Patterns and Correlates of Pubertal Development in Canadian Youth

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ABSTRACT

Background: Current health literature suggests that there has been a decline in the age of pubertal onset, and that pubertal development is influenced by social context. Unfortunately, contemporary Canadian-specific data have not been available. This study examined the odds of having entered puberty at various ages during adolescence, before and after controlling for the effects of family socio-economic status and family structure.

Methods: Longitudinal data for this study were drawn from the first four cycles of the National Longitudinal Survey of Children and Youth. The final sample consisted of 7,977 adolescents ranging in age from 10 to 17. Pubertal status of the participants was identified based on pubic hair, facial hair growth, and voice change, for boys; and pubic hair, breast development, and menstruation, for girls. Trajectories of pubertal development were analyzed with HLM growth curve modelling techniques.

Results: The results indicated that, compared to boys, the odds of having entered puberty at age 13 were 6.45 times higher for girls and that girls go through puberty more quickly. Low family socio-economic status and living with a stepfather were found to predict early onset of pubertal development.

Conclusion: Contextual factors are related to pubertal development. Additional research is needed to develop a more solid understanding of how psychosocial factors interact to predict gendered patterns of pubertal development.

MeSH terms: Adolescent development; puberty; longitudinal studies; binomial distribution; socioeconomic status; family characteristics

La traduction du résumé se trouve à la fin de l'article.

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Disclaimer: The analyses were based on the Statistics Canada master file National Longitudinal Survey of Children and Youth anonymous data that were collected during 1994-95, 1996-97, 1998-99, and 2000-01. The authors are entirely responsible for the use and interpretation of these data.

Acknowledgements: This study was partially supported by the Canadian Research Institute for Social Policy through the Social Sciences and Humanities Research Council of Canada.

It is important for public health professionals and other health care practitioners who work with adolescents to have access to up-to-date, geographic-specific, normative prevalence data on pubertal timing to guide their assessment and preventive health care practices. Early pubertal development has been associated with substance use, earlier sexual activity, and mental health problems among both girls and boys. In addition, late maturity among boys has also been associated with behaviour problems and lower educational attainment.

There is consensus that girls enter puberty approximately two years earlier than boys, and historically studies have identified the typical age ranges for pubertal development as 9.5 to 14.5 years for girls and 10.5 to 16 for boys. Current health literature suggests that there has been a decrease in the age of pubertal onset among both boys and girls. However, the only large-scale contemporary studies on pubertal onset were conducted in the United States (US) and suggest that while breast development and pubic hair are occurring earlier, the average age of menarche has remained the same over the last 45 years. We located no similar studies on Canadian youth.

Several factors have been shown to influence pubertal development, including weight, nutritional status, and exercise. Ethnic differences have also been found, although in one study, the association disappeared after controlling for the effects of socio-economic status (SES). Psychological influences (such as stressful life events in childhood) and contextual effects (such as family environment) have also been shown to influence early pubertal onset. Living in a single-parent home has been found to be associated with earlier pubertal onset in both girls and boys. Ellis and Garber also found that girls tended to enter puberty earlier if they lived with a stepfather, although in this study, the absence of a biological father did not accelerate the onset of puberty, and living with a stepfather was not significant for boys. A number of studies have found that higher SES is associated with earlier pubertal timing among both girls and boys, although a recent study found that economic anxiety predicted earlier pubertal timing among boys, but not girls.

The purpose of this study was to describe pubertal development among...
Canadian youth. Most of the research on puberty has been cross-sectional and/or retrospective in design, involving American or European samples. The current study utilized longitudinal data from a nationally representative Canadian sample to examine pubertal development for Canadian adolescents, before and after controlling for family structure and SES.

METHODS

Data for this study were drawn from the first four cycles (1994-95, 1996-97, 1998-99, 2000-01) of the Canadian National Longitudinal Survey of Children and Youth (NLSCY). The final sample for this study consisted of 7,977 adolescents aged 10-17 years, balanced by gender. Seventeen percent of the youth lived in single-parent families, 8% lived in families

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**TABLE IA**

Results of HLM Modelling (Unconditional Model 1 & Conditional Models 2 and 3)

