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The longitudinal association between pubertal timing and aggression in adolescence: Mediated and moderated by popularity

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Abstract

According to the *off-time hypothesis*, early and late maturing adolescents are at higher risk for developing aggression than normal maturers. The present longitudinal study examined whether early and late pubertal timing led to more aggression than normal puberty, and investigated whether this was mediated and/or moderated by *perceived* and *sociometric* popularity. Data from the Social Network Analysis of Risk behavior in Early Adolescence (SNARE) project was used. Adolescents in the sample (n=1,589) ranged from 11 to 15 years (M_{age}=13.02), and were first- and second-grade students in secondary school. Aggression and popularity were measured using sociometric measurement, and pubertal timing by self-report. Results from multivariate linear regression analyses indicated total mediation for *perceived* popularity on the association with early puberty and aggression. However, for late puberty and *sociometric* popularity, no mediation-effects were found. No moderation was found from popularity. Findings of this study partially support the *off-time hypothesis*, since only early puberty predicted more aggression. The results indicated that intervention- and prevention-programs for aggression should target early maturers and lower levels of *perceived* popularity.

Key words: Adolescence, Aggression, *Perceived* Popularity, *Sociometric* Popularity, Pubertal Timing.

Samenvatting

Volgens de *off-time hypothesis* hebben adolescenten met een vroege en late puberteit meer risico op het ontwikkelen van agressie dan adolescenten met een normaal getimede puberteit. De huidige longitudinale studie onderzocht of vroege en late puberteit leidde tot meer agressie en keek of deze relatie gemedieerd en/of gemodereerd werd door erkende en sociometrische populariteit. Data uit het *Social Network Analysis of Risk behavior in Early Adolescence* (SNARE) project werd gebruikt. Adolescenten in de steekproef (n=1589) hadden de leeftijd 11 tot 15 jaar ($M_{leeftijd}$=13,02) en kwamen uit de eerste en tweede klas van de middelbare school. Agressie en populariteit werden met sociometrische meetinstrumenten gemeten en de timing van de puberteit met zelf-rapportage. Resultaten lieten totale mediatie zien van erkende populariteit op de relatie tussen vroege puberteit en agressie. Voor late puberteit en sociometrische populariteit werden geen associaties gevonden. Daarnaast werd geen moderatie gevonden van populariteit. De bevindingen steunen de *off-time hypothesis* deels, omdat late puberteit niet meer agressie voorspelde. Deze resultaten geven aan dat interventie- en preventieprogramma's zich moeten focussen op vroeg puberende adolescenten en op het verlagen van erkende populariteit.

Trefwoorden: Adolescentie, Agressie, Erkende Populariteit, Sociometrische Populariteit, Pubertal Timing.

Introduction

Aggression peaks in adolescence (Moffitt, 1993). Supplementary, aggressive adolescents show higher risk for other problems, such as delinquency and substance use (Barnow, Lucht, & Freyberger, 2005; Krueger, Markon, Patrick, Benning, & Kramer, 2007). Furthermore, aggression leads to physical or psychological injuries among victims nearby the aggressive adolescent (Young, Boye, & Nelson, 2006). To prevent abovementioned outcomes, it is important to identify factors contributing to aggression in adolescence.

According to the *off-time hypothesis*, early and late maturing adolescents are at higher risk for developing aggression, in order to cope with stress they experience in being divergent (Ge & Natsuaki, 2009; Negriff & Trickett, 2010; Petersen & Taylor, 1980). Several empirical studies confirm this hypothesis (e.g. Lynne, Graber, Nichols, Brooks-Gunn, & Botvin, 2007; Najman et al., 2009). Besides this biological factor, socio-contextual factors also contribute to aggression (Graber, 2013). An important socio-contextual component in adolescents' lives is being popular among peers, which also contributes to aggression. Popularity manifests in two types, *perceived* and *sociometric* popularity (Greenberg, Siegel, & Leitch, 1983; Mayeux, Sandstrom, & Cillessen, 2008). Although the association between pubertal timing and aggression is extensively studied, no research has been conducted on the association between pubertal timing and aggression mediated or moderated by popularity (Dorn & Biro, 2011). Nevertheless, this is necessary for scientific and practical implications. If mediation is found, there will be more understanding of how processes between pubertal timing and aggression work. If moderation is found, there will be more insight in vulnerable groups. With this information, healthcare interventions on specific behavior or groups can be directed more accurately to reduce aggression. The current longitudinal study focuses on the mediating and moderating influences of *perceived* and *sociometric* popularity on the association between pubertal timing and aggression.

Pubertal Timing and Aggression

Pubertal timing is a measure of biological puberty compared to other adolescents, often classified as 'early', 'normal/average' and 'late' (Petersen, Crockett, Richards, & Boxer, 1988). Previous studies show early maturing adolescents are vulnerable for developing aggression. Longitudinal and cross-sectional studies found more aggression in early maturers compared to normal maturing adolescents (Ge, Brody, Conger, & Simons, 2006; Ge, Conger, & Elder, 2001; Lynne et al., 2007; Mrug et al., 2014; Stattin, Kerr, & Skoog, 2011). One longitudinal study among 2,784 adolescents found only females with early puberty showed

more symptoms of aggression in a 14-year follow-up (Najman et al., 2009). Therefore, it seems plausible there are differences between the sexes. Despite extensive research which has been conducted on early maturers, a meta-analysis shows there is evidence that late maturers also show more aggression than normal maturers (Negriff & Susman, 2011). For instance, a longitudinal study among 108 adolescents found that late maturers showed more externalizing behavior than normal maturers (Dorn, Susman, & Ponirakis, 2003).

Several theories explain these empirical findings. First, according to the *off-time hypothesis*, adolescents who do not mature the same time as their peers (i.e. early and late) develop stress in being divergent and use aggression as a coping mechanism to reduce stress (Negriff & Trickett, 2010; Petersen & Taylor, 1980). Second, the *early-timing hypothesis* states that only early maturers are at risk for developing aggression (Petersen & Taylor, 1980). This hypothesis assumes early biological changes are nonparallel with cognitive and psychological development, which might predict aggression as coping mechanism (Moffitt, 1993; Negriff & Susman, 2011).

