levels of one XYY retardate in a New York home for the mentally deficient. The level of F.S.H. was definitely increased while the L.H. level was in the high normal range. Charges by Skakkebaek (1970) that increased serum and urine levels of L.H. and F.S.H. in XYY males were due only to primary testicular failure were denied by Shapiro (1970b) who stated that his patient's testes were histologically normal. Therefore, the XYY male cannot be characterized by any well defined pattern of hormone excretion, although L.H. may be the hormone most likely to be abnormal.

Miscellaneous Features of the 47, XYY Syndrome

Certain phenotypic characteristics have been reported in conjunction with the XYY syndrome. Varicose veins and ulceration (Richards and Stewart 1966) and facial acne (Telfer et al. 1968; Marinello et al. 1969; Santen et al. 1970; and Voorhes 1970) have been mentioned in the literature.

Heart irregularities have also been described in connection with XYY karyotypes. Price (1968) compared the EKG readings of 20 tall, aggressive, institutionalized XYY males and 20 suitably matched controls. The XYY males were found to have prolonged P-R intervals and, in addition, a number of minor wave irregularities. Price suggested that the P-R interval was a function of the number of Y chromosomes and the increased length in XYY males represented a dosage effect of two Y chromosomes. Steiness and Nielsen (1970) compared nine XYY males

with controls and failed to confirm Price's finding of prolonged P-R intervals in XYY males.

Certain bone abnormalities have also been reported in conjunction with the XYY karyotype. Cleveland et al. (1969) described two prepubertal XYY boys who exhibited radioulnar synostosis. Price and Fraser (1969) reported pelvic abnormalities in two XYY males in Edinburgh.

Price and Whatmore (1967a) after examining the nine XYY males who were discovered in the Carstairs study brought out the following points concerning the behavior of the XYY male. The XYY males began their criminal activities at a much earlier age; the mean age at their first conviction was 13.1 years for the XYY males as compared to 18 years for the controls. In addition the XYY males when compared to matched controls displayed less violence against persons and much more violence against property than did the controls. Daly (1969a) provided some contrasting data on ten XYY males identified in a survey of men in maximum security hospitals in the Midwest (including Ionia in Michigan). Daly found that the average age at first conviction for the XYY males was 22.3 years, in contrast to the mean age at first conviction of 13.1 years as reported by Price and Whatmore (1967b) at Carstairs. Of course the variation may be due to differences between British and American judicial procedures.

In addition the ten XYY males discovered by Daly showed no special proclivity to crimes against property rather than against persons.

Homosexuality has also been reported to be associated with the XYY karyotype. Of the nine XYY males reported by Jacobs et al. (1965) at Carstairs one had a history of homosexuality. However, seven of the ten XYY males found by Daly (1969a) had a documented history of homosexuality. Bartlett et al. (1968) found two XYY males in a security prison for the psychiatric treatment of offenders both of whom were homosexuals. And finally Griffiths et al. (1970) mentioned homosexuality in the descriptions of three XYY males found in a London prison.

Behaviorally, arson seems to be a crime occasionally associated with the XYY syndrome (Kelly et al. 1967; Cowie and Kahn 1968; Bartlett et al. 1968; and Marinello et al. 1969).

Spermatogenesis in 47, XYY Males

Only one report of an XYY male fathering an XYY son has appeared in the literature (Sundequist and Hellstrom 1969). Thompson et al. (1967) studied an XYY male who was the father of seven children, all of whom were 46, XY. Since an XYY man can theoretically produce four classes of gametes (XY, YY, X, and Y) this would mean that two out of every three males might be expected to be chromosomally abnormal. Examination of the father's testicular biopsy revealed only 46 chromosomes in all metaphases, suggesting that there has been selection toward euploidy prior to this stage of development in this tissue. Melnyk et al. (1969) examined eighteen children of XYY fathers and found no aneuploidy. In addition, they found only a single Y

chromosome paired with the X in meiotic preparations. Hsu et al. (1970) and Hulten (1970) also observed only 23 tetrads (including a normal XY tetrad) in meiotic metaphase preparations from an XYY male, again suggesting that the extra Y chromosome is eliminated before entering first meiotic division (prior to primary spermatocyte formation). As an alternative Evans et al. (1970) suggested that a Y chromosome could be lost from a primitive germ cell or spermatogonium of an XYY male at random, occurring at a rate not greater than that of a single Y chromosome in an XY male. Alternatively it may be that the 46, XY germ cell has a strong proliferative advantage over the 47, XYY germ cell or perhaps when the 47, XYY spermatocytes are formed they do not develop as far as diakinesis. However, recently a report from Tettenborn et al. (1970) has described and XYY male who possessed a few 47, XYY spermatogonia confirming the occurrence of XY/XYY mosaicism in spermatogonia and raising the possibility that 47, XYY spermatogonia may develop to primary spermatocytes with the extra Y chromosome included.

MATERIALS AND METHODS

A chromosome survey of institutions designed for the detention of juvenile offenders was undertaken in June of 1968; at which time no report of such a survey had appeared in the literature. Two such institutions were selected. Lansing Boys Training School in Lansing, Michigan and Highfields Boys Camp in Onondaga, Michigan. Both institutions receive boys from 13 to 17 years of age usually on a referral basis from the Probate Court of Ingham County in Lansing. Of the two institutions Boys Training School contains those youth who have committed the most serious crimes, very often felonies. Highfields usually houses those youth who have committed less serious offenses, generally misdemeanors. At the time of the survey (September 1968 - June 1970) Boys Training School contained approximately 300 boys and Highfields contained 32 boys. Since increased height seemed to be the most common phenotypic characteristic associated with the 47, XYY constitution only the tall boys were chromosomally examined. Theoretically this group of boys would be most likely to contain an XYY male, if one did exist within the institution. Tallness was determined according to a predictive growth chart developed by Bayer and Bayley (1959). Table 3 is a reproduction of a portion of that growth chart. As can be seen an individual must have attained a certain height by a particular age to be predicted to be 72 inches tall at the age of 16 years and six months. For example, a boy of age thirteen years, nine months must be 66 inches tall in order to be

Table 3. Predictive Growth Chart.*

Age in years and months	Height in inches which must be attained in order to be 72 inches by the age of 16 years, 6 months
12-6	61
12-9	62
13-0	63
13-3	64
13-6	65
13-9	66
14-0	67
14-3	68
14-6	68
14-9	69
15-0	70
15-3	70
15-6	70
15-9	71
16-0	71
16-3	71
16-6	72

*Reproduced from Bayer, L.M. and Bayley, N. Growth Diagnosis, University of Chicago Press, Chicago 1959.

included in the group which is predicted to be six feet tall at the age of 16 years, 6 months.