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient (SE)</td>
<td>Odds Ratio</td>
<td>Coefficient (SE)</td>
</tr>
<tr>
<td>Initial Status at Age 13</td>
<td>0.29‡</td>
<td>0.04</td>
<td>1.34 (1.24-1.45)</td>
</tr>
<tr>
<td>Gender</td>
<td>1.86‡</td>
<td>0.08</td>
<td>6.45 (5.48-7.59)</td>
</tr>
<tr>
<td>SES</td>
<td>-0.14‡</td>
<td>0.07</td>
<td>0.78 (0.71-0.86)</td>
</tr>
<tr>
<td>Single Parenting</td>
<td>3.22‡</td>
<td>0.02</td>
<td>2.99 (2.78-3.22)</td>
</tr>
<tr>
<td>Stepfather</td>
<td>0.33‡</td>
<td>0.08</td>
<td>1.39 (1.18-1.63)</td>
</tr>
<tr>
<td>Gender X Stepfather</td>
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<td>0.01</td>
<td>1.01 (0.99-1.04)</td>
</tr>
<tr>
<td>Age</td>
<td>0.13‡</td>
<td>0.03</td>
<td>1.14 (1.08-1.20)</td>
</tr>
<tr>
<td>Gender</td>
<td>0.37‡</td>
<td>0.03</td>
<td>1.44 (1.33-1.56)</td>
</tr>
<tr>
<td>SES</td>
<td>-0.04‡</td>
<td>0.02</td>
<td>0.96 (0.91-1.01)</td>
</tr>
<tr>
<td>Single Parenting</td>
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<td>0.02</td>
<td>0.98 (0.93-1.03)</td>
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<tr>
<td>Stepfather</td>
<td>0.00‡</td>
<td>0.01</td>
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</tr>
<tr>
<td>Gender X Stepfather</td>
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<td>0.02</td>
<td>0.97 (0.91-1.03)</td>
</tr>
<tr>
<td>Random Effects</td>
<td>Intercept</td>
<td>2.00‡</td>
<td>1.41</td>
</tr>
</tbody>
</table>

Note: Gender was coded as boys = 0 and girls = 1. Numbers in parentheses indicate the confidence intervals. *p<0.05, †p<0.01, ‡p<0.001, § p=0.06

**TABLE IB**

Results of HLM Modelling (Conditional Models 4-6 continued)

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
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</thead>
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<td>Odds Ratio</td>
<td>Coefficient (SE)</td>
</tr>
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<td>Initial Status at Age 13</td>
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<td>0.06</td>
<td>0.55 (0.49-0.62)</td>
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<td>0.08</td>
<td>6.42 (5.46-7.55)</td>
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<tr>
<td>SES</td>
<td>-0.13†</td>
<td>0.05</td>
<td>0.88 (0.81-0.96)</td>
</tr>
<tr>
<td>Single Parenting</td>
<td>0.16</td>
<td>0.11</td>
<td>1.17 (0.94-1.45)</td>
</tr>
<tr>
<td>Stepfather</td>
<td>0.33</td>
<td>0.27</td>
<td>1.40 (0.83-2.36)</td>
</tr>
<tr>
<td>Gender X Stepfather</td>
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<td>0.04</td>
<td>1.98 (1.84-2.13)</td>
</tr>
<tr>
<td>Age</td>
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<td>0.04</td>
<td>3.01 (2.81-3.22)</td>
</tr>
<tr>
<td>Gender</td>
<td>0.35†</td>
<td>0.06</td>
<td>1.42 (1.27-1.59)</td>
</tr>
<tr>
<td>SES</td>
<td>0.11‡</td>
<td>0.03</td>
<td>1.12 (1.06-1.17)</td>
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<td>Single Parenting</td>
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<td>0.06</td>
<td>1.09 (0.97-1.23)</td>
</tr>
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<td>Stepfather</td>
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<td>0.16</td>
<td>1.14 (0.84-1.56)</td>
</tr>
<tr>
<td>Gender X Stepfather</td>
<td>0.04</td>
<td>0.09</td>
<td>0.96 (0.81-1.13)</td>
</tr>
<tr>
<td>Age</td>
<td>0.01</td>
<td>0.02</td>
<td>1.01 (0.97-1.06)</td>
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<tr>
<td>Gender</td>
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<td>0.03</td>
<td>0.95 (0.89-1.01)</td>
</tr>
<tr>
<td>SES</td>
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<td>0.02</td>
<td>1.03 (1.00-1.06)</td>
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<tr>
<td>Single Parenting</td>
<td>-0.01</td>
<td>0.03</td>
<td>0.99 (0.93-1.06)</td>
</tr>
<tr>
<td>Stepfather</td>
<td>-0.04</td>
<td>0.01</td>
<td>0.96 (0.79-1.17)</td>
</tr>
<tr>
<td>Gender X Stepfather</td>
<td>-0.07</td>
<td>0.06</td>
<td>0.93 (0.83-1.05)</td>
</tr>
<tr>
<td>Random Effects</td>
<td>Intercept</td>
<td>1.87‡</td>
<td>1.37</td>
</tr>
</tbody>
</table>

Note. Gender was coded as boys = 0 and girls = 1. Numbers in parentheses indicate the confidence intervals.*p<0.05, †p<0.01, ‡p<0.001, || p=0.07
with a stepfather, and 2% lived with a stepmother.

