**Running title: PUBERTY AND CALLOUS-UNEMOTIONAL TRAITS**

**Pubertal Timing and Callous-Unemotional Traits in Girls: Associations Across Two Samples from the UK and Cyprus**

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**Abstract**

**Introduction:** Girls remain an understudied group when examining delinquency. Callous-unemotional traits are chief among personality traits that relate to delinquency. Some suggest, however, that girls who evince callous-unemotional traits delay their delinquent behavior until adolescence. This transitional period encompasses physical factors that relate to engagement in risky decision making, but we don’t know how these factors relate to callous-unemotional traits. Early pubertal timing shows positive associations with delinquency; we tested if this was also the case for callous-unemotional traits.

**Methods:** We tested associations among pubertal timing (i.e., maturity and menarche age), delinquency, and callous-unemotional traits within girls (ages 11 to 18 years) sampled from two European countries (UK and Cyprus). We also tested the interaction between callous-unemotional traits and pubertal timing in statistically predicting delinquency to test if associations between early puberty and delinquency were moderated by callous-unemotional traits.

**Results:** Greater callous-unemotional traits were surprisingly negatively related to early pubertal timing. Those girls in the delayed menarche group had the highest level of callous-unemotional traits, higher than the typical and early menarche groups. Only callous-unemotional traits statistically predicted variance in delinquency and no moderation was evident.

**Conclusions:** The implications are that callous-unemotional traits and the transition to puberty may be particularly important for girls’ adjustment in adolescence, particularly if menarche is delayed allowing girls to avoid punishment by capitalizing on their immaturity.

 Keywords: callous-unemotional traits; puberty; maturation; delinquency.

Pubertal Timing and Callous-Unemotional Traits in Girls: Associations Across Two Samples

The developmental transition period of adolescence is important to start to understand why some girls might eschew society’s rules without feeling guilty about it. Delinquency in girls carries extreme risk for poor adult outcomes at a high cost to society, both in terms of public health but also to long term employability and socioeconomic status (Odgers et al., 2008), so this transitional period is the focus of much research. Girls who engage in delinquency early in adolescence may have intimate relationships in adulthood that involve abuse and violence, and they are more likely to experience economic deprivation, including unemployment, under education, low income, and low socioeconomic status (Odgers et al., 2008). Therefore, there are some girls who engage in delinquency in adolescence, but this behavior comes at a life-long cost to themselves, to those around them, and to society. The mechanism by which girls start to be delinquent is poorly understood (Frick & Viding, 2009), and some research suggests they may have particular risk factors related to entering adolescence. Yet, girls remain an understudied group with regard to delinquency and offending (Loeber, Jennings, Ahonen, Piquero, & Farrington, 2017).

Some level of aggression and antisocial behavior is normative in childhood and adolescence, yet girls show particular risk factors which become clear when one understands normative developmental transitions (Loeber, Capaldi, & Costello, 2013). Delinquency and antisocial behavior that is not necessarily illegal in adolescence is somewhat normative, particularly when these behaviors are transient and contextual (Moffitt, Caspi, Dickson, Silva, & Stanton, 1996). Yet, a small sample of girls engage in high rates of delinquency (Loeber et al., 2017), so identifying factors that are related to delinquency make for fruitful investigations. If we know what factors are related to antisocial personality traits – themselves relatively stable and predictive of future delinquency – then we can start to build interventions to prevent these traits or to at least dampen their negative effect on outcomes. Antisocial personality traits can include traits of psychopathy that have been downward extended to youths and include traits that are not transient developmentally immature characteristics of teenagers (Vachon, Lynam, Schell, Dryburgh, & Costa, 2018). One facet of psychopathic traits are callous-unemotional (CU) traits, which are defined as a lack of empathy and concern for others’ well-being, as well as showing emotions superficially. Callous-unemotional (CU) traits (Frick, Ray, Thornton, & Kahn, 2014) are an important marker of conduct problems and delinquency that has shown relative stability across development. Since CU traits confer risk for conduct problems and delinquency (see Frick et al., 2014 for a review), it is important to understand the ways in which CU traits are related to developmental transitions, with adolescence being a challenging time for some adolescents.

One obvious hypothesis, since both pubertal timing and CU traits are positively related to delinquency, is that CU traits and early puberty would be positively related to each other. Indeed, delinquency has shown a positive association with early puberty in girls (Haynie, 2003; Stice, Presnell, & Bearman, 2001), possibly because of factors such as the choice of peer group (Caspi, Lynam, Moffitt, & Silva, 1993; Goldstein, Malanchuk, Davis-Kean, & Eccles, 2007; Magnusson, Stattin, & Allen, 1985). Another hypothesis is that they might not have any association with each other. A third alternative, and perhaps the most relevant to disentangling risk factors for adolescent delinquency, is that they may be negatively correlated.