Popularity as Mediator on the Association Between Pubertal Timing and Aggression

Over the last decades, research has not merely focused on positive aspects of popularity, but also on possible risks of being popular. Two kinds of popularity need to be distinguished. First, *perceived* popularity, which is associated with social dominance, status and reputation. *Perceived* popularity is often linked with negative behavioral outcomes. Second, *sociometric* popularity, which is being liked by peers. *Sociometric* popularity is associated with positive behavioral outcomes. Previous studies showed strongly positive correlation between these constructs (Greenberg et al., 1983; Mayeux et al., 2008).

The present study is the first to investigate mediating factors contributing to the association between pubertal timing and aggression. One previous study found *perceived* popularity mediated the association between pubertal timing and delinquency (Felson & Haynie, 2002). No studies have been conducted on influences of *sociometric* popularity on the association between pubertal timing and aggression or other externalizing behavior. It is interesting to investigate contributions from popularity on aggression and whether it mediates associations between pubertal timing and aggression. Although no studies were found which tested these mediation effects, studies have been conducted on the associations between pubertal timing and popularity and between popularity and aggression.

Pubertal Timing and Popularity

Limited research is conducted on the association between pubertal timing and popularity. For *perceived* pubertal timing, inconsistent results were found on the association between early pubertal timing and *perceived* popularity. On the one hand, a longitudinal study among 881 adolescents showed that early-maturers are more likely to become popular due to their physical, mature appearance (Ricciardelli & McCabe, 2004). Comparable results were found in longitudinal studies among girls (Reynolds & Juvonen, 2011) and boys (Felson & Haynie, 2002). On the other hand, one study did not find an association between pubertal timing and *perceived* popularity (Teunissen et al., 2011). In addition, no significant associations between late maturers and *perceived* popularity were found (Ricciardelli & McCabe, 2004).

Theoretical explanation is offered by the degree of physical attractiveness in early maturers. Early maturing girls, due to their mature physical appearance, get more attention from peers, which results in higher status. Boys, once entering puberty, are conforming to a masculine beauty ideal. This 'adult-look' increases boys' popular status (Felson & Haynie, 2002; Reynolds & Juvonen, 2011; Ricciardelli & McCabe, 2004).

For *sociometric* popularity, empirical studies on the association between pubertal timing and *sociometric* popularity suggest early maturers are often being less liked by peers and late maturers are often more liked by peers. A longitudinal study among 999 adolescents showed that early maturers were less liked by their peers (Craig, Pepler, Connolly, & Henderson, 2001). Other longitudinal studies have shown similar findings (Blumenthal, Leen-Feldner, Trainor, Babson, & Bunaciu, 2009; Pindus et al., 2014). However, a longitudinal study among 149 adolescents showed only early maturing girls are at risk of being less liked (Conley, Rudolph & Bryant, 2012). Late maturing adolescents are found to have higher levels of *sociometric* popularity (Craig et al., 2001; Pindus et al., 2014).

Theoretical understanding for these findings comes from Petersen (1983), stating that early maturers lack understanding from peers in experiencing body changes, because peers do not experience these changes yet. This lack of understanding is linked with being less liked by peers. In contrast, late maturers are more understood by peers than early and normal maturers, since peers identify themselves with them, which leads to more *sociometric* popularity.

Popularity and Aggression

Compared to the relation between pubertal timing and popularity, more research is conducted on the relation between popularity and aggression. First, studies on the association between *perceived* popularity and aggression will be discussed. A longitudinal study among 4,516

adolescents found that *perceived* popular adolescents showed more aggression (Faris & Ennett, 2012). Other longitudinal studies confirm these findings (Mayeux et al., 2008; Prinstein & Cillessen, 2003; Puckett, Aikins, & Cillessen, 2008; Rose, Swenson, & Waller, 2004; Stoltz, Cillessen, van den Berg, & Gommans, 2016).

Ellis and colleagues (2012) explain these findings by saying it is evolutionary functional to maintain a higher social status by showing more aggression. This means adolescents with high *perceived* popularity show more aggression to keep their popular status. Prinstein and Cillessen (2003) clarify this by saying *perceived* popular adolescents were in the past reinforced by showing aggression, hence the continuing of this behavior.

Second, empirical findings for the association between *sociometric* popularity and aggression suggest that adolescents with high levels of *sociometric* popularity show less aggression. For instance, a comprehensive longitudinal study among 1,023 adolescents indicated that high levels of *sociometric* popularity predict less aggression (Sentse, Lindenberg, Omvlee, Ormel, & Veenstra, 2010). Similar findings are found in both longitudinal and cross-sectional studies (e.g., Dishion, Nelson, & Yasui, 2005; Janssens et al., 2015; Prinstein & La Greca, 2004; Véronneau & Dishion, 2010).

The *Need-to-Belong Theory* explains these findings, claiming that belonging to a group is a basic human need (Baumeister & Leary, 1995), particularly in adolescence (Parker & Asher, 1993). Belonging to a group gives adolescents higher *sociometric* popular status. When adolescents belong to a group, risks of developing behavioral problems decrease (Parker and Asher, 1993). Applying this theory, *sociometric* popular adolescents might not want to show aggression because they are afraid of being rejected by their peers (Allen, Porter, McFarland, Marsh, & McElhaney, 2005).

Popularity as a Moderator on the Association Between Pubertal Timing and Aggression

So far, no studies on moderation effects from popularity on the association between pubertal timing and aggression have been conducted. Yet, one longitudinal study investigated whether there were interaction-effects between pubertal timing and *perceived* popularity on depressive symptoms. Results indicated that this interaction, for both early and late pubertal timing, predicted depressive symptoms (Teunissen et al., 2011), which means that both divergent pubertal timing and high social status lead to more depression. These results are only applicable for internalizing behavior. However, due to high positive correlations between internalizing and externalizing behavior in adolescence (Gjone & Stevenson, 1997), similar results are expected with aggression. In contrast, no studies were found investigating an

interaction-effect of pubertal timing and *sociometric* popularity on aggression or other problem behavior.

