Chronological Age and Health-Related Quality of Life in Adolescent Females: Is

Biological Maturation a Confounding Factor?

Sean P. Cumming

Fiona Gillison

Lauren B. Sherar

School for Health, University of Bath, Bath, UK

Submitted: 21/09/09

Address Correspondence to: Sean P Cumming
                            School for Health
                            University of Bath
                            Bath, BA2 7AY
                            United Kingdom
                            Email: S.Cumming@bath.ac.uk

                            Telephone: 01225 386251

                            Fax: 01225 383833

Abstract

Purpose: To examine the potential confounding effect of biological maturation on the relations between chronological age and health-related quality of life in adolescent British females.

Methods: Biological maturation, chronological age, and health-related quality of life were assessed in 366 female British Year 7-10 students (M = 13.0 years, SD = .8). The Kid-Screen 10 was used to assess health related quality of life. Percentage of predicted adult height attained at measurement was used as an estimate of biological maturation.

Results: Pearson product moment correlation demonstrated a statistically significant inverse relation between chronological age and health-related quality of life. This relation was, however, attenuated and non-significant once biological maturation was controlled for.

Conclusions: Researchers studying health related quality of life in youth should consider and/or control for the potential confounding effect of biological maturation.

Biological Maturation as a Confounding Factor in Relations between Chronological Age

and Well-being in Adolescent Females

The World Health Organization defines health-related quality of life (HRQoL) as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations values and concerns." [1]. HRQoL measures have commonly been used by physicians and psychologists to assess the effects of chronic illness in children and adolescents, and the extent to which an illness and its treatment can interfere with the their every day life [2-3]. However, recently this has been extended to the study and treatment of healthy children [4]. Assessing HRQoL in healthy populations provides useful normative data for comparison with sick groups, and a platform for understanding the basis of positive well-being in young people.

Age-related decreases in HRQoL have been documented in adolescence, and are particularly marked in girls [5]. Adolescence is the period of physical and psychological transition between the onset of puberty and the mature state and presents a series of meaningful and significant changes that may influence HRQoL. At various stages of development these changes may be biological/physical (e.g., attaining puberty), cognitive (e.g., ability to engage in social comparisons and think abstractly), educational (e.g., exams), environmental (e.g., transition to senior school) and/or social (e.g. developing romantic relationships)[6]. Age-related decrements in HRQoL may have significant implications for adult health status as low HRQoL in adolescents is associated with greater involvement in numerous health risk behaviors, including smoking, alcohol use [7], and sedentary living [2].

Age-related decrements in HRQoL in adolescence are well documented [5, 8-9]. However, researchers studying this phenomenon have largely ignored the processes of growth and maturation, that although related to chronological age may have a different trajectory. Growth refers to changes in body size, composition, proportions and physique, whereas maturation refers to progression towards the mature state and can be described in terms of timing and/or tempo [8-9]. Tempo refers to the rate at which maturation progresses, whereas timing refers to the time at which specific maturity-related events occur (e.g., peak height velocity, menarche). Children of the same chronological age can differ considerably in their degree of biological maturation, with certain individuals entering puberty at a much younger or older age than their peers. Collectively, the processes of growth, maturation and development constitute the universal task of 'growing up' and interact to govern many of the child's experiences during their first two decades of life [10].

There is good reason to believe that variation in biological maturation might contribute to age-related decreases in HRQoL, particularly in girls where maturity-associated variation in size, physique, body-composition, functional capacity and psychological health is marked [9]. Early maturing girls are more likely to be classified as overweight or obese, and obese and overweight youth report lower levels of HRQoL when compared to their normal weight peers [2, 11-13]. In terms of mental health, early maturing girls report lower physical self-concept [14], poorer body image [15], increased distress, anxiety, depression, and psychosomatic symptoms [15-17]. Advanced maturity is also linked with early substance abuse [18], alcohol abuse [19] and early sexual initiation [20]. Accordingly, a number of recent studies have documented a negative

association between HRQoL and stage of pubertal development attained (i.e., pre-pubertal, pubertal, and postpubertal) [21-22], with those girls who were more advanced in their pubertal development reporting lower HRQoL scores.