There is some reason to think that this third alternative, a negative correlation, is plausible. Research suggests delayed puberty and CU traits could both be related to childhood maltreatment, household dysfunction, and hormones (Goulter, Kimonis, Hawes, Stepp, & Hipwell, 2017; Kimonis, Centifanti, Allen, & Frick, 2014; Li, Denholm, & Power, 2014). Indeed, high levels of foetal testosterone is linked to late-onset puberty and low levels of empathy, a key component of CU traits (Helleday et al, 1993). Yet, some of the links between puberty and hormone levels have been unreplicated among girls (see Mendle, Turkheimer, & Emery, 2007). With respect to maltreatment, delayed development of pubertal indicators in relation to child neglect was observed in a study of a British birth cohort [n=17638] (Li et al., 2014), but some research suggests early or late age of menarche may differ based on the accumulation of maltreatment or the kind of maltreatment experienced (Boynton-Jarrett et al., 2013). However, there have been no studies of this question in the literature to date with regard to CU traits and possible pubertal timing.

Specifically, adolescence may be a developmental period where girls with CU traits start to engage in delinquency. Girls, unlike boys, have been shown to show poor adjustment related to CU traits without parents noting conduct problem behavior as children (Silverthorn, Frick, & Reynolds, 2001). That is, levels of CU traits were assessed in adjudicated adolescent youths (ranging from age 13 to 18 years) based on early-onset and late-onset conduct problems. Girls in the delayed-onset group were similar to boys in the childhood-onset group in clinical correlates and high levels of CU traits, although onset was determined by parent retrospective reports which are inherently problematic and biased. Yet, the hypothesis put forward is that girls with CU traits show a ‘delayed onset’ to their conduct problems (Silverthorn et al., 2001). There have been critiques of the ‘delayed onset’ hypothesis, and longitudinal studies have found childhood-onset trajectory groups of girls: those who continue to show problems across the life-course (not just in adolescence), at least when examining offenders (El Sayed, Piquero, & TenEyck, 2017). A six-site large cohort study showed that boys’ adolescent delinquency could be predicted from early aggression and conduct problems (Broidy et al., 2003). Yet, girls’ delinquency could not be reliably predicted from stable patterns of early aggression or conduct problems. Thus, factors have still yet to be identified that relate to girls’ delinquency. It may be that factors predicting girls’ delinquency are more proximal in time to the behavior.

One reason why this transitional period from childhood to adolescence, marked by menarche, may be important for girls’ delinquent behavior is that childhood vulnerabilities may be accentuated at puberty. Girls’ adjustment to puberty is influenced by contextual factors and in some ways, puberty may be a stressful life event that triggers the use of the same coping mechanisms that have worked for girls in their early to middle childhood years. These ways of coping may become accentuated at puberty and may actually be maladaptive to use in adolescence (see Allison & Hyde, 2013 for a review; Caspi & Moffitt, 1991). So, it may be that tried and true coping methods from childhood, even if maladaptive, may provide a shorthand for dealing with the transition of adolescence. Shyness in childhood, for example, may transition to introversion or internalizing symptoms in adolescence (see Allison & Hyde, 2013 for a discussion). Fearless temperament or disinhibition may transition to risky decisions via this route, too.

Alternatively, it has been proposed that the increased pubertal hormone levels can directly effect neurological changes in the brain. In turn these developmental changes can affect stress and emotional sensitivity at a time in adolescence when self-regulatory parts of the brain are not fully online (Mendle et al., 2007). Thus, increases in sensation-seeking and risk-taking may result. There is some evidence that reorganization of some brain structures coincide with puberty (Sisk & Zehr, 2005), and difficulties in adjusting to this sometimes tumultuous and emotional event may lead to deviant behaviour (see Graber, 2003; Susman & Rogol, 2004). Social context may moderate the effects these changes have on girls. People may treat a maturing girl differently, giving her more freedom, which can lead to further risky decision making when decisions are made with little oversight. Girls may also feel isolated and confused, if their own pubertal timing is different from their peers (Mendle et al., 2007). Although the mechanisms remain largely unknown, there are several reasons why puberty has been examined with regard to girls’ adjustment. One important reason, for those interested in preventing delinquency, is that the transition at puberty can be a target for intervention for girls.

If girls’ CU traits are positively associated with early pubertal timing, then the implication is that considering either high levels of CU traits or early pubertal timing could indicate who is at greater risk for delinquency, as they would both be equally informative. If girls’ CU traits are negatively associated with early pubertal timing, then we can use the presence of CU traits to strategically target ages when interventions would be most helpful. For instance, research has found adolescent girls with CU traits report feeling overcontrolled by parents, and may be particularly motivated to seek independence (Centifanti, Fanti, Thomson, Demetriou, & Anastassiou-Hadjicharalambous, 2015), so parenting may be a useful target. If found to be a negative association, of note, girls with CU traits along with delayed pubertal timing may find that their arguments for greater independence are doubly convincing since they could argue along two fronts: age and physical maturity. Additionally, girls with late menarche could feel emboldened by their physical immaturity, since they may feel they can get away with misbehavior, and thus feel more able to display delinquent behaviors with impunity.

