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# Girls with Turner syndrome have normal muscle force but decreased muscle power

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None of the authors have any conflict of interest.

## Introduction

**Turner syndrome (TS)** is associated with **decreased bone mineral density** and **altered bone geometry**, which is assumed a risk factor leading to **increased fracture rate**. Although hypogonadism or SHOX gene haploinsufficiency are the probable causes, the exact mechanism remains unclarified. Particularly, the **muscle function as an** important **determinant of bone strength** has yet **not been focused on** in TS.

**We tested the hypothesis that there is muscle dysfunction in TS**.

Secondary aim was to describe the **influence of pubertal stage**, hormone **therapy**, **fracture history** and **genotype**.

**Table 1.** Anthropometry characteristics of TS patients.

| N=60 | mean (SD) |
|---|---|
| Age (year) | 13.7 (4.6) |
| Weight (kg) | 43.2 (16.3) |
| Weight (Z-score) | -0.63 (1.2)*** |
| Height (cm) | 142.3 (17.3) |
| Height (Z-score) | -1.8 (0.93)*** |
| BMI (kg/m²) | 20.3 (4.1) |
| BMI (Z-score) | 0.44 (0.98)** |

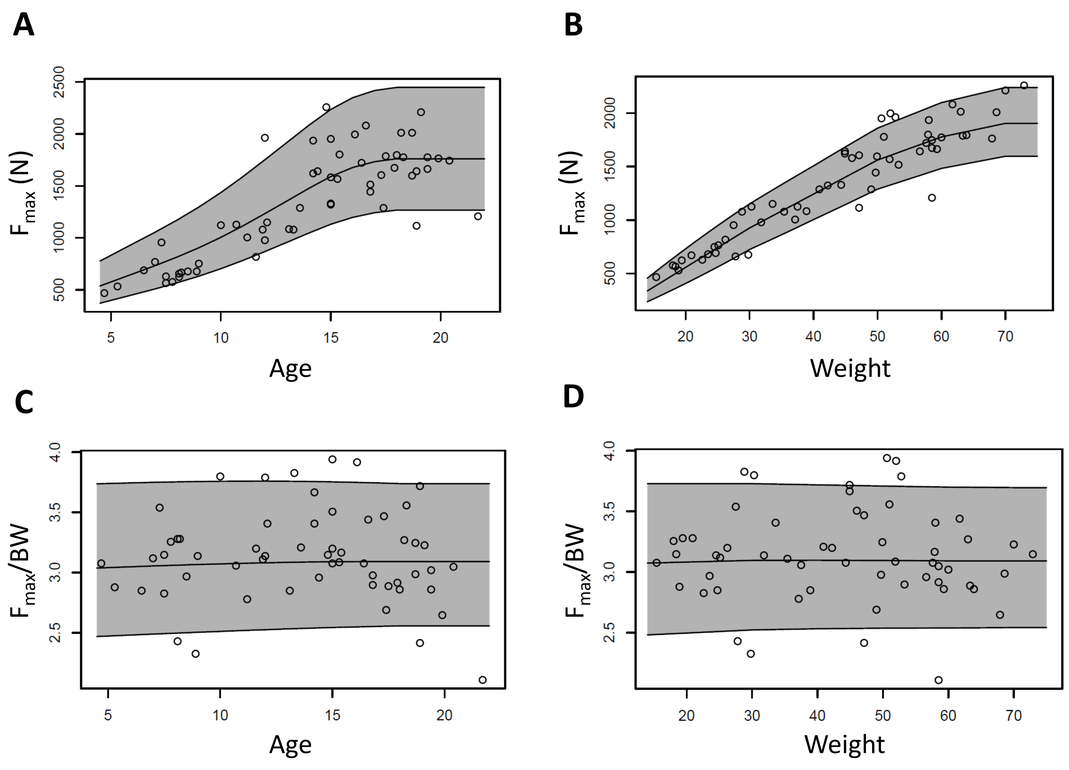
The Z-scores were tested for difference from 0 by one-sample T-test. *p<0.05 **p<0.01 ***p<0.001

## Patients and Methods

All TS patients consenting to the study and having no other chronic disease were included (**60 patients, age 13.7±4.5 years**). Age- and weight-specific **z-scores** of muscle parameters were calculated **based on control group of 432 healthy girls**.

**Leonardo Mechanograph® Ground Reaction Force Platform** was used to assess **muscle force ($F_{max}$)** by the multiple one-legged hoping test and **muscle power ($P_{max}$)** by the single two-legged jump test. Muscle functions were related to body weight ($F_{max}$/BW) and body mass ($P_{max}$/mass), respectively.

**Figure 1.** $F_{max}$ (A+B) and $F_{max}$/BW (C+D) of TS patients plotted into age- and weight-specific nomograms, respectively.