Given the limited research examining the contribution of biological maturation to age-related variance in HRQoL, the purpose of the current study is to examine the potential confounding effect of biological maturation on relations between chronological age and HRQoL in adolescent females. Assuming that advanced maturation in females is associated with lower HRQoL, it was hypothesized that relations between chronological age and HRQoL in adolescent females would be attenuated once biological maturation was controlled for. Finally, this study also examined differences in HRQoL across weight status (i.e., normal weight versus overweight+obese), controlling for chronological age and biological maturation.

Method

Participants

The participants were 366 female students (M = 13.0, SD = 0.8; actual range = 11.28-14.46 years) in years 7, 8 & 9 from two schools in the South West of England. Consent to conduct the study was issued from the local research ethics committee and written consent was obtained from the Head Teachers of the schools acting in *loco parentis*. Parents were informed of the research by post, and asked to provide passive consent (i.e. contact the school/researchers if they *did not* wish their child to take part). Finally, verbal consent was obtained from pupils.

Field Protocol

Height and weight were measured at the beginning of a physical education class, using standardized procedures [23]. Inter- and intra- observer technical errors of measurement (TEM) [24] for height were 0.26 cm. and 0.23 cm, respectively (conducted on a separate sample of college students (N=10)). TEM represents the degree of accuracy when performing and repeating anthropometric measurements (intra-observer), and when comparing measurements between investigators (inter-observer). Replicate measurements of body weight, using a portable electronic scale (Omega 783 Seca Ltd.), showed negligible variation between trials (TEM=0.06 Kg.). The body mass index (BMI, kg/m^2) was calculated. Chronological age in decimals was calculated as the difference between date-of-birth and date-of-measurement.

Measures

Health-Related Quality of Life. HRQoL was assessed using the KIDSCREEN-10 self-report index.The measure is a shortened version of the KIDSCREEN-52, a European instrument developed in consultation with adolescents, parents and carers in 13 European countries [25] that measures HRQoL over 10 dimensions (physical well-being, psychological well-being, mood and emotions, self-perceptions, autonomy, family relationships, relationships with peers, school environment, bullying, and financial resources). Participants rate each statement on a 5-point Likert scale, anchored by 1 (*never* or *not at all*) to 5 (*always* or *extremely*). Scores are transposed through item-response theory to a scale with a mean of 50 and standard deviation of 10, whereby high scores indicate better HRQoL. The index demonstrated an acceptable level of internal reliability (Cronbach's alpha = .80).

Biological Maturation. Percentage of predicted mature (adult) height attained at time of assessment was used as a non-invasive estimate of biological maturity. The Khamis-Roche [26-27] (KR) method was used to predict the mature height from current age, height and weight of the participant and self-reported mid-(biological) parent height corrected for over-estimation [28]. Self-report forms for parental height were sent home with the participants and collected on the day of assessment. The KR method assumes that among youth of the same chronological age, the individual who is closer to their predicted mature height is biologically older (i.e., more advanced in maturity)[29]. For example, a girl who has attained 98% of her predicted adult height at 12 years would be considered biologically more mature than a girl of the same chronological age who has attained 86% of her predicted adult height.

Weight Status. Using the BMI as an indicator of weight status, participants were classified as being normal weight, overweight, or obese using international standards established by Cole and colleagues[30].

Statistical Analyses

Descriptive statistics were calculated for age, body size (i.e., height, weight, weight-for-height), and percentage of predicted mature height. A combination of analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA) was conducted to examine differences in HRQOL, biological maturation, and growth indices across whole year age groups (e.g., 11 years = 11.00 to 11.99 years). Zero-order and partial correlations were conducted to examine relations between chronological age and HRQoL, before and after controlling for biological maturity, respectively.