It should, however, be stated that the use of this growth chart postulates that XYY maless have a normal growth pattern. This may not be the case; XYY males may have late epiphyseal closure and may cease growing at a later age than normal.

The records of both institutions were screened (BTS was screened on two different occasions in order to increase the number of tall boys) and, based upon height at date of admission, a tall group was selected.

To summarize: From each institution a tall group of boys was selected; the tall group consisted of all those boys from ages 13-17 who were either six feet tall or who were predicted to be six feet tall by the age of sixteen years and six months. From Boys Training School, 70 boys were examined chromosomally while at Highfields the chromosomes of 5 boys were examined.

Chromosomes for study were provided using the micro-culture technique of the Grand Island Biological Company. Using a blood lancet, 7 to 10 drops of peripheral blood were obtained from a clean, dry finger. The blood was placed in a tube of Chromosome Medium 1A (Grand Island Biological Co.) and allowed to incubate at 37°C for approximately 72 hours. Growth was stopped after 72 hours by adding 0.2 ml of 0.005% colchicine to each tube. The incubation was continued for another 3 hours at 37°C. The cells were then spun in a centrifuge leaving only a tiny button of white and red cells. The button was treated with Hanks Solution (Grand Island Biological Co.) followed by treatment with water to induce swelling. Fixation of the cells was accomplished using a 3:1 solution of methanol to acetic acid with a fixation time of 30 minutes. Following fixation the cell suspension (approximately 10 drops) was dropped on clean, chilled microscope slides. The fixative was then ignited to induce bursting of the cells; and the slides were allowed to cool for a few hours. The slides then were stained using a 1:20 dilution of Giemsa for 30 minutes. Rinsing

in distilled water followed by air drying were the final steps before analysis.

Examination of the slides was conducted using a Zeiss photomicroscope. The slides were scanned at low power. The 24 best spreads were photographed under oil immersion using Panatomic X film (Kodak). After developing the film, counting prints were made which included photographs of 4 different chromosome spreads on one piece of photographic paper. All 24 cells from each patient were counted and those cells which appeared to have 47 chromosomes were karyotyped.

RESULTS

As mentioned above 75 boys (70 boys from Boys Training School and 5 boys from Highfields Boys Camp) were examined chromosomally during the course of the present survey. No 47, XYY males were observed among the 75 boys. However, the following chromosomal variations were observed. A 17 year old, 6 feet tall male resident of Highfields Boys Camp was found, 90% of whose cells contained 47 or more chromosomes (Table 4). A representative chromosome spread from this male (patient A) is shown in Figure 1. The majority of the cells counted contained 47 chromosomes and in almost all instances the extra chromosome proved to be a C group chromosome. These data strongly suggest that the patient is a 47, XXY. A smear of buccal mucosal cells proved to be chromatin negative, however its reliability is doubted. Unfortunately the patient is truant from the institution and consequently unavailable for further study. However, the patient was given a physical examination upon admittance to the institution; during the course of which the examining phisician described the patient's testes as "small, but intact". Small testes are highly characteristic of 47, XXY Klinefelters Syndrome; consequently there is a very strong possibility that patient A is a Klinefelter male.

An instance of what appears to be 46, XY/XXY mosaicism was also found among those examined. Unfortunately, the boy is unavailable for further study because of judicial order and because the quality of the slides does not permit any additional chromosomal examination.

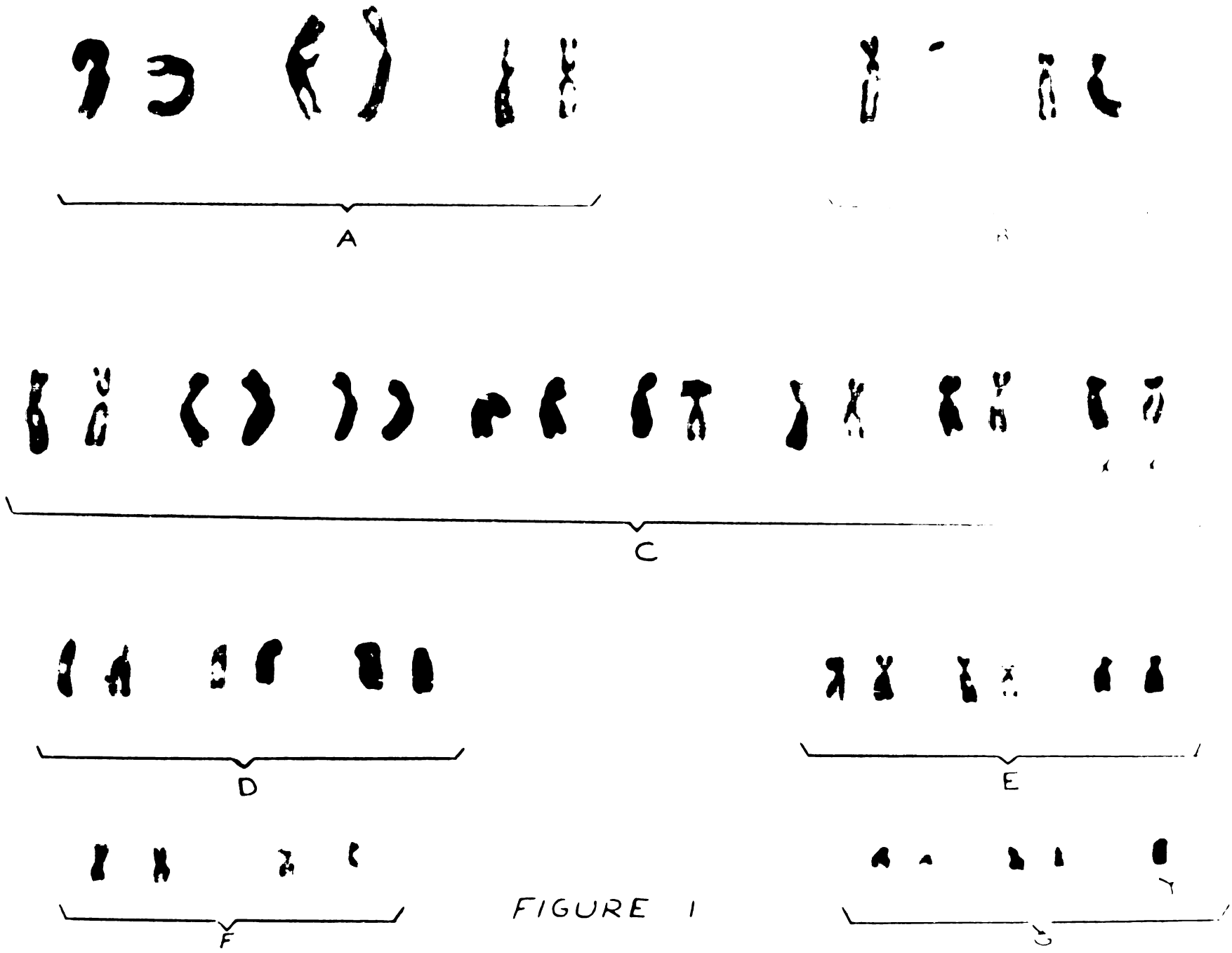

FIGURE 1

Figure 2 is a representative chromosome spread from patient B, a 13 year old, 5 feet 9 inch male. His chromosome distribution is indicated in Table 4. As seen the percentage of cells containing 47 chromosomes (27% for patient B) is relatively small, suggesting the possibility of 46, XY/47, XXY mosaicism. Patient B was not available for physical examination consequently one cannot determine whether the patient possessed any symptoms characteristic of Klinefelters syndrome.