Theoretical understanding for an interaction between pubertal timing and popularity on aggression is offered by the *contextual-amplification hypothesis*. This hypothesis claims that problem behavior (i.e. aggression) is a cumulative result of divergent pubertal timing (i.e. early and late) combined with a socio-contextual stressor. In contrast, having divergent pubertal timing in a protective context decreases the risk of developing aggression (Ge & Natsuaki, 2009; Skoog & Stattin, 2014). Applying the *contextual-amplification hypothesis* on the socio-contextual condition popularity, *perceived* popularity might be a contextual stressor because of the negative behavioral outcomes, whilst *sociometric* popularity might be a protective socio-contextual factor.

The Present Study

The present longitudinal study will examine two research-questions. The first research-question is whether popularity explains the association between pubertal timing and aggression and is twofold for both forms of popularity (see Figure 1). First, for *perceived* popularity is expected that early matures will gain more popularity due to their physical appearance (Reynolds & Juvonen, 2011; Ricciardelli & McCabe, 2004) and therefore show more aggression to maintain this popularity (Ellis et al., 2012). For late maturers no mediation is expected, since no associations were found between late maturers and *perceived* popularity. Second, *sociometric* popularity is expected to function as a mediating factor for both early and late maturers. It is expected that early maturers will show lower levels of *sociometric* popularity (Petersen, 1983) and therefore more aggression (Allen et al., 2005). For late maturers the opposite is expected, they are expected to show higher levels of *sociometric* popularity (Petersen, 1983) and therefore less aggression (Parker & Asher, 1993).

The second research-question is whether popularity moderates the association between pubertal timing and aggression (see Figure 2). Based on the *contextual-amplification hypothesis* (Ge & Natsuaki, 2009), the following hypotheses are expected. First, early and late maturers who show high levels of perceived popularity are expected to show more aggression (Ellis et al., 2012). Second, early and late maturers are expected to show less aggression when they show higher levels of *sociometric* popularity (Allen et al., 2005).

Furthermore, since previous studies found differences between sexes, the present study will examine all research-questions for both the total sample as for girls and boys separately to investigate patterns within the sexes.

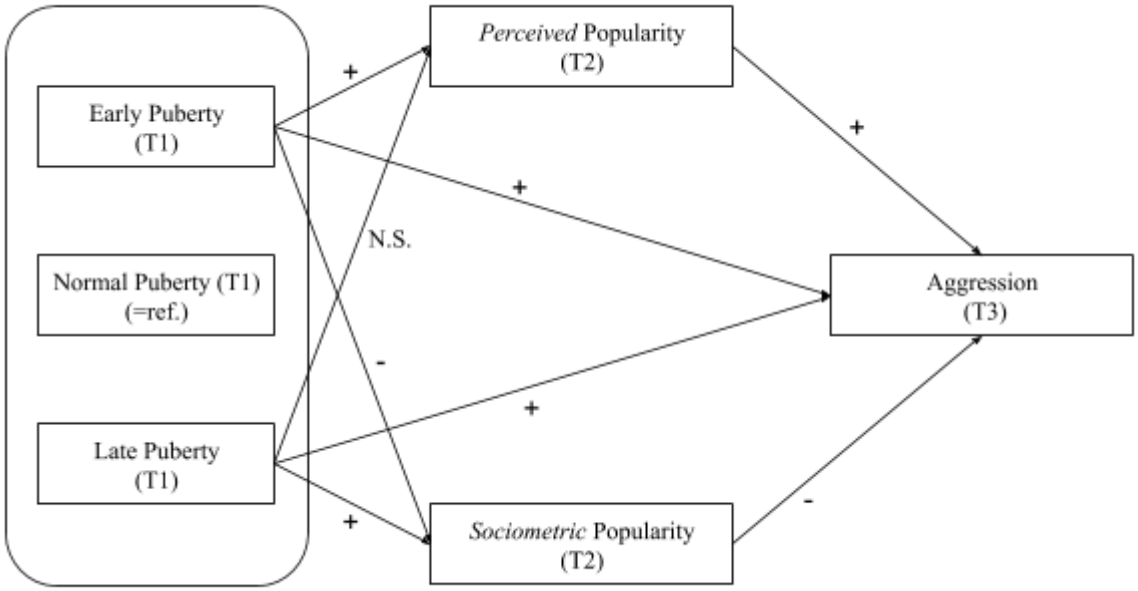

Figure 1. Mediation of *perceived* and *sociometric* popularity on the association between pubertal timing and aggression.

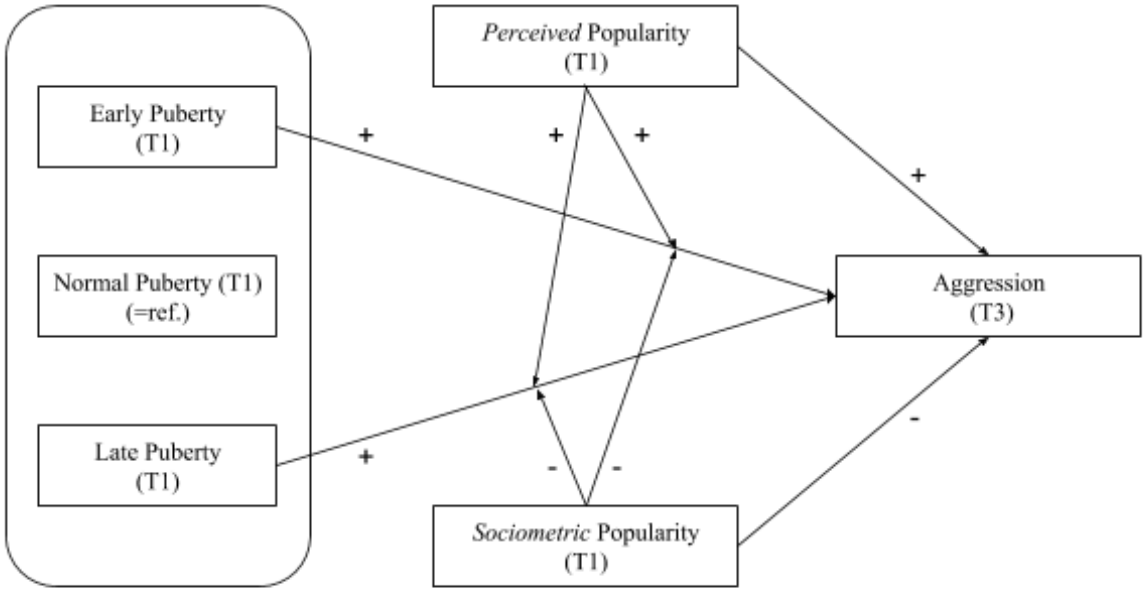

Figure 2. Moderation of *perceived* and *sociometric* popularity on the association between pubertal timing and aggression.