Results

Descriptive statistics pertaining to age group differences in HRQoL, biological maturity and growth indices are summarized in Table 1. HRQoL varied across age groups; $F_{(3,362)}=6.31$, $p<.001$, $\eta_p^2 = .05$. Post-hoc analyses (Scheffe's) revealed that 11 year olds reported significantly higher HRQoL than 12 (Cohen's d=.47), 13 (d=.56), & 14 (d=.51) year olds. The 12, 13 and 14 year olds did not differ in terms of HRQoL. Results of the MANOVA revealed a main effect for whole year age group on indices of growth and maturation, Wilks' Lambda = .57, $F_{(12,950.12)}=18.99$, $p<.001$, $\eta_p^2 = .17$. Subsequent univariate F-tests demonstrated significant age group differences in biological maturation, $F_{(3,362)}=74.83$, $p<.001$, $\eta_p^2 = .38$, height, $F_{(3,362)}=33.12$, $p<.001$, $\eta_p^2 = .22$, weight, $F_{(3,362)}=14.87$, $p<.001$, $\eta_p^2 = .11$, and weight-for-height, $F_{(3,362)}=3.75$, $p<.05$, $\eta_p^2 = .03$.

Relations between chronological age and HRQoL

Zero-order correlations for the total sample indicated an inverse relation between HRQoL and chronological (i.e., decimal) age (r=-.17, p<.01). This relation was, however, attenuated and non-significant once biological maturation was controlled for (r=-.05, p=.16). Of note, a significant inverse correlation was observed between biological maturation and HRQoL (r=-.20, p<.001).

Weight status and HRQoL

A univariate analysis of covariance (controlling for chronological age and biological maturation) was conducted in order to examine differences in HRQoL between normal weight (n=296) and overweight+obese (n=70; 24% of sample) participants. As predicted, normal weight participants reported significantly greater HRQoL (M=46.7, SD=9.0) when compared to overweight+obese participants (M=43.0, SD=6.7),

$F_{(1,362)}$=7.59, p<.01, η_p^2 = .02. The magnitude of this difference was, however, small. Significant effects were not observed for either of the covariates (chronological age: $F_{(1,362)}$=1.08, p=.30, η_p^2 = .00; biological maturation: $F_{(1,362)}$=2.95, p=.09, η_p^2 = .01), though the effect of biological maturation came close to significance.

Discussion

The results of this study support the contention that biological maturation is inversely related to HRQoL in adolescent females and also contributes to age-related variance in HRQoL within this population. The observed inverse relation between maturation and HRQoL is similar in direction and magnitude to relations between maturation and other health related behaviors, such as smoking, drinking and physical activity [31]. Although an inverse relation was observed between chronological age and HRQOL, in our sample this relation was attenuated and became non-significant once biological maturation was controlled for. Accordingly, this suggests that it is the process of maturation and not chronological age, per se, that may contribute most to the decrements in HRQoL during adolescence. As noted, there are a number of reasons as to why biological maturation should be more closely related to HRQoL than chronological age in adolescent females. First, early maturation, in girls, is associated with a less positive physical and psychological health. Second, puberty-related changes in body size and physique that may challenge or diminish HRQoL through the negative impact that a greater body size, and/or absolute and relative fat-mass has on the HRQoL domains encompassing body image and physical self-perceptions. The observed differences in HRQoL across participants of varying weight status would support this contention. The overt manifestation of secondary sex characteristics may also trigger changes in perceptions of

the self and perceived quality of life. Secondary sex characteristics are visible and hold significant social stimulus value, and as such may evoke social and behavioral responses that affect HRQoL. These mechanisms may act independently of chronological age.

The current findings suggest that researchers interested in the study of HRQoL in youth would be well advised to consider, if not control for, biological maturation. Though the assessment of biological maturation is often perceived as costly and invasive; there are a number of non invasive methods that researchers can employ. Some existing self-report measures of biological maturity (e.g., through self-assessment of secondary sex characteristics) though easy to use, are reliant on the participants' awareness of their own development and may susceptible to social desirability bias. However, the present study demonstrates the utility of a brief, non-invasive method of calculating maturity status that could be routinely employed by researchers outside a clinical setting.

