SUMMARY

1. Maximum motor nerve conduction velocities were determined under standard conditions for the median and ulnar nerves in the right forearm in males: (a) from the general population, (b) from a subnormality hospital, and (c) in males with the XYY sex chromosome abnormality. Distal latencies for these nerves were also measured.

2. No significant differences in maximum peripheral motor nerve conduction were found between the two control populations from the general population and from the subnormality hospital.

3. The maximum motor conduction velocity in the median nerve in the XYY group was significantly slowed when compared with both control groups. In the case of the ulnar nerve, maximum motor conduction was significantly slowed when compared with the general population, but not when compared with the subnormality hospital group.

4. There were no significant differences in the mean distal latencies of either the median or ulnar nerves between the two control groups.

5. In the XYY group, the distal latency in the ulnar nerve was significantly prolonged when compared with both control groups. In the case of the median nerve, the distal latency was prolonged significantly when compared with the general population; when the comparison was made with the subnormality hospital group significant prolongation was also observed but was less marked.

Key words: motor nerve conduction, XYY males.

Males with an extra Y chromosome (47 XYY) show changes in the electrocardiogram without other evidence of cardiovascular disease (Price, 1968).

This altered behaviour of an 'excitable tissue' without obvious disease prompted an i-
vestigation into the related function of nerve conduction in these men. This paper describes
the measured maximum peripheral motor nerve conduction and the distal latencies in the
median and ulnar nerves.

PATIENTS AND METHODS

XYY patients

Thirty-four XYY males were examined. Of these, eleven were in the general population, eighteen in subnormality hospitals, three in young offenders institutions and two in a maximum
security hospital. Their ages ranged from 15 to 71 years (mean age 38.3 years), and their
heights from 142 to 192 cm. Twelve of the patients were on small doses of sedation, and one
was on anti-epileptic drugs. Clinical examination revealed only one patient who had a marked
tremor of his hands at rest, and in the remainder no central nervous system (CNS) abnormality
could be found.

The results obtained from the XYY patients were compared with those from two control
populations.

Population 1. This population consisted of 102 male volunteers from a random sample
selected from the National Health Service executive council list of a local group general
practice. All these men had a normal karyotype and their ages ranged from 20 to 60 years
with a mean of 40.2 years. On clinical examination none showed any neurological abnormality,
involving the median or ulnar nerves. Four subjects were known epileptics, and three were
receiving mild sedatives.

Population 2. This population was drawn from a mental subnormality hospital and consisted
of forty-eight male patients with a normal chromosome constitution. They were selected on
the basis of being fully ambulant and having an I.Q. above 50. Their age ranged from 15 to 62
years with a mean age of 33.3 years. Ten of the patients were known epileptics and fifteen of
the patients were receiving some form of sedation.

Methods

The patients were examined while lying on a couch in a warm room. The surface temperature
of the limb to be examined was maintained between 34 and 35°C by means of a radiant lamp.
Limb temperature was recorded by means of surface thermistors. Motor conduction velocity
was estimated in the median nerve at various temperatures, so that a coefficient of variation
with temperature could be determined.

The Hewlett Packard electromyograph was used for the test; this delivered a square wave
pulse stimulus of 200 microseconds duration. A stimulation frequency of 1 Hz was used.
The stimulator probe was a plastic case containing two metal rods each 6 mm in diameter,
with a centre to centre distance between the rods of 29 mm. A variable voltage control was
built into the handle of the probe. The sweep on the oscilloscope was triggered by the stimulator.
Surface electrodes (circular metal discs, diameter 0.9 cm) were used to record the muscle
action potential from the small muscles of the hand (belly-tendon response).

Maximum motor conduction velocities. The maximum motor conduction velocities in the
median and ulnar nerves of the right forearm (between elbow and wrist) were measured. In the
case of the median nerve, the muscle recording was from abductor pollicus brevis, and for the
ulnar nerve, the muscle used was abductor digiti minimi. The measurement of motor con-
Motor nerve conduction in XYY males

Motor nerve conduction velocity was similar to that employed by Norris, Shock & Wagman (1953). The nerve under test was stimulated with supra-maximal shocks at the elbow and wrist and the latency, from the beginning of the stimulus artifact to earliest point on the muscle action potential, was recorded in milliseconds for each point of stimulation. For each nerve, the distance between proximal and distal stimulating cathodes was measured on the surface of the limb and the conduction time in milliseconds for the measured segment of nerve was obtained by subtracting the two latencies. From these measurements, the conduction velocity in metres per second was calculated.

**Distal latencies.** The distal latency for a particular nerve is the conduction time in milliseconds from the distal point stimulated to the onset of the muscle action potential, and represents conduction in the nerve trunk, nerve terminals, and the neuro-muscular junction. The measured distance between the stimulating cathode and the recording muscle electrode in this study was between 4 and 6 cm (Kaeser, 1970).

**Reliability of surface measurement.** The validity of surface measurement of the nerve between proximal and distal stimulating cathodes was investigated in seven cadavers by measuring the surface distance between two points on the median and ulnar nerves in the forearm, dissecting out the nerves between these points, and measuring the actual lengths of nerve involved. The arm was kept in the same relative position throughout the test. Tests of significance were carried out on the results obtained.