Method

Design and Procedure

Data used for this study was from the Social Network Analysis of Risk behavior in Early adolescence (SNARE) project. This project consisted of longitudinal data on social development of adolescents, focusing on risk behavior. Two Dutch secondary-schools, in the north and middle of the Netherlands, participated. In 2011, all first- and second-grade students from these schools were asked to fill in online questionnaires. These adolescents are the first cohort. In 2012, the new first-grade students were approached to participate in this study as well and are referred to as the second cohort. Both cohorts were followed for four years. All 1,911 students and their parents received information-letters in which they were asked to participate in the SNARE-study. They had the opportunity to send a reply card or e-mail within two weeks if they refused (their child) to participate in the study (i.e. passive informed-consent). Of all students and their parents, 67 (2.2%) refused to participate the study for several reasons, including having no interest, it being too time-consuming and having dyslexia. This resulted in 1,844 students who participated in the SNARE-study (Dijkstra et al., 2015; Franken et al., 2016).

Filling in online questionnaires in the classroom took approximately 45 minutes and was supervised by a teacher and one or two research assistants. Questionnaires were developed with a special software-program (i.e. Socio™ software), because of sociometric measurements. Peer-nomination questions could be answered by selecting another students' name or 'nobody'. Absent students could complete the questionnaires within one month's notice. Privacy and anonymity of the adolescents was guaranteed by changing names into numbers afterwards (Dijkstra et al., 2015; Franken et al., 2016). The current study included the first three waves of both cohorts and first- and second-grade students. The baseline measurement (T_0) was in September, first wave (T_1) in October, second wave (T_2) in December and third wave (T_3) in March.

Sample

The total sample of SNARE had 1,844 students. For this study, 227 students were removed for various reasons (i.e. total nonresponse at T_1, T_2 or T_3 (n=221), students who commented they did not want to fill in questions regarding biological puberty (n=4), one student with the age of 17.7 in first-grade, one male student for saying he was a girl at T_1 and therefore unable to answer the questions regarding puberty). In addition, students who had missings on puberty questions (n=28) were also removed from the dataset because of the small number of missings (Field, 2013). There were no missings on aggression and popularity since those were

peer-nomination questions. This resulted in a sample of 1,589 students. These students were between 11 and 15 years old during T_1 (M_{age}=13.02, SD=0.71). The sample consisted of 794 girls (50%). Furthermore, 44.1% attended vocational education (LWOO, VMBO-BG, VMBO-TH) and 55.9% attended middle- and higher education (HAVO, HAVO/VWO, VWO). The sample had 1,014 (63.8%) first-grade students. Most adolescents (89.0%) were of Dutch origin.

Measures

Aggression (T_1 & T_3). This referred to the individual level of aggression visible for students in the classroom (Molano, Jones, Brown, & Aber, 2013). It was measured with peer-nomination on five items: "Who quarrels and/or initiates fights with you?", "Who bullies you?", "Who is rude/defies teachers?", "Who spreads rumors/gossips about you?", and "Who makes fun of others?". These items were based on a factor-analysis conducted by Laninga-Wijnen, Harakeh, Dijkstra, Veenstra and Vollebergh (2016). Proportion-scores for all items were computed by dividing individual scores by the number of classmates minus one. Then, the average of these items was used to create an aggression scale. A score of 0 on this scale meant an adolescent was not nominated by peers on five aggression items. Nomination on all items by all peers was scored 1 (Laninga-Wijnen et al., 2016). Cronbach's alphas were α_{T1}=.72 and α_{T3}=.76.

***Perceived* Popularity (T_1 & T_2).** *Perceived* popularity was measured with two peer-nominations, 'Who are most popular?' and 'Who are least popular?'. Due to different class-sizes, proportion-scores were composed by dividing individual scores by the number of classmates minus one (Cillessen & Mayeux, 2004; Allen et al., 2005). Proportion-scores of 'non-popular' nominations were subtracted from the proportion-scores of 'popular' nominations (Cillessen & Mayeux, 2004). The higher the score, the more popular adolescents were among their peers.

***Sociometric* Popularity (T_1 & T_2).** *Sociometric* popularity was measured with two peer nominations, 'Who do you like?' and 'Who do you dislike?' (Cillessen & Mayeux, 2004; Cillessen & Rose, 2005). Similar with *perceived* popularity, proportion-scores from 'disliked' nominations were subtracted from 'liked' nominations. The higher the score, the more liked adolescents were by their peers.

Pubertal timing (T_1). Pubertal timing was measured with the Pubertal Development Scale (Petersen et al., 1988). This scale had seven items. Three items were for boys and girls (i.e. growth spurt, body-hair growth, and skin changes), two were for boys (i.e. voice changes and beard growth), and two for girls (breast growth and onset of menarche). All questions

were answered on a 4-point-scale from 1="Changes had not started" to 4="Changes are already past". 'Do you have your menstruation yet?' was answered with 'yes' or 'no'. By standardizing all items by age and sex, differences could be made between early, normal and late puberty. Cronbach's alphas were α_{girls}=.73 and α_{boys}=.76. Adolescents were early mature if scores were one standard deviation higher and late mature if scores were one standard deviation lower than the mean (Ge et al., 2006). Dummy variables were used with normal puberty as reference group.

Covariates. The current study controlled for sex, educational level and grade. Research indicated that boys show more aggression than girls (Najman et al., 2009). Sex was coded as a dichotomous variable (0="girls"; 1="boys"). Previous studies indicated lower-educated students show more aggression than higher-educated students (Weijters, Scheepers, & Gerris, 2007). Educational level was coded as 1="Low" (LWOO, VMBO-BG, VMBO-TH) and 0="High" (HAVO, HAVO/VWO, VWO). Research showed aggression increased during the first few years of high school (Petras et al., 2008). This means that first-grade students show less aggression than second-grade students, because aggression is still increasing. Grade was coded as 0="first-grade" and 1="second-grade". Aggression (T_1) was included to measure changes over time.