Table 1. Descriptive statistics for health-related quality of life, percentage of predicted adult stature attained, chronological age, and body size, by whole year age groups.

Variables	11 years n=56		12 years n=119		13 years n=145		14 years n=46	
	M	SD	M	SD	M	SD	M	SD
HRQoL	50.51	12.33	45.63	8.14	44.83	7.11	45.13	8.22
Percentage of predicted adult stature	91.29	2.92	94.06	4.11	97.00	1.69	97.91	1.12
Height (cm)	150.42	7.04	154.81	7.35	160.04	6.48	160.16	7.17
Weight (kg)	43.59	9.26	48.75	10.88	52.85	9.22	54.03	10.16
BMI	19.11	2.96	20.18	3.46	20.55	2.88	21.01	3.43

References

1. WHOQOL Group. (1995). The World Health Organization Quality of Life Assessment (WHOQOL): Position paper from the World Health Organization. *Social Science and Medicine, 41*, 1403-1409.

2. Williams, J., Wake, M., Hesketh, K., Maher, E. & Waters, E. (2005). Health-related quality of life of overweight and obese children. *Journal of the American Medical Association, 293*(1), 70-76.

3. Sawyer, M. G., Reynolds, K. E., Couper, J. J., French, D. J., Kennedy, D. & Martin, J. (2004). Health-related quality of life in children and adolescents with chronic illness - a two year prospecive study. *Quality of Life Research, 13*(7), 1309-1319.

4. Gillison, F. & Skevington, S. (2006). Assessing children's quality of life in health and social services: Meeting challenges and adding value. *Journal of Children's Services, 1*(2), 42-51.

5. Bisegger, C., Cloetta, B., Von Rueden, U., Abel, T. & Ravens-Sieberer, U. (2005). Health-related quality of life: Gender differences in childhood and adolescence. *Sozial- und Praventivmedizin, 50*(5), 281-291.

6. Williams, P. G., Holmbeck, G. N. & Greenley, R. N. (2002). Adolescent health psychology. *Journal of Consulting and Clinical Psychology, 70*(3), 828-842.

7. Zullig, K. J., Valois, R. F., Huebner, E. S., Oeltmann, J. E. & Drane, J. W. (2001). Relationship between perceived life satisfaction and adolescents' substance abuse. *Journal of Adolescent Health, 29*(4), 279-288.

8. Baxter-Jones, A. D. G., Eisenmann, J. C. & Sherar, L. B. (2005). Controlling for maturation in pediatric exercise science. *Pediatric Exercise Science, 17*(1), 18-30.

9. Malina, R. M., Bouchard, C. & Bar-Or, O. (2004). *Growth Maturation and Physical Activity*. Champaign, IL: Human Kinetics

10. Malina, R. M. (2008). Biocultural factors in developing physical activity levels. In S.J.H. Biddle & A.L. Smith (Eds.), *Youth Physical Activity and Sedentary Behavior: Challenges and Solutions* (pp. 141-166). Champaign, Il.: Human Kinetics.

11. Schwimmer, J. B., Burwinkle, T. M. & Varni, J. W. (2003). Health-related quality of life of severely obese children and adolescents. *Journal of the American Medical Association, 289*(14), 1813-1819.

12. Friedlander, S. L., Larkin, E. K., Rosen, C. L., Palermo, T. M. & Redline, S. (2003). Decreased quality of life associated with obesity in school-aged children. *Archives of Pediatrics & Adolescent Medicine, 157*(12), 1206-1211.

13. Swallen, K. C., Reither, E. N., Haas, S. A. & Meier, A. M. (2005). Overweight, obesity, and health-related quality of life among adolescents: The national longitudinal study of adolescent health. *Pediatrics, 115*(2), 340-347.

14. Niven, A. G., Fawkner, S. G., Knowles, A. & Stephenson, C. (2007). Maturational differences in physical self-perceptions and the relationship with physical activity in early adolescent girls. *Pediatric Exercise Science, 19*, 472-80.

