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Homophily and Contagion as Explanations for Weight Similarities Among Adolescent Friends

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A B S T R A C T

Purpose: To determine whether weight-based similarities among adolescent friends result from social influence processes, after controlling for the role of weight on friendship selection and other confounding influences.
Methods: Four waves of data were collected from a grade 8 cohort of adolescents (N = 156, *mean* age = 13.6 years) over their initial 2 years of high school. At each wave, participants reported on their friendship relations with grade-mates and had their height and weight measured by researchers to calculate their body mass index (BMI). Newly developed stochastic actor-oriented models for social networks were used to simultaneously assess the role of weight on adolescents' friendship choices, and the effect of friends' BMIs on changes in adolescent BMI.
Results: Adolescents' BMIs were not significantly predicted by the BMI of their friends over the 16 months of this study. Similarities in the weights of friends were found to be driven predominantly by friendship selection, whereby adolescents, particularly those who were not overweight, preferred to initiate friendships with peers whose weight status (overweight/nonoverweight) was the same as their own.
Conclusions: Weight-based similarities among friends were largely explained by the marginalization of overweight adolescents by their peers, rather than by the "contagion" of excess weight among friends. These findings highlight the importance of adequately modeling friendship selection processes when estimating social influence effects on adiposity.

High rates of childhood obesity have been attributed to a complex system of individual, social, and environmental factors. The role of social networks in the propagation of obesity has been emphasized in a recent series of studies, which suggests that excess weight spreads because of interpersonal "contagion." In adults, an individual's likelihood of becoming obese was found to increase when they shared a social connection, particularly a friendship, with someone who was obese [1].

Similar findings among adolescents have also been reported [2–6], based on data from the National Longitudinal Adolescent Health Survey (Add Health). A subsample of this population reported on their height, weight, and school-based friendships over two waves (12–20 months apart). The body mass index (BMI), a ratio of weight (kg) to height (m^2), of adolescents was found to be similar to the BMIs of their nominated friends, and these similarities increased over time. This effect was strongest for girls and adolescents with higher BMIs [6] and among same-gender friends [5]. Several authors have argued that these findings are evidence of an *influence effect*, whereby friends' BMIs influenced adolescents' BMIs [3,5,6]. Although not directly tested in these studies, there are at least two plausible mechanisms:

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friends may be important "weight referents", influencing adolescents' weight norms and indirectly affecting their weight management [7]; and similar engagement by friends in weight-related behaviors [8] may cause their BMIs to become increasingly alike. However, other researchers analyzing the same Add Health data have claimed that friends' assimilations in BMI was better explained by adolescents forming friendships with peers who were similar to them in weight (called *homophily* or *selection effects*) as well as by friends' shared school contexts (*confounding influences*) [2]. The authors of a recent reanalysis concluded that they could not differentiate whether weight-based similarities among friends were attributed to selection or influence processes [4], leading to cautions against the interpretation of these results as "contagion" [9,10].

Concern that these studies do not adequately account for the role of weight in friendship formation is well founded. Overweight youth are stigmatized and marginalized by their peers, thus affecting their opportunity to form friendships [11]. Overweight youth are less likely to be nominated as friends by their peers [12–14], although they tend to nominate as many friends as their nonoverweight counterparts [12–14]. Overweight adolescents also tend to be peripheral in their social networks because they have fewer friends and friends of generally lower social status [13]. These studies have also found adolescent friends to be similar in weight [12,14]. Based on the published data outlined previously, it seems plausible that both influence effects and the tendency for marginalized overweight youth to become friends with one another could be contributing to this outcome.

What is now required is an analytic strategy that models weight-based friendship selection and network influence simultaneously and controls for confounding influences to both processes. Stochastic actor-oriented models (SAOMs) have been developed explicitly for this purpose; they model the interdependencies between changes in social networks and the attributes of the individuals within them [15]. Additionally, they improve on previous methods because they account for dependencies inherent in relational data [16] and model unobserved changes in attributes and friendship ties between measurement moments (using continuous time Markov chains). A range of parameters can be specified to determine which social processes govern these changes, allowing us to assess the effect of weight on friendship formation, and after controlling for this, the effect of weights of friends on changes in adolescent weight. Moreover, we can control for confounding influences on friendship choices and BMI change, which may also explain weight-based associations among friends.