Data-Analysis

Data was analyzed in SPSS Statistics 24 (IBM-corporation, 2016). No outliers or extreme values were found in the sample of 1,589 adolescents. Initially, descriptive statistics (means and standard deviations) were obtained and analyzed regarding aggression (T_1 and T_3), popularity (T_1 and T_2) and pubertal timing (T_1). *Independent sample t-tests* were conducted for aggression and popularity to measure differences between the sexes. *Paired sample t-tests* were conducted to measure change in aggression over time. *Chi-square test* was conducted to test differences in puberty for boys and girls. Next, assumptions for linear regression (i.e., linearity, homoscedasticity, and normality in residues) were met. Bivariate linear regression analyses were conducted. Then, multivariate linear regression analyses were conducted twofold. First, two *mediation* models were tested with the Baron and Kenny method (1986), one for each popularity and controlled by the other. The first step was to analyze pubertal timing to aggression (path c), which needed to be significant to test mediation. The next step was to analyze the associations from pubertal timing to both forms of popularity (path a). Lastly, associations between popularity and aggression (path b) and pubertal timing and aggression (path c) were analyzed in one model. If path a and/or b were not significant, no mediation occurred. If path a and b were significant and path c's absolute value became

smaller (but still significant), there was partial mediation. Total mediation occurred if path a and b were significant and path c was no longer significant (Baron & Kenny, 1986). These steps were followed with and without covariates educational level and grade. Second, for *moderation*, two models were analyzed to test whether the association between pubertal timing and aggression differs for adolescents with higher or lower popularity. The first model contained main effects and covariates. The second model contained besides main effects and covariates also four interaction-terms in one model (early/late puberty dummy**perceived/sociometric* popularity). If interaction-terms were significant, the interaction-terms in the second model were interpreted. In case of non-significance, only main- and covariate results from the first model were interpreted. All tests were conducted for the entire sample and separated by sex. Results were significant at $p < .05$.

Results

Descriptive Statistics

Means and standard deviations were calculated for *perceived* and *sociometric* popularity and aggression, both for the total sample and separated by sex (Table 1). *Independent sample t-tests* were conducted to investigate differences in popularity and aggression between sexes. For *perceived* popularity, no significant differences were found between sexes ($t(1,587)=-0.18$, $p=.86$ at T_1 and $t(1,587)= -1.04$, $p=.30$ at T_2). For *sociometric* popularity, girls had significantly higher means than boys at T_1 and T_2 (respectively $t(1,587)= 8.04$, $p<.001$ and $t(1,587)=7.97$, $p<.001$). Means for aggression at T_1 and T_3 were higher for boys than girls ($t(1,587)=-6.85$, $p<.001$ at T_1 and $t(1,587)=-6.28$, $p<.001$ at T_3). *Paired sample t-tests* were conducted to measure changes in aggression over time. For the total sample, the mean at T_3 (i.e. approximately six months later) was significantly higher than at T_1 ($t(1,588) = - 8.61$, $p<.001$). For boys, means for aggression were higher at T_3 than T_1 ($t(794)= -.07$, $p <.001$). Also for girls, means for aggression were higher at T_3 than at T_1 ($t(793)= - 6.15$, $p<.001$).

Table 2 shows descriptive statistics for pubertal timing. There was no significant difference found between the sexes in pubertal timing (X^2 (2, n=1,589)=0.66, $p=.72$).

Table 1.

Descriptive Statistics of Perceived- and Sociometric Popularity and Aggression, Disaggregated by Sex

	Girls		Boys		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
Aggression T_1	.03	0.05	.05	0.06	.04	0.06
Aggression T_3	.04	0.06	.06	0.07	.05	0.07
Perceived Popularity T_1	.01	0.26	.02	0.30	.01	0.28
Perceived Popularity T_2	.03	0.28	.04	0.31	.03	0.30
Sociometric Popularity T_1	.36	0.22	.27	0.24	.32	0.23
Sociometric Popularity T_2	.36	0.24	.26	0.25	.31	0.25

Note. Girls (n=794); Boys (n=795); Total (n=1,589).

Table 2.

Descriptive Statistics of Pubertal Timing (T_1), Disaggregated by Sex

	Girls		Boys		Total	
	Number	%	Number	%	Number	%
Pubertal Timing T_1						
Early puberty	118	14.9	127	16.0	245	15.4
Normal puberty	548	69.0	549	69.0	1,097	69.1
Late puberty	128	16.1	119	15.0	247	15.5

Note. Girls (n=794); Boys (n=795); Total (n=1,589).

Bivariate linear regression analysis with aggression as dependent variable

Bivariate linear regression analysis was conducted (Table 3). Results showed *perceived* popularity (T_1;T_2) was significantly positively related with aggression (T_3) for both the total sample and for girls and boys (T_1;T_2), meaning the more popular adolescents were according to their peers, the more likely they were to show aggression three to six months later. For the total sample and for girls and boys, *sociometric* popularity (T_1;T_2) was significantly negatively related with aggression (T_3), meaning when liked by peers, adolescents were less likely to show aggression three to six months later. For the total sample, early puberty was significantly positively related to aggression, meaning early maturing adolescents were more likely to show aggression later in adolescence. However, when disaggregated by sex, early puberty was only significantly positively related with aggression (T_3) for boys. Late puberty did not predict aggression (T_3), thus late maturing adolescents are not more vulnerable for aggression later in adolescence than normal maturers.