The present study aimed to test the association between CU traits and pubertal timing to determine if early pubertal timing is a marker of higher CU traits as it is of greater delinquency in girls, or whether the association was actually different. To examine whether our findings were robust to culture, we examined relations between CU traits and pubertal timing in the UK and in Cyprus – a culture characterized by high levels of family violence and gender inequality (Mavrikiou, Apostolidou, & Parlalis, 2014). Additionally, we recruited our UK sample from a population with high social and economic deprivation to oversample for CU traits and delinquency, although we do not expect levels of delinquency to reach clinical or detained levels. We do argue community samples can more effectively tell us about developmental psychopathology, since factors related to juvenile justice and gender biases in treatment by juvenile courts are eliminated. The association between CU traits and particular features of adolescence, such as pubertal development, might be one way to understand girls’ initiation of delinquency within adolescence.

These data were collected in the two countries simultaneously, and we tested the association between CU and pubertal timing in separate analyses to see if our findings held up across these European countries. In addition, we tested the established finding that CU traits and early pubertal timing would both be related to greater delinquency. We measured pubertal timing as has been done in previous studies, using both age of menarche and physical sexual maturity indices, since our sample from Cyprus included girls 11-16 years of age and not all would be expected to have reached menarche. We examined unique associations as well as the interaction between CU traits and pubertal timing, since previous research suggests possible differences in how menarche is related to antisocial behavior. That is, environmental factors have been shown to have a greater influence on conduct disorder symptoms among girls with early menarche (<11 years), while heritability factors were more influential (67%) in the conduct disorder symptoms of girls with on-time (12-13 years) or delayed onset (>13 years) menarche (Burt, Mcgue, Demarte, Krueger, & Iacono, 2006). In twin studies, CU traits have been found to show high heritability variance, too (75%) (Viding, Jones, Frick, Moffitt, & Plomin, 2008). In our models, then, we looked at the moderating effect of CU traits to see if they would be more influential on delinquency for those with on-time and delayed onset menarche.

 **Methods**

**Participants/Procedure**

Girls from a sixth-form college (ages 16-18 preparatory for university/trade school) in northwest England (N=137; 16-18 years of age, M=16.9, SD=.8). The community from which this school draws its students has a minority ethnic population of 23%. There are also high levels of deprivation and unemployment is high. Ethical approval was granted by the Psychology Ethics Committees at University of Central Lancashire (UK). Child consent was sought following approval by the headteacher who acted *in loco parentis*, given that children 16 years and older are able to consent. Informed consent was sought from an opportunity sample of youths as they prepared to take their lunch break and the first author in addition to four research assistants supervised completion of the questionnaires to ensure confidentiality. The participation rate, calculated by comparing the number participating to the number of girls enrolled in 2010, was 44%. The researchers handed out questionnaires during lunchtime in the lunch room and we wanted to ensure participants completed the questionnaires independently, so we restricted participation to several tables with a researcher invigilating nearby. Questionnaires were also counterbalanced for order to reduce the motivation to look at other participants’ questionnaires. No incentives were offered for participation. Completed questionnaires were handed to the researchers.

Simultaneously, we collected data from a Cypriot sample, which consisted of a community sample of 614 girls (ages 11–18 years) by the last author. The schools were chosen to approximate the national demographics in Cyprus (http://www.pio.gov.cy). Almost all of the girls were Greek Cypriot (92%). About half of the parents reported having a high school (55% for fathers, 48% for mothers) or a college/university education (25% for fathers, 32% for mothers). Ethical approval, school approval and parental written informed consent were obtained before participation in the study; children’s participation was voluntary. Parents were contacted through the schools by sending a briefing sheet with a consent form for parents to tick “yes” or “no” to participation. Only if parent(s) agreed, children were approached for their assent/consent to engage in the research. The rate of response was 60%. Importantly, less than 1% of the approached parents actively dissented. The remaining failed to return a consent form, and therefore, it remains unknown whether the parents of these children did not want their child to participate or whether they had not read the consent form.

Questionnaires were completed within classrooms for the Cypriot sample, and these were also counterbalanced for order. All measures were translated into Greek for the Cypriot sample using back-translation methods.