The current study examines the evolution of an adolescent school-based friendship network, and students' BMIs, over their initial 2 years of high school. Based on four panels of data, SAOMs were applied to test for weight-related selection and influence effects. We anticipate that BMI, and particularly BMIs defined as overweight, will affect the formation of friendships among peers. Controlling for this will enable us to test for evidence of influence effects, evidenced by friends' BMIs becoming increasingly similar over time.

Methods

Sample and procedure

Participants were recruited in their first year of high school (eighth grade) at a public school located in a middle-socioeconomic neighborhood of a major Australian city. Information letters were mailed to students' homes inviting them to participate in the study and providing them and their parents/guardians with the opportunity to opt out. The letter also stated that participants would be entered into a draw for one of several $20 gift vouchers. The study was approved by the Human Research Ethics Committees at the University of Adelaide and Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Data were collected four times over 16 months: three waves when students were in the eighth grade and a fourth wave when they were finishing ninth grade. A total of 156 students (55.1% males) participated in the study, representing 91.8% of all eighth grade students enrolled during the first year of the study. New students who joined the school in the ninth grade were not invited to participate. Participants ranged in age from 12.3 to 15.6 years (*mean* age: 13.6 years, SD = .4) at the first wave of data collection, and approximately one-third (29.5%) identified as having an ethnicity other than Anglo-Australian (predominantly European and Asian backgrounds).

Measures

At each wave, participants had their height and weight measured by researchers and completed a questionnaire supervised by teachers in class. The 25-minute questionnaire, which was part of a larger study, captured information on respondents' friendship ties and demographics.

Friendships. Participants listed the names of the "friends you hang around with the most" who were in their grade at school. Ten spaces were provided and there was no limit on the gender or number of nominations. Participants were then instructed to circle their *best friends* from among the names they had listed, and these best friend nominations were used to represent friendships in all subsequent analyses. The friendship network was represented as a directed adjacency matrix, where cells coded as 1 denoted a unilateral friendship between participant *i* and *j*, and 0 the absence of friendship.

Anthropometric measures. Weight and height were measured with an electronic scale (Soehnle Alpha model 63530; Soehnle-Waagen GmbH, Murrhardt, Germany) and a portable stadiometer (Seca 214 portable stadiometer; Seca, Hamburg, Germany), to calculate BMI (kg/m^2). Raw BMIs (range 15.0 to 42.5) were re-scaled on a scale from 1 to 16 for the SAOMs, where each unit was equivalent to a 1-U change in BMI, but with outliers (n = 2) recoded. Internationally validated age- and gender-specific BMI cut-offs defined by Cole et al [17], comparable with the CDC cutoffs commonly applied to U.S. samples [18], were used to classify respondents as overweight or obese (For adolescents aged 14 years [the typical age of study participants], the BMI cut-off points are as follows: a BMI equal to or greater than 22.62 for males and 23.34 for females is classified as overweight, and a BMI equal to or greater than 27.63 for males and 28.57 for females is classified as obese).

Control attributes. Attributes associated with the formation of adolescent friendships, including gender, ethnicity, and pocket money [19], were controlled, as were variables associated with BMI (gender and ethnicity [20]). Participants recorded their gender (1 = male, 2 = female) and whether or not they identified with an ethnicity other than Anglo-Australian (1 = other ethnicity). They

Table 1
Description of the SAOM effects for testing selection and influence processes

