

Muscle strength in boys of different ages

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SUMMARY Isometric twitch contractions have been studied in extensor hallucis brevis muscles of 32 healthy male subjects aged between 3 and 25 years. The maximum twitch tensions were found to increase gradually with age and then to undergo marked enhancement at puberty. After puberty little further change occurred. In the youngest children examined the twitch contraction times were already within the adult range, though the half-relaxation times were prolonged.

As children grow older they become stronger, but few systematic observations have been made of this process.

Recently, we have had the opportunity to record isometric twitch tensions in healthy boys of various ages, some of whom served as controls for a study of Duchenne dystrophy (McComas, Sica, and Currie, 1971). The advantage of measuring twitch tension is that it does not depend on the cooperation of the subject and therefore can be made in relatively young children. The results of this study are felt to be of some interest in that they reveal a marked increase in muscle force which occurs at puberty.

METHODS

Thirty-two healthy males were studied with ages ranging from 3 to 25 years. The isometric twitch was recorded from the extensor hallucis brevis (EHB) muscle using the technique of Sica and McComas (1971). The initial length of the muscle was increased by fully plantar-flexing the first metatarsophalangeal joint. It has previously been shown that in a young subject the optimum length is greater than the maximum length attainable (Sica and McComas, 1971).

No correction has been made for variations in the distance between the recording point on the big toe and the metatarsophalangeal joint. In older, and larger, subjects this distance would be greater and hence the recorded tension would be a relatively

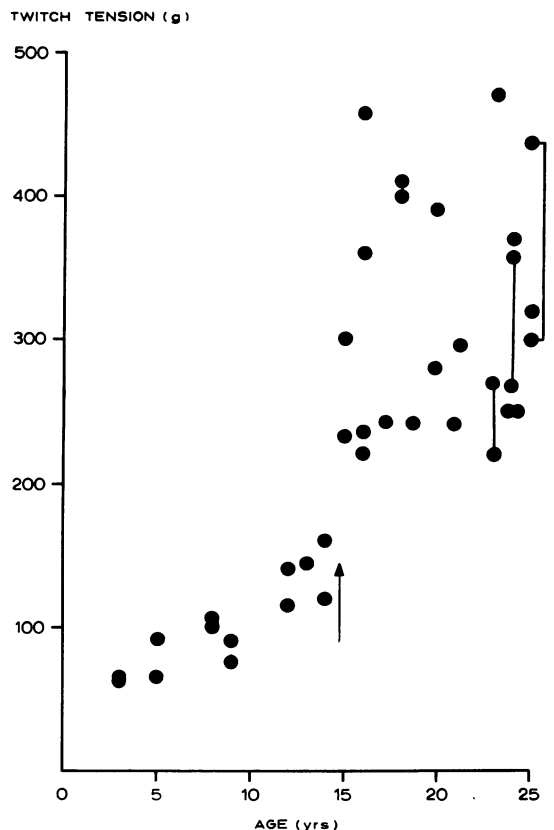


FIGURE *Isometric twitch tensions in 32 male subjects aged 3-25 years. Values to right of arrow were obtained in subjects with overt manifestations of puberty (see text). Vertical lines join values obtained in both legs of same subjects.*

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smaller fraction of the true tension (cf. Sica and McComas, 1971). It is not known to what extent this would be offset by the decrease in muscle elasticity which is known to accompany ageing.

RESULTS

TWITCH TENSION The Figure shows the twitch tensions at different ages. It can be seen that below the age of 15 years the twitch tensions

TABLE
MEAN CONTRACTION AND HALF RELAXATION TIMES
(\pm SD) IN MALES AGED 3-14 AND 15-22 YEARS

Age of subjects (yr)	n	Contraction time (msec)	Half-relaxation time (msec)
3-14	13	66.2 \pm 5.5	65.1 \pm 9.2
15-25	24	65.3 \pm 7.4 ($P = > 0.6$)	57.5 \pm 9.3 ($P = 0.02$)

Significance levels given in parentheses.

were directly proportional to the ages of the subjects. For a male subject aged t years, the isometric twitch tension, f , was given by the regression equation:

$$f = 38 + 7.3t \quad g(r = 0.80)$$

Once puberty was well advanced, as evidenced by changes in the voice and skin (Figure, arrow), there was a marked enhancement of strength. Thus the mean tension for the six boys aged 15-16 years was 301 SD \pm 93 g and was more than double the mean value for the five boys aged 12-14 years (136 \pm 18 g). Beyond the age of 18 years no further change in tension was apparent and the correlation coefficient for values between 16 and 25 years was only 0.01.

TIME COURSE OF CONTRACTION In the Table the mean contraction and half-relaxation times of the pre- and early-pubertal boys (3-14 years) have been compared with corresponding values in older male subjects. It can be seen that there was barely any difference between the mean contraction times of the two groups. In contrast, the mean half relaxation time was considerably slower in the children and this difference was probably significant ($P = < 0.02$).

DISCUSSION

In the present study we have used isometric twitch tensions to assess muscle performance in male subjects aged between 3 and 25 years. The results show that, within this age span, muscle strength increases in two phases. In the first phase, which lasts until 14 years of age, the increase in strength is proportional to the age of the subject. The second phase takes place within the next two years; it results in a doubling of muscle strength to levels which vary considerably from subject to subject. Inspection of the pooled results indicates that after the second phase has been completed there is little, if any, further increase in strength. It would obviously be of interest to complement these results with serial observations on single subjects, in order to determine the rapidity of the spurt in strength. In mammalian muscles forced to undergo work hypertrophy, there is evidence that individual fibres may reach their new size in the surprisingly short time of one and a half to two days (Goldspink, 1965). In such muscles the new fibre size is associated with an increase in the numbers of myofibrils: this increase probably results from longitudinal splitting of pre-existing myofibrils. It is unlikely that any new muscle fibres could have been formed to account for the increased strength (MacCallum, 1898; Goldspink, 1962).

Although genital staging of puberty (Tanner, 1962) was not employed in the present study, the increased muscle strength was most noticeable in boys in whom puberty was well advanced, as evidenced by deepening of the voice and coarsening of the skin. In the levator ani muscle of the rat, testosterone has been shown to have a direct effect on muscle development (Wainman and Shipounoff, 1941; Venable, 1966a, b; Gori, Pellegrino, and Pollera, 1969; Galavazi and Szirmai, 1971). It is therefore reasonable to suppose that the enhanced muscle strength at puberty results from the increased levels of circulating testosterone which are known to occur at this time (Wieland, Chen, Zorn, and Hallberg, 1971).

The twitch speeds of developing muscles are also of interest. In newborn kittens, Buller, Eccles, and Eccles (1960) demonstrated that all muscles have relatively slow twitches and that, in muscles destined to become 'fast', a speeding-

up of the twitch takes place over the next few weeks. In the present study the two youngest subjects were aged 3 years and in both the contraction times were already within the normal range. The pooled observations suggest that it takes rather longer for the relaxation phase of the twitch to assume adult values. It would clearly be of interest to determine the twitch speeds in children younger than 3 years old and to document any alterations occurring subsequently.

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