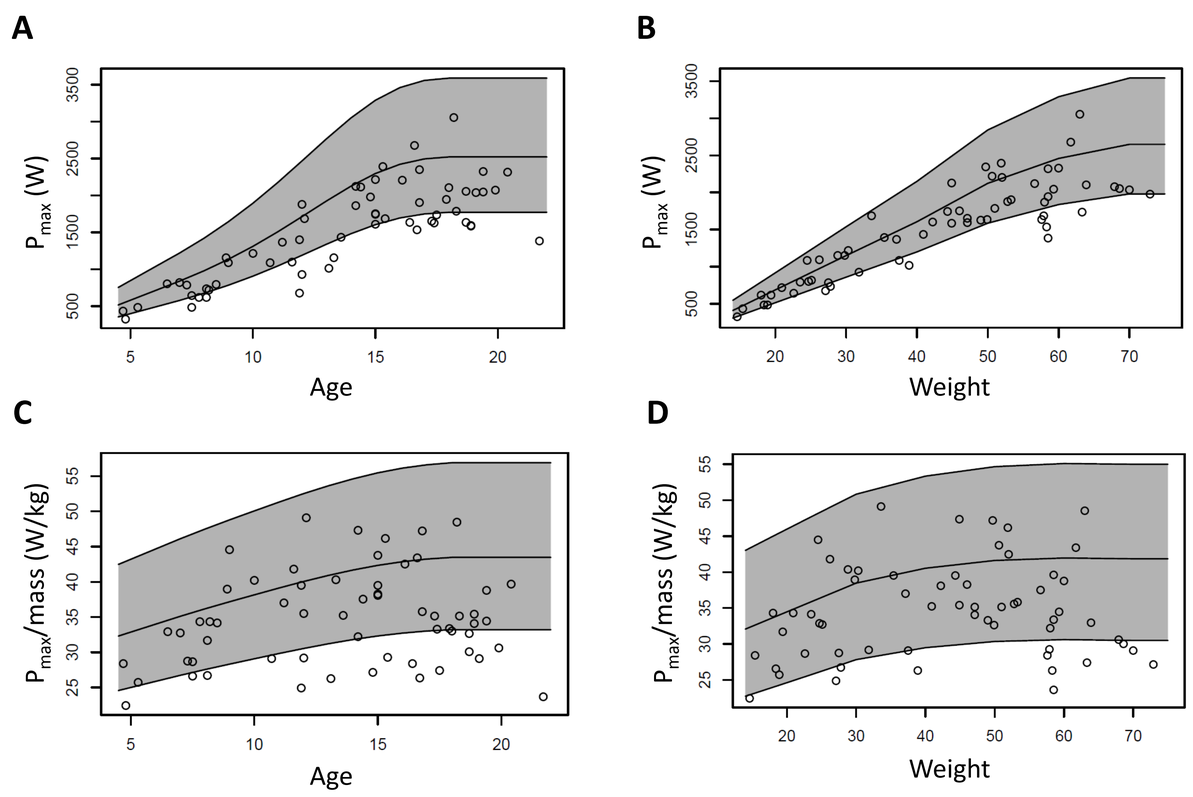



$F_{max}$ was assessed through multiple one legged hopping. Lines are mean ± 2SD, based on 432 healthy girls.

## Results

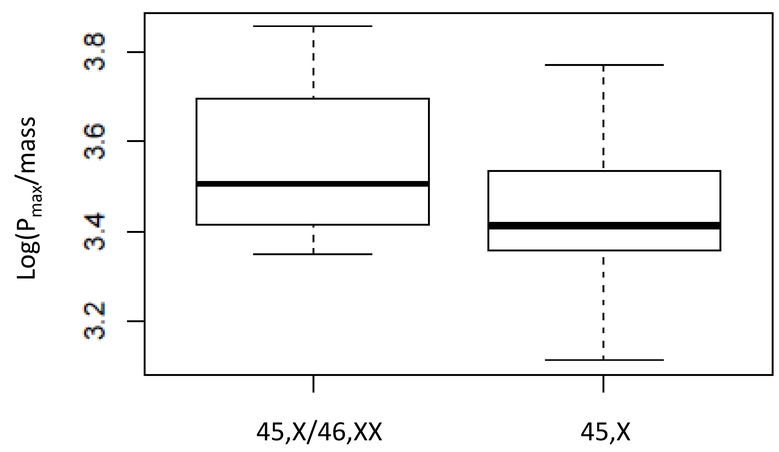
While **$F_{max}$** and $F_{max}$/BW were **normal** (mean weight-specific Z-scores 0.11±0.77, p=0.27, and 0.046±0.62, p=0.55; Fig. 1), **$P_{max}$** and $P_{max}$/mass were **decreased in TS** (Z-scores -0.93±1.5, p<0.001, and -0.45±0.58, p<0.001; Fig. 2), as compared to healthy controls. The **muscle functions** were **not** significantly **influenced by pubertal stage, hormone therapy, fracture history nor genotype** (linear regression, adjusted for age, weight and height, all p>0.05).

**Figure 2.** $P_{max}$ (A+B) and $P_{max}$/mass (C+D) of TS patients plotted into age- and weight-specific nomograms, respectively.




$P_{max}$ was assessed through single two legged jump. Lines are mean ± 2SD, based on 432 healthy girls.

**Figure 3.** The influence of karyotype on $P_{max}$/mass in TS girls.




The influence of karyotype (mosaic vs. X monosomy) was tested in linear regression model with adjustment for age, age^2, weight, weight^2 and height (β = -0.108±0.085, P = 0.22). Boxes represent median and interquartile range, lines are maximum and minimum.

## Conclusions

**$F_{max}$ as a principal determinant of bone strength is normal in TS**. The **changes in bone quality and structure in TS** are therefore not related to inadequate mechanical loading, but rather **represent a primary bone deficit**. Decreased $P_{max}$ may represent a novel indicator of impaired muscle coordination in TS.