15. Graber, J. A., Brooks-Gunn, J. & Warren, M. P. (1999). The vulnerable transition: Puberty and the development of eating pathology and negative mood. *Womens Health Issues, 9*(2), 107-114.

16. Kaltiala-Heino, R., Marttunen, M., Rantanen, P. & Rimpela, M. (2003). Early puberty is associated with mental health problems in middle adolescence. *Social Science and Medicine, 57*(6), 1055-1064.

17. Laitinen-Krispijn, S., Van der Ende, J., Hazebroek-Kampschreur, A. A. J. M. & Verhulst, F. C. (1999). Pubertal maturation and the development of behavioural and emotional problems in early adolescence. *Acta Psychiatrica Scandinavica, 99*(1), 16-25.

18. Dick, D. M., Rose, R. J., Viken, R. J. & Kaprio, J. (2000). Pubertal timing and substance use: Associations between and within families across late adolescence. *Developmental Psychology, 36*(2), 180-189.

19. Costello, E. J., Sung, M., Worthman, C. & Angold, A. (2007). Pubertal maturation and the development of alcohol use and abuse. *Drug and Alcohol Dependence, 88*, S50-S59.

20. Brown, J. D., Halpern, C. T. & L'Engle, K. L. (2005). Mass media as a sexual super peer for early maturing girls. *Journal of Adolescent Health, 36*(5), 420-427.

21. Palacio-Vieira, J. A., Villalonga-Olives, E., Valderas, J. M., Espallargues, M., Herdman, M., Berra, S., et al. (2008). Changes in health-related quality of life (HRQoL) in a population-based sample of children and adolescents after 3 years of follow-up. *Quality of Life Research, 17*(10), 1207-1215.

22. Benjet, C. & Hernandez-Guzman, L. (2002). A short-term longitudinal study of pubertal change, gender, and psychological well-being of Mexican early adolescents. *Journal of Youth and Adolescence, 31*(6), 429-442.

23. Malina, R. M. (1995). Anthropometry. In M. P.J. & C. Foster (Eds.), *Physiological Assessment of Human Fitness* (pp. 205-219).

24. Perini, T. A., de Oliveira, G. L., dos Santos Ornellas, J. & de Oliveira, F. P. (2005). Technical error of measurement in anthropometry. *Revista Brasileira de Medicina do Esporte, 11*(1), 86-90.

25. Ravens-Sieberer, U., Auquier, P., Erhart, M., Gosch, A., Rajmil, L., Bruil, J., et al. (2007). The KIDSCREEN-27 quality of life measure for children and adolescents: psychometric results from a cross-cultural survey in 13 European countries. *Quality of Life Research, 16*(8), 1347-1356.

26. Khamis, H. J. & Roche, A. F. (1994). Predicting Adult Stature without Using Skeletal Age - the Khamis-Roche Method. *Pediatrics, 94*(4), 504-507.

27. Khamis, H. J. & Roche, A. F. (1995). Predicting Adult Stature without Using Skeletal Age - the Khamis-Roche Method (Vol 94, Pg 504, 1994). *Pediatrics, 95*(3), 457-457.

28. Epstein, L., Valoski, A. M., Kalarchian, M. A. & McCurley, J. (1995). Do children lose and maintain weight easier than adults? A comparison of child and parent weight changes from six months to ten years. *Obesity Research, 3*, 411-417.

29. Cumming, S. P., Standage, M., Gillison, F. & Malina, R. M. (2008). Sex differences in exercise behavior during adolescence: is biological maturation a confounding factor? *Journal of Adolescent Health, 42*(5), 480-485.

30.   Cole, T. J., Bellizzi, M. C., Flegal, K. M. & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal, 320*(7244), 1240-1243.

31.   Sherar, L. B., Cumming, S. P., Eisenmann, J. C., Baxter-Jones, A. D. G. & Malina, R. M. (in press). Adolescent biological maturity and physical activity: Biology meets behaviour *Pediatric Exercise Science*.