Since karyotype prints were done only on those patients who exhibited at least one good cell containing 47 chromosomes, and since the slides from all other patients were not examined thoroughly, minor variance of chromosome structure was not always detected. However, one fairly consistent example of a satellited G group chromosome was uncovered. Figure 3 indicates a fairly typical satellited G group chromosome, which was found in approximately 50% of the patient's cells.

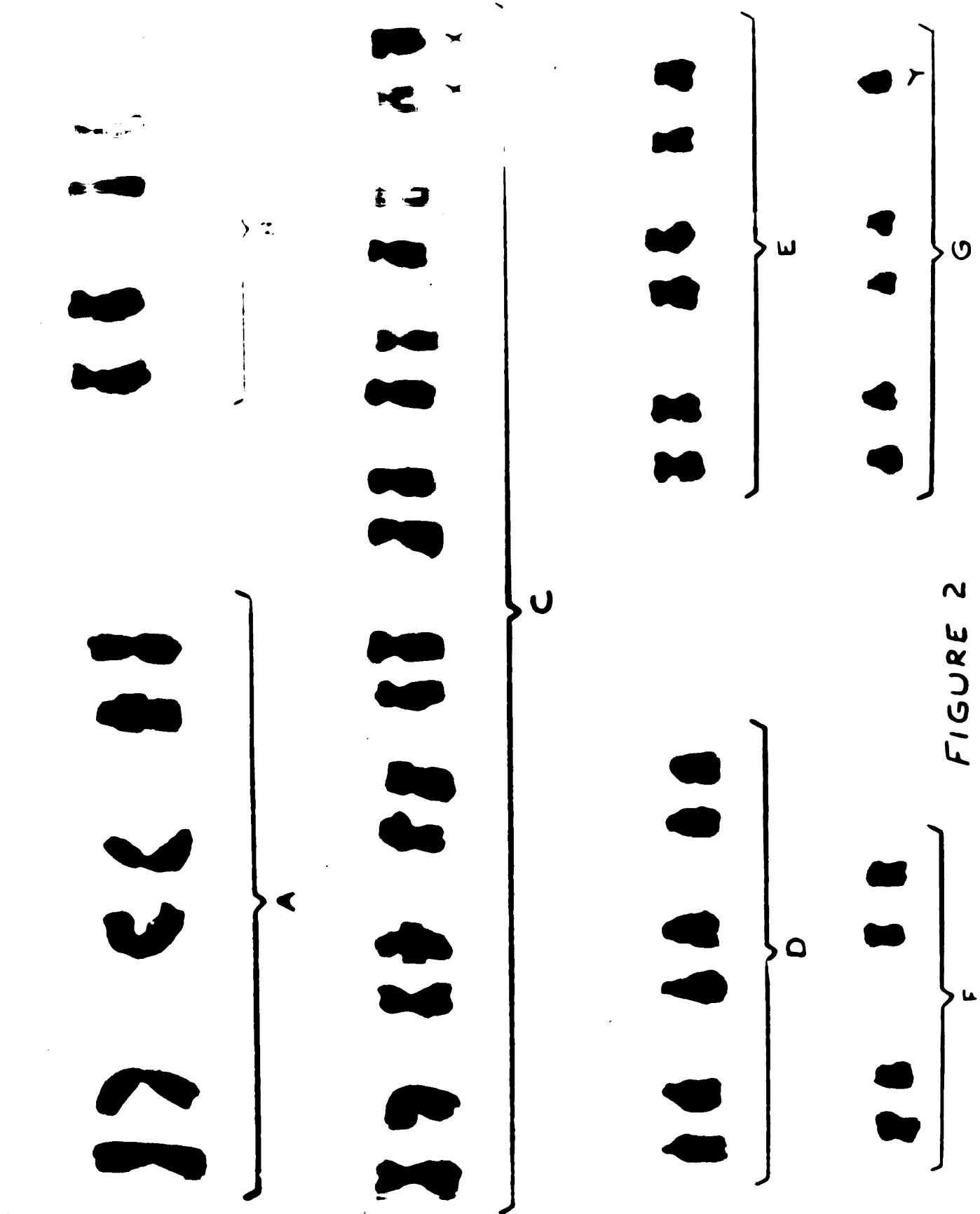

FIGURE 2

Table 4. Distribution of Chromosome Number.