Measures

**Pubertal Development Scale (PDS)**
This self-report measure has been shown to be a valid way of assessing puberty. Three items from the PDS were used: pubic hair, facial hair, and voice change for boys; and pubic hair, breast development, and menstruation for girls. The response options for all but the menarche item were: 1) has not yet started growing, 2) barely started, 3) is definitely underway, and 4) seems complete; the menarche item was scored dichotomously. The three items yielded Cronbach’s alpha coefficients above .90 for both sexes. A single dichotomous measure representing pubertal status was computed at each data collection point, based on these three items. Presence of puberty among boys was deemed to have occurred when two or three secondary sexual characteristics were definitely underway or complete; presence of puberty among girls required that at least two secondary sexual characteristics were definitely underway or that menarche had occurred and at least one other secondary sexual characteristic was definitely underway. As a baseline, according to this operational definition, 5% of the girls and 3% of the boys reported having entered puberty by age 10.

**SES and Family Structure**
The parent (or other person most knowledgeable about the child) provided information on SES and family structure. A composite measure of family SES was developed based on five variables which described household income, parental education and occupation levels, weighted by the factor loadings obtained through principal components factor analysis with varimax rotation. This variable was standardized, with a mean of 0 and a standard deviation of 1. For family structure, three dummy variables were created (living with a single parent, stepmother, or stepfather), based on who the child lived with at 10 years of age.

**Statistical analysis**
Growth curve analyses were conducted using Hierarchical Linear and Nonlinear Modeling software (HLM, 5.40%). Bernoulli’s logistic regression procedures to show the probability of entering puberty at each age. We first identified the shape of the trajectories of pubertal timing with a series of unconditional models. We then examined a series of conditional growth models to obtain gender-specific estimates and to describe the influence of family context on pubertal timing. The age variable was centered on 13, which represented the middle point of the age range and the most interesting with respect to pubertal timing. Longitudinal sample weights were applied to generate unbiased population estimates in all analyses. (See Appendix for further details of analytic procedures.)

**RESULTS**
As noted in the Appendix, a non-linear unconditional model was found to provide the best fit for the data, with age and age-squared both being positively correlated with the likelihood of entering puberty (see Model 1, Table Ia). The influence of gender was examined in Model 2 and found to be significant for both the intercept and slope of the pubertal trajectories. Compared to boys, the...
PUBERTY IN CANADIAN YOUTH

The results of this study provide a contemporary description of pubertal development among Canadian youth. Our findings showed the enormous variability in the timing and tempo of puberty, and identified the relative likelihood that boys and girls had entered puberty between the ages of 10 and 17. We also described the effects of family context on pubertal timing. Consistent with prior findings from multiple countries (although mostly from the US) regarding gender differences in pubertal development, our results indicated that girls were almost six and a half times more likely than boys to have entered puberty by age 13.

Knowledge of the developmental trajectories for each gender is important for school nurses and counsellors in planning primary prevention programs related to sexual health education and mental health. Results can also be used to guide the assessment and preventive health care practices of public health nurses who directly work with adolescents, for example, in youth clinics. Given the abundant literature showing that atypical pubertal status or timing is a predictor of poor psychosocial outcomes, it is important that early maturing adolescents be identified and equipped to manage the emotional sequelae of hormonal changes or sexual attention related to early maturation, and that late matures who may feel that they do not ‘measure up’ to socially constructed notions of gender, also be supported. The variability in pubertal timing found in this study suggests that sexual health education programs be designed to emphasize individual differences in pubertal development over normative development. By expanding our notion of normative development, we may serve to reduce stigmatization for those who do not develop at the ‘average’ time and pace.

Regarding the influence of family context on pubertal development, our findings indicated that adolescents from higher SES families were less likely to have entered puberty by age 13. This is in contrast to other research conducted in Iran, Nigeria, India, and the US which showed that higher SES is associated with earlier puberty. However, our study utilized longitudinal data, which enabled us to determine the rate of change during puberty. We found that adolescents from higher SES families were more likely to go through puberty at a faster rate. Thus, it is likely that previous studies conflate the presence and rate of pubertal change, whereas our study distinguishes between these. It is possible that adolescents from higher SES families may experience less economic-related stress, and therefore, are less likely to have entered puberty by age 13, but that the rate of pubertal development is steeper due to the health-promoting conditions associated with higher SES, such as good nutrition and regular physical activity.