Effects on friendship dynamics	Description
BMI effects	
Adolescent BMI	Effect of BMI on outgoing friendship nominations
Potential friend BMI	Effect of BMI on receiving friendship nominations
Similar BMI friend	Preference to nominate friends based on similar BMI
Similar BMI reciprocated friend	Preference to reciprocate friendship nominations based on similar BMI
Covariate effects	
Adolescent covariate	Effect of the attribute on outgoing friendship nominations
Potential friend covariate	Effect the attribute on receiving friendship nominations
Same covariate friend	Preference to nominate friends who share the same binary attribute
Similar covariate friend	Preference to nominate friends who are similar on a continuous attribute
Same dyadic covariate	Effect of a dyadic attribute (characteristic of a pair of actors) on friendship nominations
Structural effects	
Outgoing friendship ties	Tendency to form friendship ties
Reciprocating ties	Preference to reciprocate an existing friendship nomination
Transitivity	Preference to nominate a friend who is a friend of a current friend
Effects on BMI dynamics	**Description**
BMI friend	Effect of friends' BMIs on adolescent BMI
Covariate	Effect of a covariate on adolescents' own BMI

BMI = body mass index; SAOM = stochastic actor-oriented model.
Because associations in BMI amongst friends may be affected by the strength of the relationship [3], we specified weight-related selection and influence effects for mutual (reciprocated) friends and for nonmutual friendships. In the model selection process, the effect of reciprocated friends on BMI dynamics was found to be nonsignificant and so was omitted from the final model.

also indicated the typical amount of pocket money that was available to them each week on a 4-point scale (1 = <$10, 2 = $10–$20, 3 = $20–$30, 4 = >$30). Class lists were obtained to create a dyadic covariate where pairs of students who shared a home group class were coded as 1 because shared classroom contexts were also hypothesized to predict friendships.

Analytic strategy

Interdependencies between changes in friendship ties and BMI were tested using SAOMs, which have been implemented in the SIENA 4.0 software [21], and described in several recent publications [15,19,22]. The models assume that individuals (called *actors*) make choices about changing (or not changing) their friendship ties or BMI given the current state of the network. A rate function estimates how many opportunities for change occur between observations, whereas the probabilities of actors making particular changes are dependent on an objective function. Rules that govern changes in friendships and BMI are therefore captured in the objective function, which is a linear combination of specified effects, as in generalized linear models. The SAOM has two components, each with rate and objective functions, a *friendship dynamics submodel* that predicts changes in friendship ties, and a *BMI dynamics submodel* that predicts changes in BMI. These submodels are estimated simultaneously, each controlling for effects in the other.

Our model was specified using a forward selection process [22], and only covariates with significant effects were retained in the final model to avoid issues of collinearity. Parameters included in the final model are described in Table 1. Four effects tested whether changes in friendship ties were governed by BMI. The first tested the effect of actors' BMIs on their propensity to nominate a new friend (adolescent BMI), and the second tested the effect of peers' BMIs on the propensity for them to receive an actor's friendship nomination (potential friend BMI). Two additional effects assessed whether BMI similarity between actors and potential friends affected the likelihood of actors establishing a new unilateral friendship (similar BMI friend) and the likelihood of actors reciprocating an existing unilateral friendship (similar BMI reciprocated friend). Effects of covariates (gender, ethnicity, and pocket money) on friendship choices were controlled (these are described in Table 1). We also included three effects of network structure on actor's friendship choices. Peers who have nominated an adolescent as a friend are often more likely than others to receive a friendship nomination (*reciprocating ties*), as are friends of friends (*transitivity*) [23]. Adolescents are also unlikely to nominate friends arbitrarily (*outgoing friendship ties*).

The hypothesized influence effect was tested by the effect of friends' BMIs on changes in adolescents' BMIs, with a positive estimate indicating that adolescents' BMIs change such that they become more similar to their friends' BMIs. (To note, there are several variations for representing this influence effect in the SAOM framework; refer to Reference 22 for further details. Because there was no strong theoretical reason to select one over another, three different specifications were score-tested during the model selection processes, and the "total similarity effect" was found to be the best fit. This effect is defined as the sum of centered similarity scores between adolescents and their nominated friends and suggests that BMI change may be influenced by a person having some friends who are quite different with respect to BMI, irrespective of the number of similar BMI friends. Thus, large differences in BMI between friends would be highly salient to the individual and likely to result in BMI change.) The model also controlled for effects of gender and ethnicity on changes in BMI, and linear and quadratic shape effects (which capture the overall distribution over time). Moreover, because weight-based similarities among friends have been found to differ by gender [6,11], interactions between adolescent gender and BMI selection and influence effects were examined.