	<45	45	46	47	48	
Patient A	0	1	7	64	6	
Patient B	1	1	14	6	0	

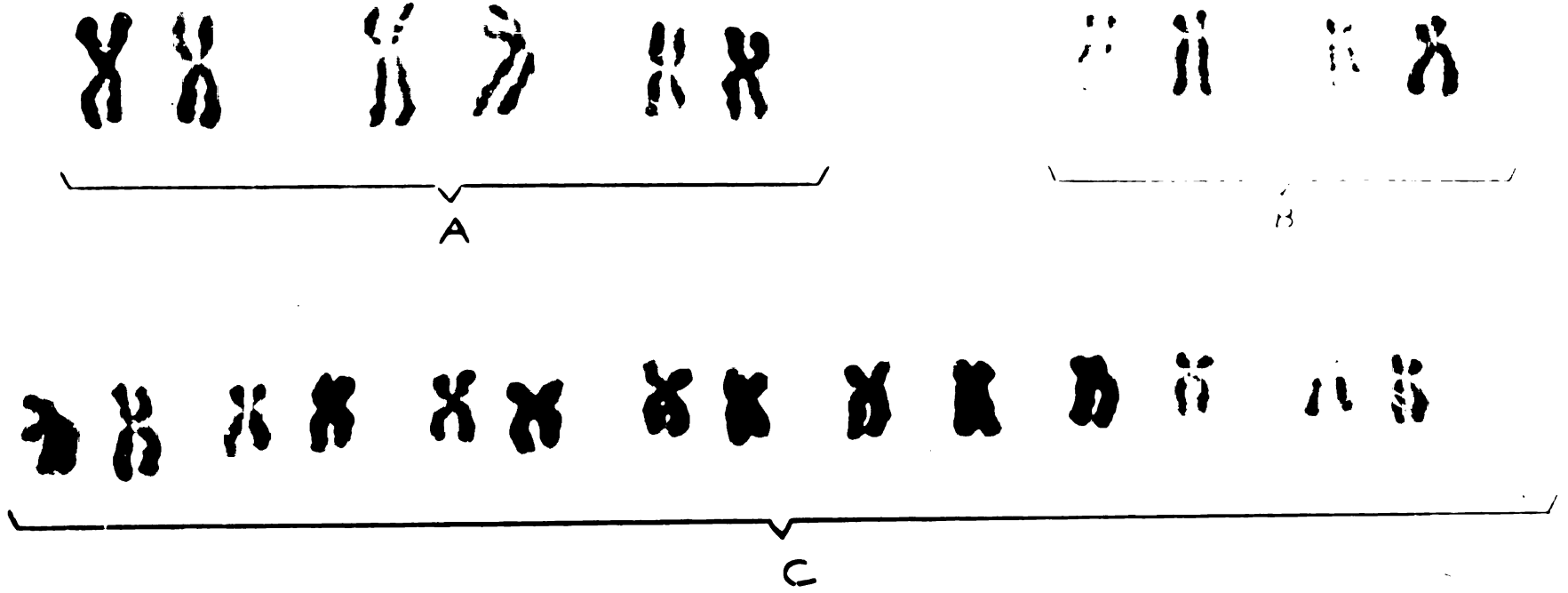

FIGURE 3

DISCUSSION

When the idea for this study was conceived very few data concerning the frequency of 47, XYY males among juvenile offenders existed. The results of the surveys of juvenile offenders are summarized in Table 5.

The current study involved 75 boys (Table 6), 19 of whom were actually six feet (72 inches) tall or taller at the time of the survey. There were 23 boys among the 75 who were 71 inches or greater at the time they were surveyed. The remainder, namely 56 boys, were predicted to attain a height of at least 72 inches by the age of 16 years and 6 months. Since the study under discussion uncovered no 47, XYY males among 19 young men six feet or over the most pertinent question involved the significance of such a finding. As can be seen in Table 5, five studies of institutions for juvenile offenders have been conducted. The studies by Court Brown (1966-67), Marinello *et al*. (1969), and Hook Kim (1970) cannot be considered in the statistical test (reported below) simply because their studies made no selection as to height. Telfer *et al*. (1968) and Hunter (1968) both selected boys according to height. The problem arises as to the consistency of the definition of tallness by which the boys are selected. Throughout the literature the most widely accepted definition of what constitutes tallness is six feet. For purposes of comparison the assumption that the two investigations above defined tallness as 71 inches or greater will have to be made. This is known to be the case in the study of

Table 5. Studies of Institutions Designed for Juvenile Offenders.

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However, the use of only 23 boys who actually were 71 inches or taller neglects a considerable number of boys who were purposely included in this survey. On the basis of the previously mentioned growth chart 75 male juvenile offenders were selected for analysis. Of the 75, 56 were predicted to be 72 inches tall by the age of 16

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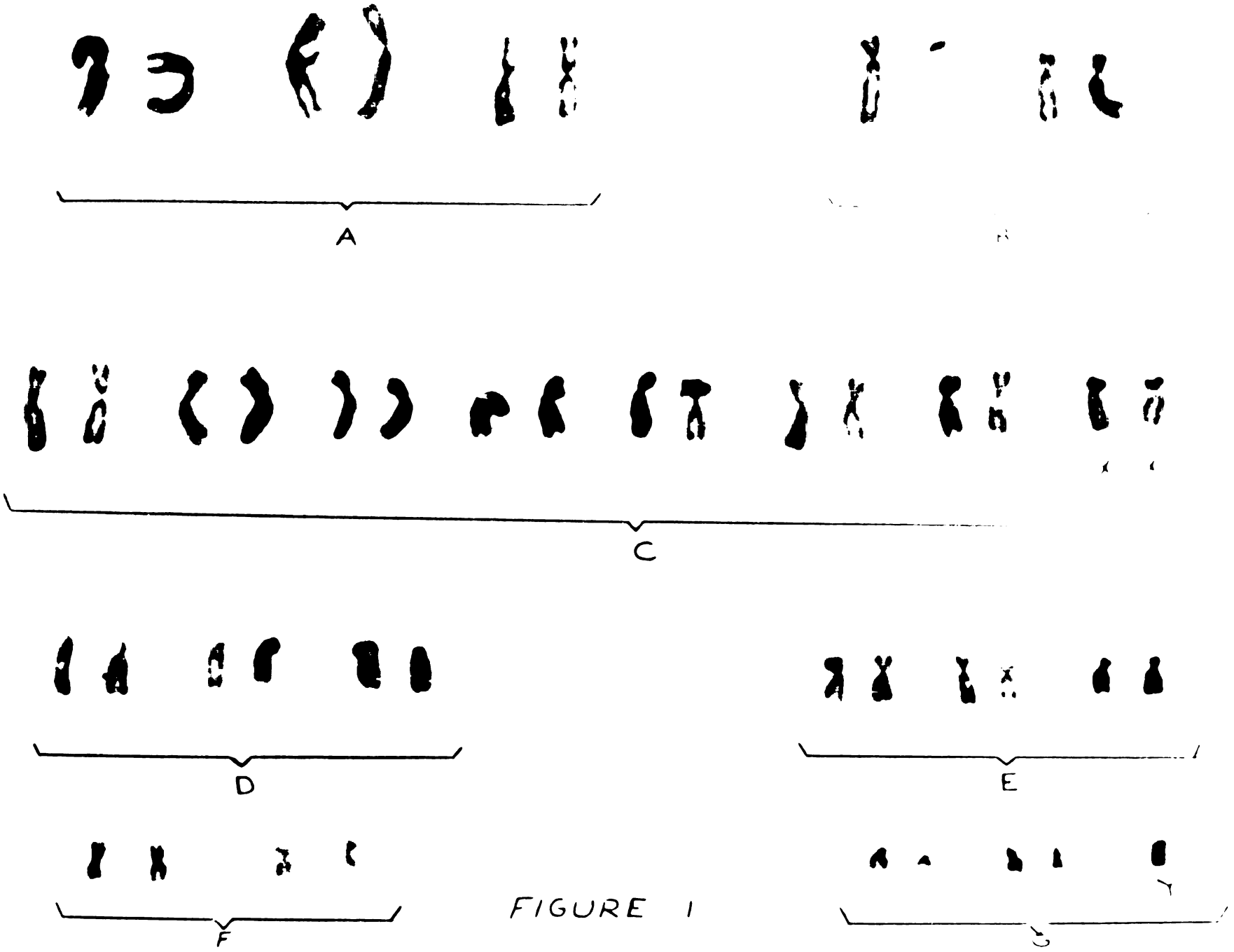