Table 3

Bivariate Linear Regression Analysis with Popularity (T_1 and T_2) and Pubertal Timing (T_1) and as predictors of Aggression (T_3), Disaggregated by Sex

	Girls			*Boys*			*Total*		
	B	*SE*	*β*	*B*	*SE*	*β*	*B*	*SE*	*β*
Perceived Popularity T_1	.07	.01	.34***	.08	.01	.37***	.08	.01	.35***
Perceived Popularity T_2	.07	.01	.35***	.10	.01	.42***	.08	.01	.39***
Sociometric Popularity T_1	-.02	.01	-.09*	-.04	.01	-.15***	-.04	.01	-.15***
Sociometric Popularity T_2	-.04	.01	-.18***	-.05	.01	-.17***	-.05	.01	-.20***
Early Puberty T_1 (ref.=normal)	.004	.01	.02	.02	.01	.11**	.01	.01	.07**
Late Puberty T_1 (ref.=normal)	-.01	.01	-.03	-.01	.01	-.03	-.01	.01	-.03

Note. * $p < .05$, ** $p < .01$, *** $p < .001$; Dummies (i.e., early and late puberty) were analyzed in one model; Girls (n=794); Boys (n=795); Total (n=1,589).

Mediation of popularity on the association between pubertal timing and aggression

Mediation of popularity was tested using the Baron and Kenny method (1986), which contained three steps. The first step was to analyze the association between pubertal timing and aggression (path c). Results of this step are depicted in Table 3 and were discussed above. It is noteworthy that there was no significant association between late puberty (T_1) and aggression (T_3). This meant no mediation of *perceived* and *sociometric* popularity could occur (Baron & Kenny, 1986).

The second step was to analyze path a, which is the association between pubertal timing (T_1) and both forms of popularity (T_2; Table 4). For the total sample, early maturers were more likely to show *perceived* popularity three months later than normal maturers. When disaggregated by sex, this association is only significant for boys, not for girls. For the total sample, late puberty was not significantly related to *perceived* popularity. However, when disaggregated by sex, late puberty was only significantly related to less perceived popularity three months later for girls. No significant associations were found for the total sample between early and late puberty and *sociometric* popularity. Thus, having deviant pubertal timing gave adolescents no extra vulnerability for being liked or disliked by peers three months later.

Table 4.

Linear Regression Analyses with Pubertal Timing (T_1) as Predictor for Perceived and Sociometric Popularity (T_2), Disaggregated by Sex

	Girls			*Boys*			*Total*		
	B	*SE*	*β*	*B*	*SE*	*β*	*B*	*SE*	*β*
Perceived Popularity T2									
Early Puberty T1 (ref.= normal)	.01	.03	.01	.09	.03	.11**	.05	.02	.07*
Late Puberty T1 (ref.= normal)	-.07	.03	-.09*	-.01	.03	-.01	-.04	.02	-.05
Sociometric Popularity T2									
Early Puberty T1(ref.= normal)	-.004	.02	-.01	.01	.03	.01	.001	.02	.002
Late Puberty T1 (ref.= normal)	-.03	.02	-05	.01	.03	.01	-.01	.01	-.01

Note. * $p < .05$, ** $p < .01$, *** $p < .001$; Dummies (i.e., early and late puberty) were analyzed in one model; Girls (n=794); Boys (n=795); Total (n=1,589).

The final step was analyzing associations between popularity and aggression in one model with pubertal timing and aggression (path b and c). Results of this step are displayed in Table 6, which showed results from both uncorrected and corrected analyses. No mediation was possible when the association between the dependent variable and the mediator are not significant (Baron & Kenny, 1986). Applied to this study, *sociometric* popularity (T_2) could not mediate the association between pubertal timing and aggression (Table 4). Uncorrected analyses (table 5) showed pubertal timing (T_1) and *perceived* popularity (T_2) predicted aggression (T_3). For the total sample, *perceived* popularity totally mediated the association between early pubertal timing and aggression. This conclusion was drawn because the association between early pubertal timing (T_1) and aggression (T_3) disappeared, whilst the association between pubertal timing and *perceived* popularity and between *perceived* popularity and aggression remained (Tables 4 and 5). This was total mediation (Baron & Kenny, 1989). For boys, similar results were found. For girls, no mediation occurred since the association between early pubertal timing and aggression was not significant. As mentioned before, no mediation was possible for *perceived* popularity on the association between late puberty and aggression, since this association was not significant. Corrected analysis (table 5) showed that the total mediation from *perceived* popularity on the association between early pubertal timing and aggression for the total sample and for boys decreased, but was still significant.

Table 5.

Linear Regression Analysis with Pubertal Timing (T_1) and Popularity (T_2) as Predictors of Aggression (T_3), Disaggregated by Sex

	Girls			*Boys*			*Total*		
	B	*SE*	*β*	*B*	*SE*	*β*	*B*	*SE*	*β*
Uncorrected Analysis									
Early Puberty T_1 (ref.=normal)	.003	.01	.02	.01	.01	.07	.01	.004	.05
Late Puberty T_1 (ref.=normal)	.000	.01	.001	-.01	.01	-.04	-.002	.004	-.01
Perceived Popularity T_2	.08	.01	.35***	.10	.01	.42***	.09	.01	.39***
Sociometric Popularity T_2	-.04	.01	-.18***	-.05	.01	-.17***	-.05	.01	-.20***
Corrected Analysis									
Early Puberty T_1 (ref.=normal)	.000	.004	-.003	-.001	.01	-.01	-.001	.003	-.01
Late Puberty T_1 (ref.=normal)	.001	.004	.004	-.001	.01	-.01	.000	.003	-.002
Perceived Popularity T_2	.07	.01	.32***	.08	.01	.33***	.07	.01	.32***
Perceived Popularity T_1	-.01	.01	-.05	-.01	.01	-.06	-.01	.01	.05
Sociometric Popularity T_2	-.08	.01	-.32***	-.06	.01	-.21***	-.07	.01	-.27***
Sociometric Popularity T_1	.04	.01	.13**	.02	.01	.06	.03	.01	.08**
Aggression T_1	.71	.04	.64***	.66	.04	.58***	.68	.03	.57***
Educational level T_1 (ref.=high)	.003	.003	.03	.000	.004	.000	.002	.002	.01
Grade T_1 (ref.=first grade)	-.01	.003	-.09**	-.02	.004	-.11***	-.01	.002	-.10***

Note. * $p < .05$, ** $p < .01$, *** $p < .00$; Dummies (i.e., early and late puberty) were analyzed in one model; Girls (n=794); Boys (n=795); Total(n=1,589)

Moderation of popularity on the association between pubertal timing and aggression

Two models were analyzed to test whether the association between pubertal timing (T_1) and aggression (T_3) differs for adolescents with higher or lower popularity (T_1). The first model contained main effects and covariates, the second model also contained interaction-terms. After conducting multivariate regression analyses, all interaction-terms appeared to be non-significant (Table 6).