**Reproducibility.** To test reproducibility of the observation of conduction velocities, tests were carried out on nine different people of normal chromosomal karyotype on two different days.

**RESULTS**

**Maximum motor conduction velocities**

The results for the maximum motor conduction velocities in the median and ulnar nerves in the forearm of the three groups tested are given in Table 1 and Fig. 1.

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Population</th>
<th>No.</th>
<th>Mean conduction velocity (m s⁻¹)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>Normal</td>
<td>100</td>
<td>55.9</td>
<td>5.4</td>
</tr>
<tr>
<td>Subnormal</td>
<td>48</td>
<td>56.1</td>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td>XYY</td>
<td>34</td>
<td>50.5</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>Ulnar</td>
<td>Normal</td>
<td>102</td>
<td>58.9</td>
<td>5.2</td>
</tr>
<tr>
<td>Subnormal</td>
<td>48</td>
<td>58.2</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>XYY</td>
<td>34</td>
<td>54.9</td>
<td>7.7</td>
<td></td>
</tr>
</tbody>
</table>

The maximum conduction velocity in the median nerves in males from the general population and from the mental subnormality hospital were not significantly different ($P > 0.90$). The same was also true of velocities in the ulnar nerve in the two groups ($P > 0.50$).

The variances of the velocities in the median and ulnar nerves were greater in the XYY
males than the variances of the conduction velocities in either of the two control populations. Because of the differences in variances, the non-parametric Mann Whitney U Test (Siegel, 1956) was used to test for significant differences between the groups. In the case of the median nerve, the maximum motor nerve conduction in the XYY group was found to be significantly slowed when compared with both the normal population and the subnormality hospital groups ($P<0.01$ in both instances).

The ulnar nerve conduction velocity in the XYY group was significantly slowed when compared with the general population ($P<0.01$), but not when compared with the subnormality group ($P>0.10$).

![Fig. 1. Maximum motor conduction velocities in the median and ulnar nerves for the three groups tested.](image-url)
**Motor nerve conduction in XYY males**

**TABLE 2. Distal latencies for the median and ulnar nerves**

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Population</th>
<th>No.</th>
<th>Mean distal latency (ms)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>Normal</td>
<td>94</td>
<td>3.58</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>Sub-normal</td>
<td>48</td>
<td>3.64</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>XYY</td>
<td>34</td>
<td>4.09</td>
<td>0.80</td>
</tr>
<tr>
<td>Ulnar</td>
<td>Normal</td>
<td>96</td>
<td>2.95</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>Subnormal</td>
<td>48</td>
<td>3.11</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>XYY</td>
<td>34</td>
<td>3.48</td>
<td>0.63</td>
</tr>
</tbody>
</table>

**FIG. 2. Distal latencies in the median and ulnar nerves for the three groups tested.**
Maximum motor conduction velocities and age

A significant correlation of maximum motor conduction velocity with age was shown in the case of the median nerve for the normal population ($r = -0.4$); the maximum motor conduction velocity falling by approximately $1.5 \text{ m s}^{-1} \text{ decade}^{-1}$ after the age of 20 years. In the case of the other groups tested, no correlation with age could be shown.

Distal latencies

Distal latencies for the median and ulnar nerves were examined in the three groups tested (Table 2 and Fig. 2).

The variance ratios of latencies of the XYY males and the normal controls were significantly greater than unity and the Mann Whitney U Test was used in testing for significant differences between the groups. No significant difference in distal latencies in either nerve was found between the control groups, but the distal latencies in both were found to be significantly prolonged in the XYY group when compared with the normal population ($P<0.01$) and the subnormality hospital group ($P<0.05$, median nerve; $P<0.01$, ulnar nerve).

Motor conduction and forearm temperature

For the wrist to elbow segment of the median nerve, between skin temperatures of 25 and 37°C, a change in maximum motor conduction velocity of $1.8 \text{ m s}^{-1} \text{ °C}^{-1}$ change in temperature was found.

Reliability of surface measurements

No significant difference was found between the surface lengths of the median and ulnar nerves in cadavers and the length of the exposed nerves between these points (Table 3). In neither instance did ‘$t$’ reach the 5% level of significance.
Reproducibility

No significant difference was found between the maximum motor conduction velocities in the median and ulnar nerves determined on different days. The mean theoretical difference was assumed to be zero. The mean difference between the two sets of observations for each nerve was calculated taking due account of mathematical sign. The standard deviation of the mean difference and then 't' were calculated. At no time did 't' approach the 5% level of significance (Table 4). The mean difference between the two sets of observations was found to be 2·0 (SD 3·06) m s\(^{-1}\) for the median nerve, and 0·54 (SD 3·02) m s\(^{-1}\) for the ulnar nerve. The standard deviation of the mean difference between paired measurements expressed as a percentage of the mean value of the dimension concerned was 4·7% for the median nerve and 3·3% for the ulnar nerve.