Effects are tested based on *t*-ratios of the estimate divided by the standard error. Estimates can also be interpreted as conditional odds ratios (ORs) and reflect the likelihood of an actor who is making a change in his or her friendships or BMI, choosing

Table 2
Descriptive statistics for weight status and friendship relations

Characteristic	Wave 1	Wave 2	Wave 3	Wave 4
Individual characteristics				
M (SD) pocket money[a]	2.0 (.9)	2.0 (1.0)	2.0 (.9)	2.1 (1.1)
M (SD) BMI	20.1 (3.4)	20.6 (3.9)	20.5 (3.9)	21.1 (3.2)
% overweight	12.3	18.0	16.5	15.7
% obese	4.9	4.7	4.5	2.9
% missing BMI data	21.2	17.9	14.7	35.3
Network characteristics				
M (SD) friends nominated	3.4 (2.5)	3.6 (2.3)	3.5 (2.4)	3.5 (2.5)
Reciprocity index	.33	.33	.37	.26
% missing friendship data	13.5	12.8	10.3	32.7
Network autocorrelation for BMI[b]	.19 (.73)	.15 (.72)	.06 (.74)	−.10 (1.03)
	Period 1	Period 2	Period 3	
M new friendship ties	1.6	1.5	2.0	
M stable friendship ties	1.9	2.1	1.5	
M friendship ties dissolved	1.5	1.4	2.3	
Composition change (joined, left)	6, 1	5, 0	0, 24	

The reciprocity index is the proportion of friendship nominations that were reciprocated.
[a] 1 = <$10, 2 = $10–$20, 3 = $20–$30, 4 = >$30.
[b] Network autocorrelation coefficients: Moran's *I* (Geary's C in parentheses). Moran's I ranges from −1 to 1, with values greater than 0 indicating positive autocorrelation (meaning that friends are very similar with respect to BMI), and values <0 indicating negative autocorrelation. Geary's C ranges between 0 and 2, with a value <1 indicating positive autocorrelation.

between two possible outcomes (see [24] for another example of the use of ORs to interpret SAOM effects).

Results

Descriptive results

Table 2 summarizes changes in participants' BMIs and friendship ties. Average BMIs were in a healthy range and the proportions of overweight and obese students were comparable with current national figures [25]. Participants consistently nominated an average of three to four friends, and about one-third of these friendships were reciprocated. Although participants' average number of friends remained stable, *who* they were friends with varied: despite maintaining close to two stable friends between waves, they dissolved and established a similar number of friendships. Changes in the composition of the network at each wave as a result of students joining or leaving the school (Table 2) were also accounted for in the models [26].

The extent to which friends' BMIs were alike at each wave, known as *network autocorrelation*, is also summarized in Table 2. Coefficients for Moran's *I* and Geary's C are measures of spatial correlation applied in this study as general descriptive measures of BMI similarity between connected individuals in a matrix (i.e., pairs of friends). The coefficients indicate that friends' BMIs were somewhat alike over the first two waves of the study, but there is less evidence of similarity by the third and fourth wave.

Modeling the evolution of the friendship network and BMI

To determine whether adolescents' friendships and BMI were interdependent and whether this resulted from selection or influence processes, a SAOM was estimated for the evolution of the friendship network and BMI (Table 3).