Table 6.

Results of Interaction-Terms from Multivariate Linear Regression Analysis

	Girls		*Boys*		*Total*	
	β	*p*	*β*	*p*	*β*	*p*
Early Puberty T_1 * *Perceived* Popularity T_1	.01	.84	.002	.94	.01	.82
Late Puberty T_1 * *Perceived* Popularity T_1	.01	.86	.01	.64	.01	.62
Early Puberty T_1 * *Sociometric* Popularity T_1	-.003	.96	.07	.14	.04	.22
Late Puberty T_1 * *Sociometric* Popularity T_1	-.03	.57	-.07	.15	-.05	.17

Note. Girls (n=794); Boys (n=795); Total (n=1,589).

Results from main effects and covariates (Table 7) show for the total sample both early and late puberty at T_1 were not related to more aggression six months later, compared to normal puberty. Separated for girls and boys, this association remained non-significant for early and late puberty. For the total sample and for girls and boys, *perceived* popularity (T_1) was found to be significantly positively related to later aggression for girls and boys, meaning when adolescents showed more *perceived* popularity, they were more aggressive six months later. For the total sample, *sociometric* popularity did not predict later aggression. Separated by sex, this association remained non-significant. Aggression (T_1) predicted later aggression (T_3) for the total sample and for girls and boys. No differences were found in aggression between higher and lower education for the total sample and between sexes. First-grade students showed more aggression than second-grade students in the total sample and between sexes.

Table 7.

Multivariate Linear Regression Analysis with Pubertal Timing (T_1) and Popularity (T_1) as Predictors of Aggression (T_3), Including Covariates Educational Level, Grade and Aggression (T_1), Disaggregated by Sex

	Girls			*Boys*			*Total*		
	B	*SE*	*β*	*B*	*SE*	*β*	*B*	*SE*	*β*
Early Puberty T_1 (ref.= normal)	-.001	.004	-.01	.000	.01	-.001	-.001	.003	-.01
Late Puberty T_1 (ref.= normal)	.001	.004	.01	.000	.01	.002	.001	.003	.01
Perceived Popularity T_1	.03	.01	.14***	.04	.01	.15***	.04	.01	.15***
Sociometric Popularity T_1	-.01	.01	-.03	-.01	.01	-.03	-.01	.01	-.04
Aggression T_1	.79	.04	.63***	.74	.04	.65***	.76	.03	.65***
Educational level T_1 (ref.=high)	.01	.003	.04	.004	.004	.03	.01	.002	.04
Grade T_1 (ref.=first grade)	-.01	.01	-.08**	-.02	.004	-.13***	-.02	.002	-.11***

Note. * $p < .05$, ** $p < .01$, *** $p < .001$; Girls (n=794): $R^2=.48$, Boys (n=795): $R^2=.53$, Total(n=1,589): $R^2=.52$

Discussion

This study investigated the association between pubertal timing and aggression in adolescence and whether this was mediated and/or moderated by *perceived* and *sociometric* popularity. Results indicated that early puberty led to more aggression compared to normal puberty. No support was found that late puberty predicted more aggression than normal puberty. Results showed support for mediation, but no support for moderation. That is, *perceived* popularity totally mediated the association between early pubertal timing and aggression. This means early maturers had more chance of becoming more popular and, subsequently, showed more aggression. When separated by sex, this mediation only occurred for boys. Mediation from *sociometric* popularity was not found.

The Association between Pubertal Timing and Aggression

Early puberty influences adolescents' aggression more than normal puberty. Thus, early maturing adolescents are more prone to develop aggression than normal maturers. Late puberty did not lead to more aggression compared to normal puberty. When separated by sex, these findings, unexpectedly, only occurred with boys. These findings showed more support for the *early-timing hypothesis* than for the *off-time hypothesis* and are in accordance with previous studies (Ge et al., 2001; Mrug et al., 2014; Petersen & Taylor, 1980). It is recommended that future research should include a comparison between early and late puberty to measure differences between these groups.

A possible explanation for the finding that more aggression is found in early maturers is that hormonal changes at the start of puberty increases vulnerability for rewards, which normal and late maturers do not experience yet. Because their emotion-regulation is not developed yet, early maturers are more vulnerable for rewards than normal and late maturers (Steinberg, 2008). Showing aggression is rewarding because of positive peer-feedback, because it is considered as mature behavior (Moffitt, 1993). Positive feedback reinforces the continuing of aggression (Steinberg, 2008).

A second possible explanation is the *maturity gap* (Moffit, 1993), which is the discrepancy between social and biological maturation. This means that whilst adolescents are adults in a biological perspective, social factors such as independence and autonomy are not fully developed yet. Being aggressive provides one a mature status, which is desirable in adolescence (Moffitt, 1993). Early maturers experience the maturity gap more often than normal and late maturers, because there is a wider time-span between biological maturation and social maturation (Haynie & Piquero, 2006). Subsequently, future research should focus

on independence and autonomy in relationship with early maturers and externalizing behavior.

Mediation from *Perceived* Popularity on the Association between Pubertal Timing and Aggression

In accordance with the hypothesis and previous studies, *perceived* popularity did mediate the association between early pubertal timing and aggression, but not for late maturers (Felson & Haynie, 2002; Reynolds & Juvonen, 2011; Ricciardelli & McCabe, 2004). This means that early maturers are more likely to show *perceived* popularity and this leads towards more aggression. When separated by sex, these findings unexpectedly only occurred with boys. Explanations for this mediation are twofold. Firstly, a possible explanation is that male puberty brings social advantages, such as dominance and leadership, because other adolescents admire their adult-like body (McCabe & Ricciardelli, 2004; Moffitt, 1993; Prinstein & Cillissen, 2003; Simmons & Blyth, 1987). Dominance and leadership are linked with higher levels of aggression (Prinstein & Cillissen, 2003). In contrast, girls' reaction to their early physical maturation and mature body is to show more social anxiety (Blumenthal et al., 2009). When they show this anxiety among their peers, they are less likely to become popular (Crick & Ladd, 1993). However, the current study did not find that early maturing girls were significantly less popular than normal matures. Future research should include social anxiety to examine whether it influences popularity levels and aggression for early maturers.