**England and Cyprus Measures**

**Pubertal timing.** Participants for both samples retrospectively reported age of first menstruation (i.e., menarche), which is found to be consistent with paediatrician-rated puberty assessments (Petersen, Crockett, Richards, & Boxer, 1988). Parent-report and child-report show good agreement in retrospective reports (Moffitt, Caspi, Belsky, & Silva, 1992). Further, self-report ratings show predictable developmental changes consistent with paediatrician-rated puberty assessments (Petersen et al., 1988). We only had measures of physical maturity, beyond age of menarche,in the Cypriot sample, who completed the Pubertal Developmental Scale (PDS; Petersen et al., 1988). The PDS measures growth spurt, skin changes, and body hair growth as well as breast development and menarcheal status, scored as "development not yet started" (1) to "development seems complete" (4) (range 5-20; M=16.72, SD=2.83), which have been validated in prior research (Petersen et al., 1988). PDS is less relevant within late adolescence but all girls were expected to have reached menarche by age 16 years (Storvoll & Wichstrøm, 2002).

We classified all girls into early (≤11 years [n=123)], typical (12-13 years [n=276]), and late (≥14 years [n=114]) menarche, consistent with categories used in prior research (Li et al., 2014; Burt et al., 2006). This allowed us to examine on-time menarche versus menarche that was different (early or delayed) in time in comparison to most peers who experience menarche within a typical age range.

**Callous-unemotional traits.** Inventory of Callous-Unemotional Traits (Frick, 2004) (removing items 2 and 10 as has been done previously (Kimonis et al., 2008) to ensure good internal consistency) contains 24 items rated on a four-point scale (“Not at all true” [0], “Definitely true” [3]); this showed good internal consistency (α=.72 in UK and α=.77 in Cyprus) and has previously been validated across different European and American samples (Essau, Anastassiou-Hadjicharalambous, & Muñoz, 2011; Kimonis et al., 2008; Muñoz, Qualter, & Padgett, 2011; Roose, Bijttebier, Decoene, Claes, & Frick, 2010). All participants in England and Cyprus reported on callous-unemotional traits.

**Delinquency.** A delinquency-variety measure (Huizinga & Elliott, 1986) assessed the self-reported number of crimes committed by the youth by listing 36 questions about illegal juvenile acts selected from a list of all offenses reported in the Uniform Crime Report with a juvenile base rate of greater than 1% (Elliott & Huizinga, 1984). Self-reported delinquency, as used here, has been shown to be valid when compared to actual arrests (Farrington, Loeber, Stouthamer-Loeber, Van Kammen, & Schmidt, 1996; Paschall, Ornstein, & Flewelling, 2001). The items used were property offences, drug offences, status offences and items regarding violent offences. A study reviewed the literature comparing self-reported delinquency with official records of delinquency and concluded that both ways of measuring delinquency “provide valid indicators of the demographic characteristics of offenders” (Hindelang, Hirschi, & Weis, 1979, p. 995); this research gives support to the reliability and validity of self-report measures. The severity of the delinquency was measured by the mean number of items that were endorsed. Therefore, we asked participants to say if they had *ever* engaged in the activity as a variety measure of delinquency, since we were simply interested in level of lifetime delinquency. Variety scores are typically used to assess criminal activity (Huizinga & Elliott, 1986; Piquero, Macintosh, & Hickman, 2002) and are strongly related to frequency scores (Monahan, Steinberg, & Cauffman, 2009). However, variety scores have an obvious benefit in that it is much easier to remember if one has engaged in an illegal activity than it is to remember the frequency. This is especially the case with activities that tend to occur with greater frequency, such as drug offenses (Monahan et al., 2009). Again, delinquency was measured across England and Cyprus (α=.77 in UK and α=.84 in Cyprus).

**Data analyses**

Correlations were conducted to test the hypotheses regarding associations among CU traits, early puberty, and delinquency. In addition, to examine whether CU traits were related age of menarche and whether that was similar across the two countries, an Analysis of Covariance (ANCOVA) was conducted using Jamovi 0.8.0.8 (www.jamovi.org) on levels of CU traits with the between-subjects effects of country (UK and Cyprus) and timing of menarche (early, typical, and late); we also controlled for age.

We also examined whether there were moderating effects of CU traits on the association between menarche and delinquency using hierarchical regression. In the Cypriot sample only, we were able to take advantage of having 559 complete data sets for girls ages 11-18 years for examining whether CU traits and pubertal timing (for those with data, that is, who had already started menstruating) related to delinquency. We included the interaction term on the last step of the regression. These regressions were conducted using zero-inflated Poisson regression to deal with the high number of zeros (0.15 proportion of zeros in a range of 0 to 21) and the large overdispersed distribution (standard deviation that is higher than the mean) in our self-report of delinquency measure; we included age on step 1, and CU traits and age of menarche on step 2 since these were our variables of interest. The two-way interaction was entered on step 3. Since scaled Log-Likelihood estimates (using Maximum Likelihood with Robust standard errors) were employed, Satorra-Bentler correction (Asparouhov & Muthén, 2010) was consistently applied to adjust for non-normality. The effect size of variance explained in delinquent behavior between the models was informed by the proportion of residual variance (i.e., dispersion) change between models. To interpret effect sizes, we included confidence intervals of the unstandardized estimates (i.e., betas).