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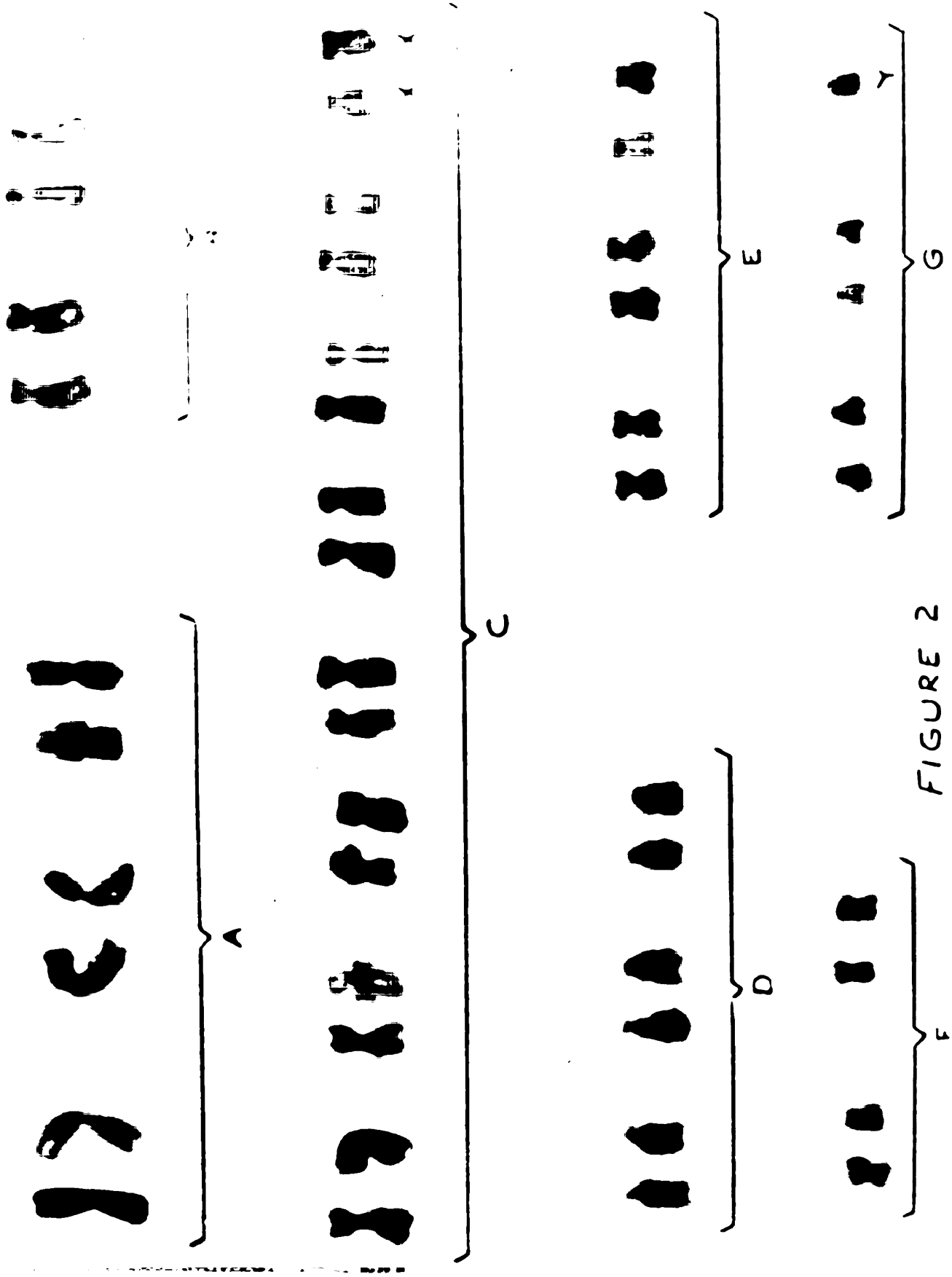

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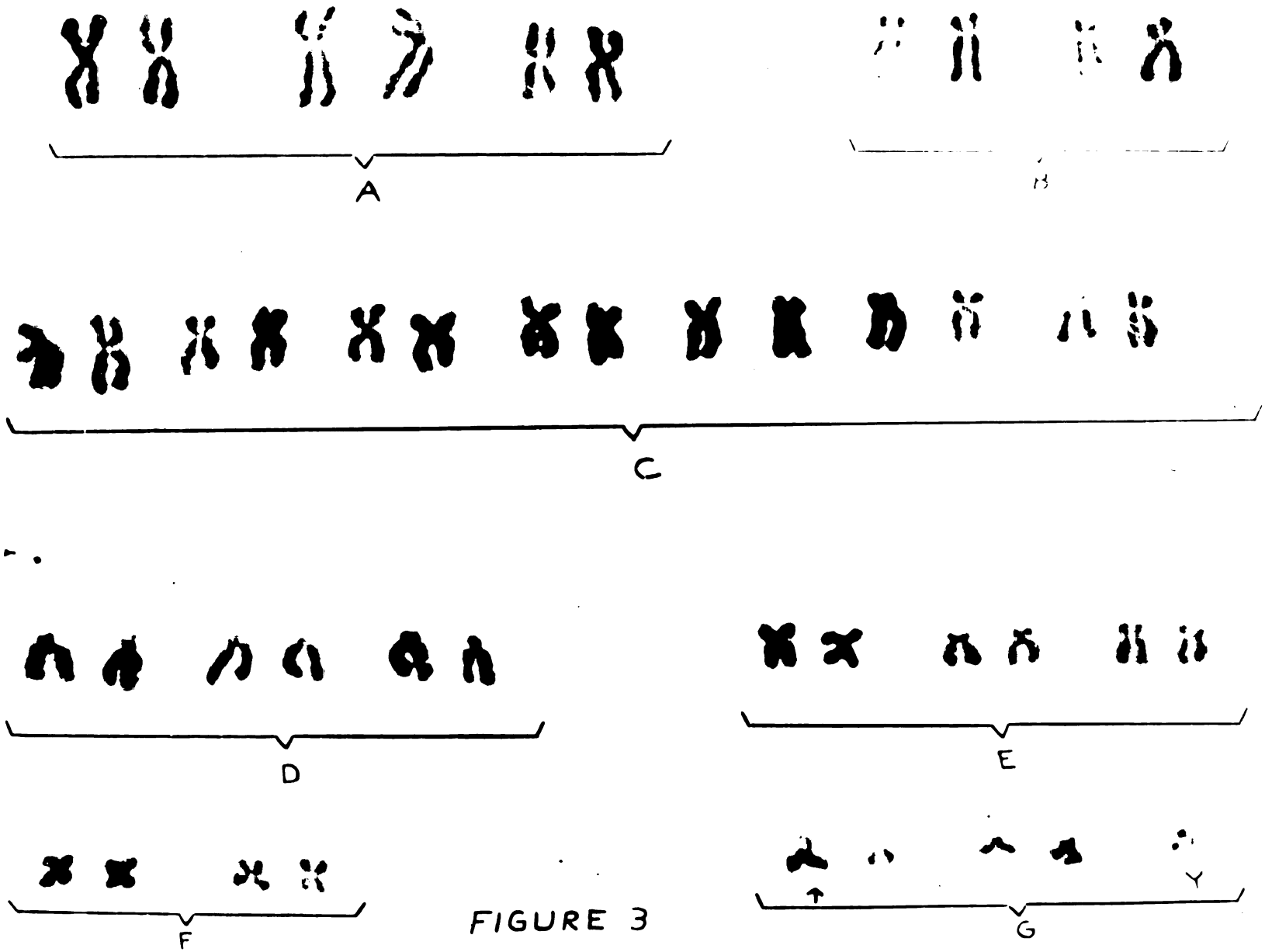