Our findings also found non-significant effects for the influence of living in a single-parent home, which is also inconsistent with earlier research. This inconsistency may be explained by the strong controls used for SES in this study (including family income and parents’ education and occupational status) which are strong correlates of single parenting. Future work in this area is needed to determine whether these inconsistent findings are unique to Canadian adolescents, or if they are due to unique factors associated with this study. Finally, our results supported recent findings, which suggest that the presence of a stepfather predicts earlier pubertal onset.

A limitation of the study is that the measurement of puberty was based solely on adolescents’ self-reports. Thus, the data may represent adolescents’ subjective experiences of puberty including their personal aspirations and social comparisons, as well as their self-perceptions of actual physical development.

A major strength of this study is that it used a large, nationally representative longitudinal sample of Canadian youth. As far as we know, this is the first Canadian study to have examined the impact of family context on pubertal development, and the first study to have used growth curve modelling to identify trajectories of pubertal development rather than simply identifying a mean age for the development of various sexual characteristics. However, further research should be pursued to examine the interaction between the contextual factors identified here and the mechanisms that link social context with the biological processes of pubertal development in order to develop a more solid understanding of the psychosocial factors and processes predicting gendered patterns of pubertal development.

DISCUSSION

The results of this study provide a contemporary description of pubertal development among Canadian youth. Our findings showed the enormous variability in the timing and tempo of puberty, and identified the relative likelihood that boys and girls had entered puberty between the ages of 10 and 17. We also described the effects of family context on pubertal timing. Consistent with prior findings from multiple countries (although mostly from the US) regarding gender differences in pubertal development, our results indicated that girls were almost six and a half times more likely than boys to have entered puberty by age 13.

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REFERENCES


Appendix

Analytic Methods

Bemoulli’s logistic regression procedures were used to model the probability of entering puberty at various ages. In each model, we used a two-level analysis to describe within-person developmental change and to distinguish between-person differences through a specification of fixed and random effects. In these analyses, we observed y, a binary response for adolescent i at time j and x, an explanatory variable at the within-person level. We defined the probability of entering puberty as equal to p_r = Pr(y = 1) where p_r was modelled using a logit link function.

Unconditional Growth Model 1

In determining the shape of the trajectories, we first explored the log-odds of entering puberty for an adolescent at age 13, as well as the linear rate of change for each year. As expected, findings indicated that as age increases, so does the likelihood of entering puberty. We then examined the trajectories for non-linearity by including a quadratic (age-squared) term, and found that inclusion of the age-squared variable significantly improved the fit of the model. Thus, our unconditional growth model was represented by the following level-1 and level-2 equations.

Level 1:

\[
\log(\frac{p_r}{1-p_r}) = \beta_0 + \beta_1 \text{age}_i + \beta_2 \text{age}_i^2 + \epsilon
\]

Level 2:

\[
\begin{align*}
\beta_0 &= \beta_{00} + r_{0j} \\
\beta_1 &= \beta_{10} + r_{1j} \\
\beta_2 &= \beta_{20} + r_{2j}
\end{align*}
\]

Where \( \beta_r \) represents the log-odds of pubertal status of an adolescent at age 13; \( \beta_i \) represents the linear rate of change each year; \( \beta_j \) represents the nonlinear change in the rate of development; and \( r_{ij} \) is the amount of random error variance around the intercept. We did not model the random variation for the age or the age-squared terms as these models would not converge due to their complexity for the given number of data collection points.

Contexte : Selon les études actuelles sur la santé, la puberté démarrerait plus tôt, et le développement pubertaire serait influencé par le contexte social. Malheureusement, on ne dispose pas de données contemporaines spécifiquement canadiennes sur le sujet. Notre étude porte sur les probabilités d’entrée dans la période pubertaire à divers âges de l’adolescence, avant et après avoir apporté des ajustements pour tenir compte des effets de la structure et du statut socioéconomique de la famille.


Résultats : Les probabilités d’être entrés dans la période pubertaire à 13 ans étaient 6,45 fois supérieures chez les filles que chez les garçons, et la durée de la période pubertaire était plus courte chez les garçons. Le faible statut socioéconomique familial et le fait de vivre avec un beau-père étaient des variables prédictives d’une puberté précoce.

Conclusion : Des facteurs contextuels sont liés au développement pubertaire. Il faudrait mener d’autres études pour mieux comprendre l’interaction des facteurs psychosociaux et leur portée sur les modes de développement pubertaire selon le sexe.

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