Mplus 7.3 (Muthén & Muthén, 2012) was used with MLR estimations and using manifest (not latent) variables. When using zero-inflated Poisson models, Mplus creates a continuous outcome as well as a binary outcome, since zero-inflated measures benefit from examining whether participants who score zero versus any other value other than zero might differ in relation to the independent variables. Negative values on the binary outcome are interpreted to mean that higher values on the independent variable are related to non-zero values on the dependent variable. All variables were centered prior to creating the multiplicative terms (to test for interaction).

**Results**

**Are CU Traits Related to Early Pubertal Timing?**

We compared Cypriot girls of the same age as the British sample to aid comparisons between these samples on age of menarche. Thus, we limited the Cypriot sample to those girls 16-18 years of age, n=388 girls; 16-18 years, M=16.9, SD=.7 and examined age of menarche in this subpopulation to compare to the British sample of girls.

To examine if CU traits were related to early puberty (i.e., earlier ages of menarche), we performed zero-order correlations (see Table 1) with the UK and Cypriot samples separately. Higher CU traits were associated with later pubertal timing across the samples from England and Cyprus, and these associations were significant independently across the two samples. We also tested if the correlations differed by country. Fisher’s r-z transformations showed that the magnitude of the correlations was not significantly different across the two countries (z= -0.14). Figure 1 shows the scatterplots of the associations across the two countries. The scatterplot of CU and menarche shows good coverage across levels of CU traits and age of menarche; thus, it does not appear results are driven by a few outliers.

To examine whether CU traits were related to truly *delayed* menarche rather than simply *later* than others in the distribution, we examined the menarche classifications. An ANCOVA was conducted on levels of CU traits with country (UK and Cyprus) and timing of menarche (early, typical, and late) as between-subjects effects, while controlling for age. There was a significant effect of timing of menarche on CU traits *F*(2, 505)=6.16, *p*<.01, *η2*=.024. There was no significant effect of country *F*(1, 505)=0.01, *p*=.905, *η2*<.000, and no interaction *F*(2, 505)=0.37, *p*=.690, *η2*=.001, suggesting that later pubertal timing related to CU traits was not specific to one country. Figure 2 shows the means and confidence intervals by country and timing of menarche, thus, the overlaps in 95% confidence intervals reflect the overlap of the two countries. Tukey’s post-hoc tests examining the differences in CU traits by timing of menarche revealed higher CU traits were reported by those in the delayed menarche classification, as compared to those in the early (*t* = -2.78, *p* = .016) and as compared to the typical age range menarche group (*t* = -3.33, *p* = .003). Thus, the possibility that CU traits might show a negative association with early pubertal timing was supported, since girls with higher levels of CU traits showed delayed pubertal timing across both cohorts of girls from the UK and Cyprus.

**Do the Results Found With Menarche Also Generalize to Indices of Maturational Progression?**

One could argue that only examining age of menarche might mask effects in maturational progression before age 16 years of age, since pubertal development indexes multiple physical maturation signals than simply menarche. We looked at maturation because pubertal development encompasses breast and hair development, for example, and these can develop to some extent prior to menarche. So we tested whether the results found with age of menarche generalize to results indicating less maturational progression (or later pubertal timing) in girls with higher levels of CU traits. To test this, we used the Cypriot data, since the full sample of girls covered the age range before most girls reach menarche (11-16 years of age). Zero-order correlations are shown in Table 1. First, the correlation between maturity and age was moderate, *r* = .474. The correlation between maturity and CU traits was small and nonsignificant, *r* = -.030, but since age was correlated with maturity and CU traits, we partialled for age in correlations. The partial correlation between maturity and CU traits was still small and nonsignificant, *pr* = -.093, *p*=.09. Thus, when we examined maturity, there was no evidence for associations between CU traits and pubertal timing.

**Is Early Pubertal Timing Related to Delinquency?**

We examined relations with delinquency, as a test of whether our results are consistent with prior research showing early pubertal timing related to greater delinquency. As shown in Table 1, the correlations with age of menarche were not significant, either in the UK or Cypriot samples, although delinquency was significantly associated with greater CU traits, which is itself consistent with prior research. When examining maturity within the Cypriot sample for which maturation was available, advanced levels of maturity were significantly and positively related to delinquency (*r*=.13, *p*=.02). That is, girls with higher levels of delinquency reported being more developed. As above, we partialled age to see if delinquency was still associated with advanced maturity, and the association was no longer significant (*pr*=.02, *p*=.777).