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Table 7. Juvenile Offender Groups.

Author	Number Examined	Number 47, XYY
Telfer et al. (1968)	14 (all 71" or >)	1
Hunter (1968)	29 (including predicted six feet males)	3
Current Srusy	23 (all 71" or >)	0

Table 8. Calculation of Fisher Exact Probability Test.

	-	+	Total
Group 1	A	B	A+B
Group 2	C	D	C+D
Total	A+C	B+D	N

A = 39
B = 4
C = 23
D = 0
N = 66

$$p = \frac{(A+B!\ (C+D)!\ (A+C)!\ (B+D)!}{N!\ A!\ B!\ C!\ D!}$$

$$p = 0.171$$

years and 6 months. In order to include these 56 subjects within the survey it is essential to have some idea as to the predictive accuracy of the growth chart which was used. In other words, how many boys predicted to be 72 inches tall by the age of 16 years, 6 months would actually be that tall at that age? Since many of the boys selected were only 13 or 14 years of age and since their availability following release from Boys Training School was severely limited, a detailed study to determine how many of the 56 boys actually were 72 inches tall by the age of 16 years, 6 months was impossible. As a consequence, it was necessary to devise some other method of testing the accuracy of the predictive growth chart. At Boys Training School there were a number of boys who were admitted, measured for height, subsequently released and then later readmitted and remeasured for height. Therefore, these boys had their heights taken on two separate occasions which permitted two separate predictions of their heights. Intervals were sometimes as great as three years. The current (October, 1970) enrollment of Boys Training School and the releases for approximately the past five years were surveyed for any boy having two admission dates. Out of approximately 700 boys, 70 were found to have been admitted and readmitted. The criteria of the growth chart were applied to all 70 of the boys and Table 9 shows the results. Since a substantial number of boys predicted to be 72 inches tall will actually be that tall, the entire 75 boys will be used in a statistical comparison with the studies in the literature. Table 10 represents a summary of the surveys. The question is whether or not the finding of no 47, XYY males among 75 juvenile offenders is significantly

Table 9. Predictive Growth Chart as Applied to BTS Data.

Prediction at first admission		Prediction at second admission	
Predicred height at 16 years, 6 months		Predicted height at 16 years, 6 months	
≥72 in.	<72 in.	≥72 in.	<72 in.
7	-	4	3
-	63	4	59

Table 10. Juvenile Offender Groups.

Author	Number Examined	Number 47, XYY
Telfer et al. (1968)	14	1
Hunter (1968)	29	3
Current Study	75	0

different from the previously reported findings of four XYY males among 43 juvenile offenders. A Fisher Exact Probability Test (Table 11) yields a value of 0.0160 which is interpreted to mean that there is a 1.6% probability of finding no 47, XYY males out of 75 juvenile offenders due solely to chance alone. In other words, if one studied 75 male juvenile offenders from the same population which produced the four previously mentioned XYY males one could expect that only 1.6% of the time would no XYY males be found.

One might interpret a finding such as this in three ways: (1) the relatively uncommon event has occurred, no XYY males among 75 juvenile offenders; (2) the populations under discussion (Lansing Boys Training School and Highfields) differed in some respect from those populations described in the literature; or (3) institutions housing male juvenile offenders in Michigan are not necessarily good places to search for 47, XYY males. On the basis of the data which are available it is impossible to state which of the above three alternatives (if any) is correct.

Certain other considerations must be stated in the interpretation of the results of this study. There is the possibility that there exist other negative studies which may be unpublished, so that the published results lead to an overestimation of the frequency of XYY. An error in the experimental design would certainly allow for other interpretations of the results (predictions of growth pattern might be incorrect). The possibility of an over-representation of blacks (who are known to exhibit a greater variance in height than whites

Table 11. Calculation of Fisher Exact Probability Test.

	-	+	Total
Group 1	A	B	A+B
Group 2	C	D	C+D
	A+C	B+D	N

A = 39
B = 4
C = 75
D = 0
N = 118

$$p = \frac{(A+B)!\ (C+D)!\ (A+C)!\ (B+D)!}{N!\ A!\ B!\ C!\ D!}$$

$$p = 0.0160$$

and consequently may more frequently be taller than 72 inches) at BTS might have placed in the sample a large number of tall, normal black males.

In the course of the study under discussion it was learned that there is an institution in Whitmore Lake, Michigan (Gree Oaks Center) which houses those delinquent youth who have resided in delinquent homes across the state but who have proved to be too difficult to handle in terms of aggressiveness and truancy. Green Oaks Center, therefore, contains those boys who best fit one of the criteria which stimulated this survey - aggressiveness.

Consideration is currently being given to a survey of Green Oaks making use of the new technique of fluorescent staining using quinacrine derivatives (Pearson et al., 1970). With this technique buccal mucosal cells can be stained to indicate the presence of two Y chromosomes. A complete survey of the 110 residents of this institution would be relatively simple and very interesting.

REFERENCES

Akesson, H. O.; Forssman, H.; and Wallin, L. Chromosomes of tall men in mental hospitals. Lancet 2, 1040, 1968.

Anders, J. M.; Jagiello, G.; Polan, P. E.; Giannell, F.; Hamerton, J. L. and Leiberman, D. M. Chromosome findings in chronic psychotic patients. British Journal of Psychiatry, 114, 1167, 1968.

Boczkowski, K. and Casey, M. D. Pattern of DNA replication of the sex chromosomes in three males, two with XYY and one with XXYY karyotype. Nature 213, 928, 1967.

Bartlett, D. J.; Hurley, W. P.; Brand, C. R.; and Poole, E. W. Chromosomes of male patients in a security prison. Nature 219, 351, 1968.

Baughman, F. E. Personal communication, 1971.