Secondly, in accordance with our hypothesis, being highly *perceived* popular among peers predicted more aggression (Ellis et al., 2012; Prinstein & Cillissen, 2003). A possible explanation is that they show more externalizing problem behavior, such as aggression, to maintain their popular status (Ellis et al., 2012; Mayeux et al., 2008). Aggression is adult-like behavior, which adolescents admire in other adolescents (Moffitt, 1993). If adolescents show aggression at the beginning of high-school, they might gain a popular and dominant status, which they want to maintain later in high-school by repeating or exacerbating aggression. Future research should focus on bidirectional effects between *perceived* popularity and aggression, since the current study did not investigate if early aggression leads to more popularity.

Non-Significant Mediation from *Sociometric* Popularity on the Association between Pubertal Timing and Aggression

Unexpectedly, *sociometric* popularity did not mediate the association between pubertal timing and aggression for early and late maturers compared to normal maturers, since no associations were found between pubertal timing and *sociometric* popularity. This means that early or late maturers did not have higher or lower scores on *sociometric* popularity than normal maturers. A possible explanation is that having early or late pubertal timing is deviant from peer-norms. Feeling divergent might function as a trigger for deviant maturing adolescents to become more liked by peers, meaning they are doing more effort for being liked (Johnson & Collins, 1988; Lindfors et al., 2007). Results from the current study indicate that they succeed in their efforts of being liked equally as much as normal maturers. Future research should explore this hypothesis (Benoit, Lacourse, & Claes, 2013). For example, motivations for adolescents obtaining a higher *sociometric* status could be examined. In accordance with expectations, high scores on *sociometric* popularity predicted less aggression (Allen et al., 2005; Baumeister & Leary, 1995; Parker & Asher, 1993). A possible explanation is offered by the *Need-to-Belong Theory* (Baumeister & Leary, 1995). When adolescents are liked, chances are higher that they belong to a group. This feeling of belonging decreases aggression (Parker & Asher, 1993).

Moderation from Popularity on the Association between Pubertal Timing and Aggression

Perceived and *sociometric* popularity did not moderate the association between pubertal timing and aggression, for the entire sample and separated by sex. This means, in contrast to what was expected, early or late maturers with high *perceived* popularity had no extra risk of becoming aggressive, and early or late maturers with high *sociometric* popularity had no extra protective factor compared to normal maturers. A possible explanation is offered by the *contextual-amplification hypothesis*, which says contextual stressors and divergent pubertal timing together lead to more aggression (Ge & Natsuaki, 2009). It is possible *perceived* and *sociometric* popularity were not strong enough contextual stressors or protective factors in combination with deviant pubertal timing. Possibly peer-rejection, the opposite of popularity, is a stronger socio-contextual stressor in the peer-context. Adolescents with divergent puberty are at greater risk of being rejected by peers (Lynne et al., 2007). Also, rejected adolescents are at greater risk to develop externalizing problem behavior (Coie & Dodge, 1998; Parker & Asher, 1993). Furthermore, previous studies compared the impact of peer-rejection the same

as impacts from other stressful life-events, such as rape, loss of a parent and the experience of victimization by bulling (Coie & Dodge, 1998). In accordance with these previous studies, it is plausible peer-rejection functions as a stronger contextual stressor and in interaction with divergent pubertal timing affects aggression. Future research should explore peer-rejection as a moderator on the association between pubertal timing and aggression.

Strengths and Limitations

Several limitations of this study need to be acknowledged. First, pubertal timing was measured with self-reports, which may tempt adolescents to answer in socially desirable manner because of shame, despite guaranteed anonymity (Carter, Caldwell, Matusko, Antonucci, & Jackson, 2011). This may cause underreporting of deviant puberty, since adolescents do not want to deviate from the norm. A second limitation is that this study did not use three-way interaction between pubertal timing, popularity and sex. With the current study, only statements about patterns in sex can be made, no statements on the strengths of effects between sexes. Also, the power of these tests is lower because of the separation by sex. A third limitation is that only within-classroom nominations were obtained instead of adding outside classroom nominations. This may not give a complete view on the subject. A fourth limitation is that it was possible that the adolescents in the current sample did not understand the questions regarding *sociometric* popularity or interpreted these questions differently. During the completion, it was remarkable that a high number of adolescents filled in all their classmates in this question, which explains the higher means on this variable. Furthermore, relatively high correlations occurred between *perceived* and *sociometric* popularity (between .47 and .54, see appendix A), which makes it more likely adolescents did not understand the questions properly.

These limitations notwithstanding, this study has several strengths. Firstly, the longitudinal design offers more understanding on the development of aggression. Secondly, this study is the first to examine both mediation and moderation effects from popularity. The present study provides therefore more insight in the relationship between pubertal timing and aggression. Thirdly, this study used peer-nomination questions for popularity and aggression, which gave insight into relations of the classroom-setting. Besides this insight, sociometric measurement is a more reliable instrument than self-reports (Cillissen & Bukowski, 2000).

Conclusions and Implications

The current study provides insight into the importance of pubertal timing and popularity on aggression in adolescence. Mediation was found by *perceived* popularity on the association between early pubertal timing and aggression. No interactions found were between pubertal timing and popularity. This mediation occurred for early maturers and *perceived* popularity. This means early maturers are more *perceived* popular and therefore show more aggression. No mediation occurred for *sociometric* popularity. It is noteworthy that there seems to be differences between boys and girls, since the mediation by *perceived* popularity was significant for boys and not for girls. In conclusion, early maturation and *perceived* popularity are risk factors for aggression, whilst late maturation and *sociometric* popularity seem to have no influence. These results are in accordance with the *early-timing hypothesis* and previous studies (Felson & Haynie, 2002; Ricciardelli & McCabe, 2004). Future research should investigate whether additional factors influence this mediation. Results from this study suggest that interventions should target early maturers and should also aim to lower *perceived* popularity in the classroom. Furthermore, high schools could educate their students in the social impacts of puberty.

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