**Examining Moderation of CU on Association Between Menarche and Delinquency**

Table 2 shows the results of the zero-inflated regression predicting delinquency from age on step 1, including CU traits and age of menarche on step 2, and the interaction on step 3. On the first step of the regression, age positively predicted delinquency (estimate=.098, SE=.026, *t*=3.719, *p*<.001, 95%CI= .047, .150). Age also predicted the zero-inflation binary factor, with older ages less likely to score a zero value on delinquency (estimate= -.338, SE=.075, *t*= -4.521, *p*<.001, 95%CI= -.485, -.192). Next, including CU and age of menarche in the second step significantly improved model fit, Satorra-Bentler *Δ -2LL* (4) = 235.849, *p* < .001. The standardized residuals went from an average of 4.95 to 1.37, a reduction of 72% with the explained variance of CU traits and menarche added. We found significant unique associations between delinquency and CU traits (estimate= .036, SE=.004, *t*=8.324, *p*<.001, 95%CI= .028, .045) but not with pubertal timing (estimate= -.038, SE=.024, *t*= -1.578, *p*=.115, 95%CI= -.086, .009). CU was not associated with the binary factor (estimate= -.032, SE=.019, *t*= -1.629, *p*=.103, 95%CI= -.070, .006).

On step 3, age was still positively associated with greater levels of delinquency (when examining the continuous measure; estimate=.085, SE=.028, *t*=3.013, *p*=.003, 95%CI= .030, .140). Also, age continued to be associated with the binary outcome measure (estimate= -.286, SE=.091, *t*= -3.143, *p*=.002, 95%CI= -.464, -.107), such that older girls were unlikely to score zero on delinquency. Adding the interaction term between menarche and CU did not result in a significant change in model fit, Satorra-Bentler *Δ -2LL* (2) = 1.492, *p* >.05. Thus, pubertal timing did not appear to relate to delinquency differently among girls with varying levels of CU traits.[[1]](#footnote-1)

**Discussion**

We found CU traits were related to *delayed* pubertal timing (later age of menarche) across two European cohorts. This held even when accounting for variations in age and delinquency. We compared girls from the UK and Cyprus, by recruiting school and community samples, oversampling from those from socioeconomically deprived areas. When analysing the results within the separate countries, we showed that CU traits were negatively related to early pubertal timing. That is, menarche was reported as being delayed when girls had higher CU traits. Of note, no studies have previously examined pubertal timing as one developmental factor to explain delinquency in girls with varying levels of CU traits. In regressions, we found only CU traits were uniquely associated with delinquency. Yet, our results must be interpreted within several limitations: the present study was a cross-sectional survey in community samples and participation rates were low to moderate across the two samples. We have attempted to interpret our findings with regard to multiple directions of effects, using prior research to guide our rationale. However, longitudinal research is needed to determine how these processes unfold over time and within different types of samples.

Our findings suggest that CU traits, unlike delinquency, are related to delayed menarche in girls. Research suggests delayed puberty could both be related to childhood maltreatment, household dysfunction, and hormones (Li et al., 2014). Similarly, these childhood and hormonal factors have been shown to relate to CU traits (Gao, Raine, Chan, Venables, & Mednick, 2009; Li et al., 2014), possibly providing a mechanism for our results. There might be variations in levels of testosterone in relation to CU traits; testosterone, for example, has been implicated in psychopathy (which includes a lack of empathy and callous-unemotional traits, along with other antisocial personality dimensions of impulsivity and grandiosity; Gao et al., 2009). Interestingly, girls with congenital adrenal hyperplasia, marked by high levels of foetal testosterone, evidence delayed menarche and lower empathy (Helleday, Edman, Ritzén, & Siwers, 1993). Although CU traits were not measured in that study, a lack of empathy is one of the hallmarks of CU traits (e.g., Lui, Barry, & Sacco, 2016; Muñoz, 2009; Schwenck et al., 2014). At least one study, however, showed children with CU traits and early conduct problem behaviors (at age 5-6 years) had evidence of greater exposure to testosterone prenatally (Blanchard & Centifanti, 2017), possibly laying the foundations for delinquency as well as delayed pubertal timing later in life. Further research is needed on CU traits in females, such as data on childhood maltreatment and hormone levels, particularly as a possible mechanism for the delayed “jump start” to puberty.

The present study aimed to test the association between CU traits and early pubertal timing as possible explanations of delinquency, and the aim was not to test developmental trajectories of delinquency that start at adolescence. Arguably, whether females have different developmental pathways to problem behaviors as compared to males is an area of continued debate (Broidy et al., 2003; Fontaine, Carbonneau, Vitaro, Barker, & Tremblay, 2009; Loeber et al., 2013). Although delinquency may be normative at adolescence, many argue CU traits are a risk factor in themselves (Frick et al., 2014).