Bayer, L. M. and Bayley, N. Growth Diagnosis. University of Chicago Press, Chicago, 1959.

Berghe, H. V. D.; Verresen, H.; and Cassiman, J. J. A male with 4 Y chromosomes. Journal of Clinical Endocrinology 28, 1370, 1968.

Borgaonkar, D.; Murdoch, J. L.; McKusick, V. A.; Borkowf, S. P.; and Money, J. W. The YY syndrome. Lancet 2, 461, 1968

Casey, M. D.; Segall, L. J.; Street, D. R. K.; and Blank, C. E. Sex chromosome abnormalities in two state hospitals for patients requiring special security. Nature 209, 641, 1966a.

Casey, M. D.; Blank, C. E.; Street, D. R. K.; Segall, L. J.; McDougall, J. H.; McGrath, P. J.; and Skinner, J. L. YY chromosomes and anti-social behaviour. Lancet 2, 859, 1966b.

Cleveland, W. W.; Arias, D.; and Smith, G. F. Radioulnar synostosis, behavioral disturbance, and XYY chromosomes. Journal of Pediatrics 74, 103, 1969.

Close, H. G.; Goonetilleke, A. S. R.; Jacobs, P. A.; and Price, W. H. The incidence of sex chromosomal abnormalities in mentally subnormal males. Cytogenetics 7, 277, 1968.

Court Brown, W. M. Genetics and crime. Journal of the Royal College of Physicians, London 1, 311, 1966-1967.

Court Brown, W. M. Males with an XYY sex chromosome complement. Journal of Medical Genetics 5, 341, 1968.

Court Brown, W. M.; Price, W. H.; and Jacobs, P. A. Further information on the identity of 47, XYY males. British Medical Journal 2, 325, 1968.

Cowie, J. and Kahn, J. XYY constitution in a prepubertal child. British Medical Journal 2, 748, 1968.

Dallapiccola, B. and Malacarne, L. Bone abnormalities and XYY syndrome. Lancet 1, 311, 1970.

Daly, R. F. The frequency and characteristics of XYY males in selected populations. American Society of Human Genetics - Dec., 1967.

Daly, R. F. Mental illness and paterns of behavior in 10 XYY males. Journal of Nervous and Mental Disease 149, 318, 1969a.

Daly, R. F. Neurological abnormalities in XYY males. Nature 221, 472, 1969b.

Daly, R. F. Editor's Note. Pediatrics 44, 621, 1969c.

Daly, R. F.; Chun, R. W. M.; Ewanowski, S.; and Osborne, R. H. The XYY condition in childhood: clinical observations. Pediatrics 43, 852, 1969.

Elbualy, M. S. The XYY condition in childhood: clinical observations. Pediatrics 44, 620, 1969.

Evans, E. P.; Ford, C. E.; Chaganti, R. S. K.; Blank, C. E.; and Hunter, H. XY spermatocytes in an XYY male. Lancet 1,719, 1970.

Ferrier, P. E. and Ferrier, S. A. XXYY Klinefelters syndrome: Case report and a study of the Y chromosome's DNA replication pattern. Annals of Genetics (Paris) 11, 145, 1968.

Forssman, H. Epilepsy in an XYY man. Lancet 1, 1389, 1967.

Forssman, H.; Akesson, H. o.; and Wallin, L. The YY syndrome. Lancet 2, 779, 1968.

Gerald, P. and Walzer, S. in Human Population Cytogenetics. P.A. Jacobs, W. H. Price, P. Law Eds. Edinburgh University Press, Edinburgh, 1970.

Goodman, R. M.; Miller, F.; and North, C. Chromosomes of tall men. Lancet 1, 1318, 1968.

Goodman, R. M.; Smith, W. S.; and Migeon, C. J. Sex chromosome abnormalities. Nature 216, 942, 1967.

Griffths, A. W.; Richards, B. W.; Zaremba, J.; Abramowicz, T.; and Stewart, A. Psychological and sociological investigation of XYY prisoners. Nature 227, 290, 1970.

Hauschka, T. S.; Hasson, J. E.; Goldstein, M. N.; Koepf, G. E.; and Sandberg, A. A. An XYY man with progeny indicating familial tendency to non-disjunction. American Journal of Human Genetics 14, 22, 1962.

Hienz, H. A. YY syndrome forms. Lancet 1, 155, 1969.

Hook, E. B. and Kim, D. S. Prevalence of XYY and XXY karyotypes in 337 non-retarded young offenders. New England Journal of Medicine 283, 410, 1970.

Hope, K.; Philip, A. E.; and Loughran, J. M. Psychological characteristics associated with XYY sex chromosome complement in a state mental hospital. British Journal of Psychiatry 113, 495, 1967.

Hsu, L. Y.; Shapiro, L. R.; and Hirschhorn, K. Meiosis in an XYY male. Lancet 1, 1173, 1970.

Hudson, B.; Burger, H.; Wiener, S.; Sutherland, G.; and Bartholomew, S. Plasma testosterone and luteinising hormone in XYY men. Lancet 2, 699, 1969.

Hultén, M. Meiosis in XYY men. Lancet 1, 717, 1970.

Hunter, H. Chromatin-positive and XYY boys in approved schools. Lancet 1, 817, 1968.

Ismail, A. A. A.; Harkness, R. A.; Kirkham, K. E.; Loraine, J. A.; Whatmore, P. B.; and Brittain, R. P. Effect of abnormal sex chromosome complements on urinary testosterone levels. Lancet 1, 220, 1968.

Jacobs, P. A.; Brunton, M.; Melville, M.M.; Brittain, R. P.; and McClemont, W. F. Aggressive behaviour, mental subnormality, and the XYY male. Nature 208, 1351, 1965.

Jacobs, P. A.; Price, W. H.; Court Brown, W. M.; Brittain, R. P.; and Whatmore, P. B. Chromosome studies on men in a maximum security hospital. Annals of Human Genetics 31, 339, 1968.

Jarvik, L. F.; Abdullah, S.; Kato, T.; Chang, P.; and Straus, D. XYY karyotype among selected psychiatric patients. American Society of Human Genetics - Dec. 1967.

Kelly, S,; Almy, R.; and Barnard, M. Another XYY phenotype. Nature 215, 405, 1967.

Knox, S. J. and Nevin, N. C. XYY chromosomal constitution in prison populations. Nature 222, 596, 1969.

Kosenow, E. W. and Pfeiffer, R. A. YY syndrome with multiple malformations. Lancet 1, 1375, 1966.

Leff, J. P. and Scott, P. D. XYY and intelligence. Lancet 1, 645, 1968.

Lehrnbecher, W. and Lucas, G. J. Disorders of brain and connective tissue in a patient with 47, XYY karyotypw. Lancet 2, 796, 1969.

