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Introduction

Understanding the timing of pubertal changes is important given the association between off-timed puberty and adverse health outcomes. Identifying markers of early puberty is therefore important for clinicians, parents and adolescents.

Foot length has been suggested as an early marker in studies using indirect markers of puberty (Tanner stage, peak height velocity, age at menarche) (1,2,3), but not with hormone measures.

Aim: to describe foot length changes in early puberty and relate these to anthropometric (height, weight), Tanner stage and hormone measures in a longitudinal cohort of healthy Australian adolescents.

Methods

The Adolescent Rural Cohort study of Hormones, health, Education, environments and Relationships (ARCHER) recruited a community sample of adolescents (n=342; aged 9-14y at baseline) who were followed for three years (4).

Adolescents had annual anthropometry (height, weight, foot length), self-rated Tanner stage, date of menarche and provided annual serum samples assayed for T, E₂, DHEA (all via LC-MS/MS) and IGF-1 (via radioimmunoassay).

Pre-puberty was defined by baseline T <0.5 nmol/L for males or E₂ <40 pmol/L for females.

Results

Data were available for 293 adolescents (128 female). 13% (17/128) of females and 43% (71/165) of males were pre-pubertal at baseline.

Average annual % increase in foot length was greater for adolescents classified as pre-pubertal compared to pubertal at baseline (F:2.7% vs 1.5% p<0.001; M:4.2% vs 2.9%, p<0.001) (Figure 2).

In the three years from baseline to final follow-up, both sexes showed expected increases in anthropometry, Tanner stage and most serum hormones.

Table 1. β -coefficients for regression analyses of foot length with T, E₂, DHEA and IGF-1. **Bold:** significant association (p<0.05)

	Male	Female (pre-menarche)	Female (post-menarche)
T	0.2cm (0.16-0.20)	0.7cm (0.09-1.4)	0.2cm (-0.16-0.59)
E ₂	0.02cm (0.012-0.022)	0.004cm (0.001-0.006)	0.0006cm (-0.00069-0.0020)
DHEA	0.02cm (-0.015-0.047)	-0.03cm (-0.069-0.0057)	0.005cm (-0.011-0.021)
IGF-1	0.03cm (0.017-0.038)	0.03cm (0.014-0.050)	0.007cm (0.00067-0.013)

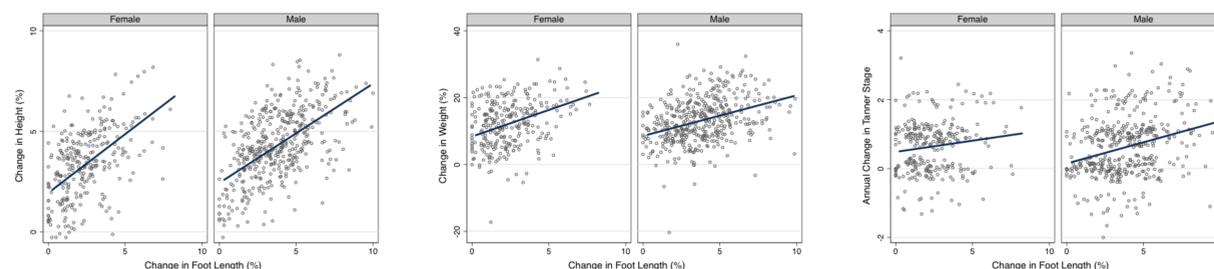


Figure 1. % changes in height (left), weight (centre) and Tanner stage (right) compared to change in foot length.

Conclusions

Foot length growth is greater in pre-puberty for both males and females, whereas height and weight show sex-specific patterns. Foot growth is longitudinally associated with anthropometric markers, Tanner stage, serum sex steroids and IGF-1.

Using foot length as a marker of early puberty is novel, cost-effective and simple. Importantly, it is related to the true hormonal drivers of puberty.

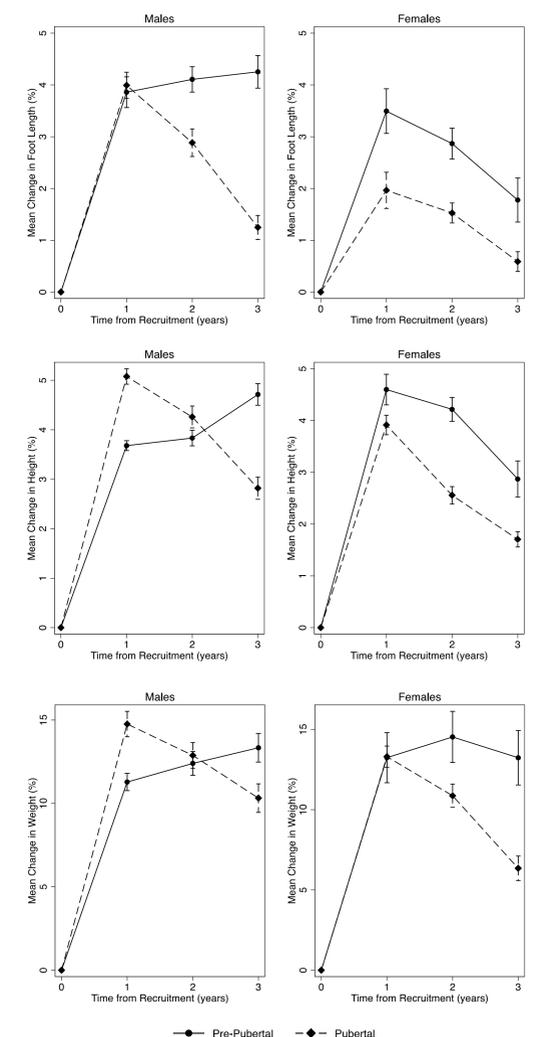


Figure 2. % changes in foot length (top), height (middle) and weight (bottom) over study duration, by pubertal status at baseline.

References

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