CU traits and the (later) transition to puberty may be particularly important for predicting girls’ adjustment in adolescence. With the newfound freedom and emotional and stress sensitivity that may be generated by pubertal hormones (Graber, Brooks-Gunn, & Warren, 2006), it may be difficult for girls to regulate their behavior. When pubertal timing is delayed, as the present study suggests for girls with CU traits, these girls may experience isolation since they may feel they are experiencing maturational changes alone. However, our results show that CU traits do not moderate effects of pubertal timing on delinquency. We found no evidence that high CU traits had a greater influence on delinquency when modeling the interaction with delayed menarche.

If we aim to identify girls at risk for delinquency, then CU traits are important. Only CU traits were uniquely related to delinquency when included with age and menarche. Prior research suggests that pubertal timing only accounts for 4% of the variance in delinquency (Flannery, Rowe, & Gulley, 1993), and it was not significant in our regression analyses after accounting for age. It appears CU traits limited the amount of unique variance menarche could have explained in our models.

The lack of a significant relationship between CU traits and maturity (e.g., pubic hair growth and breast development) could be due to the diversity of influencing factors for pubertal events; these are controlled by specific hormones independently. Our findings suggest CU traits may share common mechanisms only with menarche, rather than all aspects of puberty. Menarche, for example, may be a more salient marker of the transition from being a child to being an adult, and research finds parents relax the rules when their girls physically mature, leading to risky behavior (Allison & Hyde, 2013; Schelleman-Offermans, Knibbe, Engels, & Burk, 2011). In prior research adolescent girls with CU traits reported wanting to be free from their parents’ controlling behavior (Centifanti et al., 2015). In this way, adolescent girls with CU traits may see menarche as a perfect reason for them to “(knife)-off childhood apron strings” (Moffitt, 1993, p. 688).

A study such as this is limited by a number of additional factors. First, this study is a self-report study and many of the associations may reflect shared method variance rather than construct variance. We have no reason to believe that pubertal timing should reflect shared method biases in relation to delinquency and CU traits, but we cannot rule out this possibility. Measuring hormone levels would be a next step in this research. Also, research on girls’ delinquency reveals the need to assess delinquent behavior more broadly, including measures of violence, risk-taking, breaking of social norms, and indirect aggression (Fontaine et al., 2009). This may explain why we failed to find an association between delinquency and pubertal timing in this study, in addition to the small effect sizes observed in prior research (Flannery et al., 1993). Additionally, recent research suggests there may be subtypes of CU traits in girls, and girls with different subtypes of CU show different risk factors when examine longitudinally (Goulter et al., 2017).

We did not measure body mass index or other measures that might be confounding variables in the CU traits and pubertal timing association. Indeed, those with extremely low body weight experience later puberty and girls with anorexia show deficits in empathy (Kucharska-Pietura, Nikolaou, Masiak, & Treasure, 2004) as do those with CU traits (e.g., Muñoz, 2009; Schwenck et al., 2014) (e.g., emotion recognition deficits in labeling other people’s facial expressions). Yet, there are many psychiatric disorders that show associations with deficient emotion recognition performance (Harrison, Tchanturia, & Treasure, 2010), and the associations with CU traits appear to be specific to problems in understanding expressions of distress, such as fear, pain, and sadness, but not anger (Muñoz, 2009), unlike in anorexia. It may still be useful for future research to examine other personality traits that are related to empathy problems (such as borderline personality traits), since these are overrepresented in women and girls and may be mistaken for psychopathic-like traits (e.g., Hunt, Bornovalova, & Patrick, 2014). Indeed, girls have been shown to have many more emotional and behavioral problems concomitant with CU than has been typical of boys (Centifanti et al., 2015).

The present study was unique in examining CU traits in females with findings replicated within two diverse European samples, from UK and Cyprus. CU traits were negatively associated with early pubertal timing. This delayed onset of puberty in girls with high CU traits was not shown to add explanatory variance to delinquency involvement. It may be that girls with CU traits experience later pubertal development for many reasons, including genetic factors, yet causal directions remain unknown. It may be that girls who are delayed in reaching maturity feel emboldened by physical immaturity to show psychosocial immaturity. That is, girls who do not mature as quickly may feel that they can get away with being cruel and unempathetic to others, since they might be perceived as child-like. Some girls may take advantage of this. In prior research, looking at how parents perceive their immature and pseudomature youths – which were based on clustering factors related to pubertal development, problem behaviors, as well as self-reliance and work orientation – pseudomature and immature youths were perceived as having more problem behaviors, desiring to be older in age, and less psychosocially mature (Galambos, Barker, & Tilton-Weaver, 2003). Also, youths who were immature and pseudomature tried to emulate their older brothers (who tend toward greater rule-breaking). Adolescents “caught in a maturity gap” (Galambos et al., 2003) are attracted to delinquent behavior because the behavior is often seen as a rite of passage to adulthood, since many of the behaviors are considered delinquent solely by virtue of being underage (i.e., smoking and drinking alcohol; Moffitt, 1993). Thus, interventions may be timed to better make use of this developmental transition into adolescence, particularly for girls, who continue to be an understudied group.