Lisker, R.; Zenzes, M. T.; and Fonesca, M. T. YY syndrome in a Mexican. Lancet 2, 634, 1968.

Lubs, H. A. and Ruddle, F. H. Chromosomal abnormalities in the human population: estimation of rates based on New Haven newborn study. Science 169, 495, 1970.

Marinello, M. J.; Edwards, J. A.; and Bannerman, D. M. A study of the XYY syndrome in tall men and juvenile delinquents. American Medical Association Journal 208, 321, 1969.

Matthews, M. B. and Brooks, P. W. Aggression and the YY syndrome. Lancet 2, 355, 1968.

Melnyk, J.; Thompson, H.; Rucci, A. J.; Vanasek, F.; and Hayes, S. Failure of transmission of the extra chromosome in subjects with 47, XYY karyotype. Lancet 2, 797, 1969.

New York Times 22 April 68 - R. D. Lyon.

New York Times 21 April 68 - R. D. Lyon

Nielsen, J.; Christensen, A. L.; Johnsen, S. G.; and Frøland, A. Psychopathology and testis histology in a patient with the XYY syndrome. Acta Medica Scandinavica 180, 747, 1966.

Nielsen, J.; Tsuboi, T.; Strürup, G.; and Romano, D. XYY chromosomal constitution in criminal psychopaths. Lancet 2, 576, 1968.

Papanicolaou, A. D.; Kirkham, K. E.; and Loraine, J. A. Abnormalities in urinary gonadotrophin excretion in men with a 47, XYY sex chromosome constitution. Lancet 2, 608, 1968.

Parker, C. E. Luteinising hormone in XYY men. Lancet 1, 1101, 1969.

Pearson, P. L.; Bobrow, M.; and Vosa, C. G. Technique for identifying Y chromosomes in human interphase nuclei. Nature 226, 76, 1970.

Persson, T. An XYY man and his relatives. Journal of Mental Deficiency Research 11, 239, 1967.

Philip, A. E.; Hope, K.; Loughran, J. M. Physiological characteristics associated with XYY sex chromosome complement in a state mental hospital. British Journal of Psychiatry 113, 495, 1967.

Price, W. H.; Strong, J. A.; Whatmore, P. B.; and McClemont, W. F. Criminal patients with XYY sex chromosome complement. Lancet 1, 565, 1966.

Price, W. H. The electrocardiogram in males with extra Y chromosomes. Lancet 1, 1106, 1968.

Price, W. H. and Fraser, G. M. Heterotopic bone formation in two males with the 47, XYY karyotype. Lancet 2, 1134, 1969.

Price, W. H. and Whatmore, P. B. Behaviour disorders and patterns of crime among XYY males identified at a maximum security hospital. British Medical Journal 1, 533, 1967a.

Price, W. H. and Whatmore, P. B. Criminal behaviour and the XYY male. Nature 213, 815, 1967b.

Price, W. H. and Van Der Molen, H. J. Plasma testosterone levels in males with the 47, XYY karyotype. Journal of Endocrinology 47, 117, 1970.

Rainer, J. D.; Jarvik, L. F.; Abdullah, S.; and Kato T. XYY karyotype in monozygotic twins. Lancet 2, 60, 1969.

Ratcliffe, S. G.; Melville, M. M.; Stewart, A. L.; Jacobs, P. A.; and Keay, A. J. Chromosome studi4s on3500 newborn male infants. Lancet 1, 121, 1970.

Richards, B. W. and Stewart, A. The YY syndrome. Lancet 1, 984, 1966.

Rudd, B. T.; Galal, O. M.; and Casey, M. D. Testosterone excretion rates in normal males and males with an XYY complement. Journal of Medical Genetics 5, 286, 1968.

Sandberg, A. A.; Koepf, G. F.; Ishihara, T.; and Hauschka, T. S. An XYY human male. Lancet 2, 488, 1961.

Santen, R. J.; DeKrester, D. M.; Paulsen, C. A.; and Vorhees, J. Gonadotrophins and testosterone in the XYY syndrome. Lancet 1, 371, 1970.

Sergovich, F.; Valentine, G. H.; Chen, A. T. L.; Kinch, R. A. H.; and Smout, M. S. Chromosome aberrations in 2159 consecutive newborn babies. New England Journal of Medicine 16, 851, 1969.

Shapiro, L. R. Hormones and the XYY syndrome. Lancet 1, 623, 1970a.

Shapiro, L. R. Hormones and the XYY male. Lancet 1, 1347, 1970b.

Skakkebaek, N. E. Hormones and the XYY male. Lancet 1, 949, 1970.

Steiness, E. and Nielsen, J. The electrocardiogram in males with the 47, XYY karyotype. Lancet 1,1402, 1970.

Stenchever, M. A. and Macintyre, M. N. A normal XYY man. Lancet 1,

Stewart, A. L.; Keay, A. J.; Jacobs, P. A.; and Melville, M. M. A chromosome survey of unselected liveborn children with congenital abnormalities. Journal of Pediatrics 74, 449, 1969.

Sundequist, U. and Hellström, E. Transmission of 47, XYY karyotype. Lancet 2, 1367, 1969.

Tanner and Whitehouse. University of London Institute of Child Health, for the Hospital for Sick Children, Great Ormond Street, London W. C. 1, 1966.

Telfer, M. A.; Baker, D.; Clark, G. R.; and Richardson, C. E. Incidence of gross chromosomal errors among tall criminal American males. Science 159, 1249, 1968.

Tettenborn, U.; Gropp, A.; Murken, J. D.; Tennefels, W.; Fuhrmann, W.; and Schwinger, E. Meiosis and testicular histology in XYY males. Lancet 2, 267, 1970.

Thompson, H.; Melnyk, J.; and Hecht, F. Reproduction and meiosis in XYY. Lancet 2, 831, 1967.

Thorburn, M. J.; Chutkan, W.; Richards, R.; and Bell, R. XYY sex chromosomes in a Jamaican with orthopaedic abnormalities. Journal of Medical Genetics 5, 215, 1968.

Voorhees, J. Personal communication 1970.

Walzer, S.; Breau, G.; and Gerald, P. S. A chromosome survey of 2400 normal newborn infants. Journal of Pediatrics 74, 438, 1969.

Welch, J. P.; Borgaonkar, D. S.; and Herr, H. M. Psychopathy, mental deficiency, aggressiveness, and the XYY syndrome. Nature 214, 500, 1967.

Wiener, S. and Sutherland, G. A normal XYY man. Lancet 2, 1352, 1968.

Wiener, S.; Sutherland, G.; Bartholomew, A. A.; and Hudson, B. XYY males in a Melbourne prison. Lancet 1, 150, 1968.

Williams, E. R. Bone abnormalities in the XYY syndrome. Lancet 1, 570, 1970.