Friendship dynamics. The effect of BMI on friendship choices was tested, with participants showing a preference to befriend peers whose BMIs were similar to their own, indicated by the significant positive effect of "similar BMI friend" (OR = 1.06, 95% CI = 1.01–1.11; [the OR can be interpreted as follows: if a participant was changing a friendship tie and making a choice between two potential friends, one whose BMI was the same as the participant and another whose BMI differed by 4 U, the participant would be 24% more likely [6% per BMI unit] to befriend the peer with the same BMI]). However, the effect of BMI on establishing mutual friendships was significant and negative, indicating that BMI similarities were not a driver for reciprocating friendships; in fact, similarities seemed to discourage mutual friendships (similar BMI reciprocated friend: OR = .85, 95% CI = .76–.96). There were no significant effects of BMI on the number of friends nominated (adolescent BMI) or on the number of friendship nominations received (potential friend BMI).

The formation of friendships was also predicted by covariates: participants were more likely to nominate friends who were of the same gender (OR = 1.82, 95% CI = 1.61–2.07), the same ethnic background (OR = 1.15, 95% CI = 1.02–1.31), and who were in their home group class (OR = 1.46, 95% CI = 1.27–1.68). As compared with males, female students nominated fewer friends (OR = .83, 95% CI = .72–.97) but received more friendship nominations (OR = 1.41, 95% CI = 1.22–1.62), and students with more pocket money

Table 3
SAOM estimates for friendship network and BMI dynamics

Parameter	PE (SE)	OR (95% CI)
Friendship dynamics		
Rate period 1	8.379 (.790)	
Rate period 2	6.535 (.508)	
Rate period 3	18.464 (2.252)	
BMI effects		
Adolescent BMI	.011 (.011)	1.01 (.99–1.03)
Potential friend BMI	−.014 (.011)	.99 (.96–1.01)
Similar BMI friend	.853 (.369)[a]	1.06 (1.01–1.11)
Similar BMI reciprocated friend	−2.395 (.901)[b]	.85 (.76–.96)
Covariate effects		
Adolescent gender	−.182 (.076)[a]	.83 (.72–.97)
Potential friend gender	.343 (.072)[b]	1.41 (1.22–1.62)
Same gender friend	.601 (.064)[b]	1.82 (1.61–2.07)
Adolescent ethnicity	−.072 (.072)	.93 (.81–1.07)
Potential friend ethnicity	.011 (.065)	1.01 (.89–1.15)
Same ethnicity friend	.143 (.064)[a]	1.15 (1.02–1.31)
Adolescent money	−.116 (.031)[b]	.89 (.84–.95)
Potential friend money	.003 (.031)	1.00 (.94–1.07)
Similar money friend	.166 (.100)	1.06 (.99–1.13)
Same class friend	.377 (.072)[b]	1.46 (1.27–1.68)
Structural effects		
Outgoing friendship ties	−3.180 (.084)[b]	.04 (.04–.05)
Reciprocating ties	1.957 (.136)[b]	7.08 (5.42–9.24)
Transitivity	.416 (.024)[b]	1.52 (1.45–1.59)
BMI dynamics		
Rate period 1	1.332 (.211)	
Rate period 2	.985 (.146)	
Rate period 3	3.451 (.493)	
Linear shape	.477 (.076)[b]	1.61 (1.39–1.87)
Quadratic shape	−.026 (.013)[a]	
Friend BMI	1.210 (1.015)	1.08 (.95–1.24)

Rate parameters represent the estimated number of opportunities each actor has to change their friendship ties or 1 U of BMI, and are assumed to differ from zero. An odds ratio is not reported for the quadratic shape effect because this effect is not linear.
PE = parameter estimate.
[a] $p < .05$, two-tailed.
[b] $p < .01$, two-tailed.

Table 4
SAOM estimates for the effects of adolescent overweight on friendship dynamics