A delayed onset to puberty was evident among girls with CU traits. They may be perceived as less psychosocially mature, which could put these girls at risk for emulating older male siblings or male peers. In addition, perceived immaturity could put them at risk for maltreatment or trauma; trauma is evident in the case file histories of female adult offenders with psychopathic traits (Hicks, Vaidyanathan, & Patrick, 2010). It is clear early interventions and early protections for girls are key to preventing psychopathology, possibly targeting the peer group or role models for girls. While delayed puberty does not seem to relate to their greater delinquency, girls who lack guilt and take advantage of other people may actually find it easier to do this in the context of delayed puberty when others might perceive them as being emotionally immature and, thus, able to get away with it.

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| **Table 1.**Zero-order correlations (UK above the diagonal and Cyprus below the diagonal) among CU, delinquency, and puberty. |
|  Measures: | UK  | Cyprus M(SD) | 1 | 2 | 3 | 4 | 5 |
| M(SD) |
| 1. Age | 16.89(.79) | 16.89(.74) [14.71(1.28)] | - | 0.09 | n/a | 0.08 | -0.06 |
| 2. Callous-Unemotional Traits | 17.75(6.17) | 17.63(7.4) [17.37(7.37)] | 0.06 [0.11\*] | - |  | .19\* | .21\* |
| 3. Maturation | - | [11.94(2.78)] | [0.47\*\*\*] | [-0.03] | - | n/a | n/a |
| 4. Age of Menarche | 12.69(1.33) | 12.39(1.36) | 0.07 | 0.15\*\*  |  | - | -0.03 |
| 5. Delinquency | 6.78(3.73) | 4.82(4.06) [3.75(4.12)] | 0.08 [0.24\*\*\*] | 0.37\*\*\* [0.35\*\*\*] |  [0.13\*] | 0.07 | - |
|  |  |  |  |  |  |  |  |
| Note: \*p<.05, \*\*p<.01, \*\*\*p<.001; Estimates are for the UK and Cypriot cohorts ages 16 to 18 years. Extended Cypriot sample data for examining maturational progression in 11 to 18 year-old girls are shown in square brackets. |

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| **Table 2.** Regression beta estimates, standard errors, and 95% confidence intervals of the estimates for zero-inflated Poisson regression predicting self-report delinquency from age, CU traits and the interaction of CU traits and age of menarche. |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|   |   | Delinquency |   | Delinquency (zero-inflated factor) |
|  |  | B |  | SE |  | Percentile 95% CI |  | B |  | SE |  | Percentile 95% CI |
| **Step 1** |  |  |  |  |  |  |  |  |  |  |  |  |
| Age |  | 0.098 |  | 0.026 |  | 0.047, 0.150 |  | -0.338 |  | 0.075 |  | -0.485, -0.192 |
| **Step 2** |  |  |  |  |  |  |  |  |  |  |  |  |
| Age |  | 0.085 |  | 0.028 |  | 0.030, 0.140 |  | -0.284 |  | 0.091 |  | -0.462, -0.105 |
| CU Traits |  | 0.036 |  | 0.004 |  | 0.028, 0.045 |  | -0.032 |  | 0.019 |  | -0.070, 0.006 |
| Age of Menarche | -0.038 |  | 0.024 |  | -0.086, 0.009 |  | 0.054 |  | 0.112 |  | -0.165, 0.273 |
| **Step 3** |  |  |  |  |  |  |  |  |  |  |  |  |
| Age |  | 0.085 |  | 0.028 |  | 0.030, 0.140 |  | -0.286 |  | 0.091 |  | -0.464, -0.107 |
| CU Traits |  | 0.036 |  | 0.004 |  | 0.027, 0.045 |  | -0.03 |  | 0.019 |  | -0.068, 0.008 |
| Age of Menarche | -0.044 |  | 0.026 |  | -0.096, 0.007 |  | 0.045 |  | 0.108 |  | -0.166, 0.256 |
| CUxMenarche | 0.002 |   | 0.003 |   | -0.004, 0.007 |   | -0.016 |   | 0.014 |   | -0.044, 0.011 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| Note: CU=Callous-unemotional; Estimates (B) are unstandardized regression estimates and confidence intervals not containing zero are significantly different from zero. |

Figure 1. Scatterplots of main study variables involving age of menarche for UK and Cypriot samples together.



Figure 2. Levels of callous-unemotional traits (ICU total) by stages of menarche (1=early, 2=typical, 3=late) within samples from UK and Cyprus with 95% confidence intervals.

1. Similar results were found when including menarche as a trichotomous variable using contrast coding in regression. Similar findings were found when we used maturity, also. [↑](#footnote-ref-1)