DISCUSSION

Normal values for maximum motor conduction in the median and ulnar nerves have been well documented (see article by Kaeser, 1970). These normal values differ slightly in different laboratories and in this study, account had also to be taken of the possible influence that an ascertainment in mental subnormality hospitals and related institutions might have on the results. 'Normal' values were therefore obtained from subjects in a mentally subnormal group of institutionalized patients and a general population sample. Ideally an unselected group of XYY individuals should be examined, but as yet insufficient males with this sex chromosome abnormality have been identified in samples of the general population.

As well as allowing for ascertainment bias in the selection of subjects, attention was paid to several points in the technique to standardize the method as far as possible. Ambient temperature and temperature of the forearm were controlled as it had been shown previously that motor nerve conduction varied significantly with temperature (Henriksen, 1956; Johnston & Olsen, 1960). Henriksen found that between skin temperatures of 29 and 38°C, the conduction velocity changed by approximately 2·4 m s\(^{-1}\) °C\(^{-1}\) change in temperature. Johnston & Olsen found a drop in conduction velocity of about 5% per °C. The result for the coefficient of variation with temperature determined in this study was comparable with these values. Possible errors owing to measurement of the nerve segment were also considered but no significant difference was found between the surface lengths of the median and ulnar nerves in the forearm in cadavers, and the actual lengths of the nerves between these points when exposed, providing the limb was kept in the same position. This is in agreement with Carpendale's (1956) observations on four cadavers.

In testing reproducibility of conduction velocity measurements from day to day, Norris et al. (1953) estimated the standard deviation of day-to-day measurement of motor conduction velocity in the elbow to wrist segment of the ulnar nerve as 5·6 m s\(^{-1}\). Henriksen (1956) carried out duplicate measurements on different days, and found a mean difference of 1·9 (maximum 7·8) m s\(^{-1}\). In this survey, the difference between the two sets of observations was not found to be significant for either nerve.

It could be argued that the results might be influenced by medication received by the subjects, but the amount of sedation received by XYY males was small, and a large proportion of the subnormality group was also receiving some form of sedation. Daly (1969) found neurological abnormalities in six out of twelve XYY males examined, but in this sample of XYY patients, no neurological signs could be elicited to account for the results obtained.
Ageing effects in motor conduction velocity in peripheral nerves have been shown by several authors (Norris et al., 1953; Wagman & Lesse, 1952). Wagman & Lesse measured motor conduction velocity in the ulnar nerve for various age groups and found a mean conduction velocity in the ulnar nerve of 49.7 m s\(^{-1}\) for the 50–60 years age group, compared with 58 m s\(^{-1}\) for the 20–30 years age group. In this study the only significant correlation with age was shown in the case of the median nerve for the normal population. No regression of conduction velocity with age could be demonstrated for the XYY males but it may be that this was due to the small number of subjects studied. However, only two out of the thirty-one XYY subjects tested were over 60 years, and their motor conduction velocities were not slower than the rest of the XYY group. The normal population were in fact older than the XYY group so that slowing due to age seems an unlikely explanation for the results.

Local nerve lesions, e.g. carpal tunnel syndrome or ulnar nerve compression syndromes, could be responsible for the slowing in conduction velocity seen in the median and ulnar nerves in the forearm of the XYY group. Gilliatt & Thomas (1960) found that when the ulnar nerve was compressed at the elbow motor conduction from elbow to wrist may be slowed. In the carpal tunnel syndrome, too, conduction velocities in the median nerve in the forearm can be normal or reduced. Thomas, Lambert & Cseuz (1967) found an average conduction velocity in the forearm of 53.3 m s\(^{-1}\) in patients with the carpal tunnel syndrome compared with an average normal median motor conduction velocity of 59.1 m s\(^{-1}\). However, no history of symptoms referable to the median or ulnar nerves could be obtained in the XYY group, and no signs of carpal tunnel syndrome or ulnar nerve compression could be found on clinical examination.

It may be that there is a generalized reduction in motor nerve conduction velocity in these nerves which represents a physiological variation in males with this karyotype. Alternatively there may be a reduction in the number of large diameter fibres, as it has been shown that conduction velocity is proportional to fibre diameter (Hursh, 1939). Reduction in thickness of the myelin sheath is another possible explanation for a reduction in motor conduction (Saunders & Whitteridge, 1946). Vascular changes which may be present have been shown not to reduce conduction velocity (Chopra & Hurwitz, 1968).

The prolonged distal latencies seen in both nerves in the XYY group as compared with the two control groups could be due either to slow conduction in the distal portion of the nerve, or to abnormalities at the neuromuscular junction. However, when either the median or ulnar nerve was stimulated repetitively at 3 Hz in the XYY individuals, there was no reduction in the voltage of the muscle response after six stimuli. Thus the prolonged distal latencies seen in this group are probably due to slow conduction in the terminal fibres of the nerve concerned, rather than to abnormalities of the neuromuscular junction.

At present there is no evidence on which to choose between the possible explanations for the observed slowing in motor nerve conduction velocities in forty-seven XYY males, but other subjects with different presentations of sex chromosome abnormality are under investigation in an attempt to determine the significance of the karyotypic abnormality.

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REFERENCES