Parameters for friendship dynamics	PE (SE)	OR (95% CI)
Rate period 1	8.269 (.713)	
Rate period 2	6.508 (.555)	
Rate period 3	18.432 (3.138)	
Weight category effects		
Adolescent overweight	.329 (.159)[a]	1.39 (1.02–1.90)
Potential friend overweight	−.267 (.137)[b]	.77 (.59–1.00)
Same overweight friend	.501 (.239)[a]	1.65 (1.03–2.63)
Same overweight reciprocated friend	−1.077 (.445)[a]	.34 (.14–.81)
Covariate effects		
Adolescent gender	−.169 (.074)[a]	.84 (.73–.98)
Potential friend gender	.326 (.069)[c]	1.38 (1.21–1.59)
Same gender friend	.581 (.061)[c]	1.79 (1.58–2.01)
Adolescent ethnicity	−.066 (.074)	.94 (.81–1.08)
Potential friend ethnicity	.014 (.069)	1.01 (.89–1.16)
Same ethnicity friend	.128 (.063)[a]	1.14 (1.00–1.29)
Adolescent money	−.110 (.033)[c]	.90 (.84–.95)
Potential friend money	.001 (.030)	1.00 (.94–1.06)
Similar money friend	.165 (.096)	1.06 (.99–1.13)
Same class friend	.377 (.072)[c]	1.46 (1.27–1.68)
Structural effects		
Outgoing friendship ties	−3.465 (.198)[c]	.03 (.02–.05)
Reciprocating friend ties	2.575 (.025)[c]	13.13 (6.19–27.82)
Transitivity	.417 (.198)[c]	1.52 (1.44–1.60)

Score tests for BMI effects	PE	c	*df*	*p*
Adolescent BMI	−.013	.26	1	.607
Potential friend BMI	.022	1.51	1	.219
Similar BMI friend	−.435	.98	1	.322
Similar BMI reciprocated friend	−.116	.44	1	.506

Rate parameters represent the estimated number of opportunities each actor has to change their friendship ties, and are assumed to differ from 0. The relatively large SE for the reciprocity effect is a result of this parameter being strongly correlated with the same overweight reciprocated friend effect. The convergence diagnostics for this model were nonetheless good.

[a] $p < .10$, two-tailed.
[b] $p < .05$, two-tailed.
[c] $p < .01$, two-tailed.

also nominated fewer friends (adolescent money OR = .89, 95% CI = .84–.95). The structure of the friendship network also predicted the formation of friendships. Participants were unlikely to select friends arbitrarily (negative outgoing friendship ties effect), and they were likely to befriend a grade-mate who had nominated them as a friend (positive reciprocating ties effect) and who was a friend of a friend (positive transitivity effect).

BMI dynamics. Controlling for factors affecting the formation of friendships, the BMI dynamics submodel tested effects predicting changes in participants' BMIs (Table 3). The effect of a friend's BMI on an adolescent's BMI was positive, but not statistically significant ($p = .23$), indicating that "contagion" processes did not explain BMI similarities among friends. The positive linear shape and negative quadratic shape effects indicate that participants BMIs tended to move toward higher values but maintained a unimodal distribution. Changes in BMI were not found to be explained by gender or ethnicity, assessed during the forward model selection process.

Modeling the evolution of the friendship network and adolescent weight category

Because weight-related similarity among friends was found to be explained by selection effects, we tested whether it was driven by the marginalization of overweight adolescents. This model included four effects of overweight (where 1 = overweight or obese) on (1) the number of friends nominated (adolescent overweight), (2) the number of friendship ties received (potential friend overweight), (3) the selection of friends with the same weight category (same overweight friend), and (4) the reciprocation of friendship ties based on the same weight category (same overweight reciprocated friend). Effects of BMI on friendship dynamics were score-tested against this model [21] to see whether they predicted friendship nominations over and above effects of overweight.

Weight category significantly predicted friendship choices, controlling for the same structural and covariate effects as the previous model (Table 4). As compared with their nonoverweight peers, overweight participants nominated more friends (OR = 1.39, 95% CI = 1.02–1.90), and were marginally less likely to receive friendship nominations (OR = .77, 95% CI .59–1.00). Adolescents also showed a preference for unilateral friends of the same weight category (OR = 1.65, 95% CI = 1.03–2.63), meaning that participants were 65% more likely to initiate a friendship with a peer of the same weight category. However, sharing the same weight category mitigated against reciprocating friendships (OR = .34, 95% CI = .14–.81). The score tests for BMI-related effects on friendship dynamics were not significant (Table 4), indicating that BMI did not account for any additional effect on friendship choices over and above the effects of weight category.

To summarize, weight-based similarities among friends were found to be driven by preferences for friends of the same *weight category*. To clarify whether this was the case for both nonoverweight and overweight students, parameter estimates were interpreted in terms of the "attractiveness" of particular tie changes. (This can be thought of as the contribution of a single tie to the objective function of the SAOM, similar to log-odds in that a positive value indicates a preference to form ties; refer to Reference 22 for further details.) As illustrated in Table 5, nonoverweight adolescents showed a preference to befriend nonoverweight peers (.19) and a strong aversion to overweight peers (−.77). Overweight students were not opposed to forming friendships with nonoverweight peers (−.06), but were still more likely to nominate overweight friends (.33).

Additional analyses

We tested interactions between respondent gender and the significant weight-based selection effects (BMI and overweight). None of these interactions was significant, indicating that these social selection processes did not operate differently for males and females.

Because the network autocorrelation coefficients for BMI declined in wave 4 (Table 2), we also explored interactions between weight-related selection effects and time (assessed by creating a dummy for each of the three periods). Although none of these interactions was found to be statistically significant, the prefer-

Table 5
Attractiveness of potential friends based on weight category

Adolescent weight category	Potential friend weight category	
	Nonoverweight	Overweight
Nonoverweight	.19	−.77
Overweight	−.06	.33

ence to befriend peers with similar BMIs was somewhat weaker in period 3, indicated by a trend for a negative interaction between period 3 dummy and "similar BMI friend" (parameter estimate = −.605, standard error = .409, p = .138).

Discussion

In this cohort of adolescents, excess body weight was found to be an important factor in friendship choices over the initial 2 years of high school. There was a trend for overweight youth to receive fewer friendship nominations than their nonoverweight peers, despite nominating a greater number of friends. Participants were also found to nominate friends whose weight status was the same as their own, with nonoverweight students particularly averse to befriending overweight peers. Negative attitudes and stereotyping of youth with excess weight may be the basis of this marginalization [27], as might be decreased participation by overweight youth in sports or other activities that provide opportunities for friendship formation [28]. Interestingly, similarities in weight were not a driver for desired friendships to be reciprocated: in fact, mutual friendships between peers whose weight status *differed* were more probable. One possible explanation is that overweight adolescents feel safer initiating friendships with other overweight peers, but prefer to reciprocate friendship offers (unilateral nominations) from students who differ on a status-related characteristic, such as weight, in an attempt to advance their own social standing [29]. This process could explain the decrease in network autocorrelation found for BMI over time, along with the trend that preferences to initiate friendships based on similar weight status declined by wave 4.

Controlling for the role of BMI in the structuring of adolescents' friendship ties, as well as alternate selection mechanisms, such as preferences based on gender and ethnicity, there was no evidence that friends' BMIs became increasingly alike. Thus, adolescents' BMIs were not found to be influenced by their friends' BMIs over the 16 months of the study, and weight-based similarities among friends were primarily explained by friendship selection rather than by the "contagion" of excess weight.

These findings support previous research showing the effect of weight-based stigma on adolescent friendships, but the lack of evidence for peer effects on BMI contrasts with some of the findings from the Add Health cohort [3,5,6]. Although the total duration of this study was comparable with those using the Add Health data, it was strengthened by the collection of more frequent panels of data, enabling a more accurate estimation of processes underpinning changes in friendship ties and BMI. Additionally, we controlled for various mechanisms (structural- and attribute-based) contributing to the formation and clustering of friendship ties. The current findings were also based on objective anthropometric measures, whereas Add Health captured self-reported height and weight. Friends' assimilations in *self-reported* BMI could, to some extent, be explained by friends' perceptions of their weight becoming increasingly alike. Despite these strengths, the generalizability of the current study was limited by the small sample size and narrow age range, and because friendships outside of the grade cohort were not considered. Moreover, at this stage of middle-adolescence, there is likely to be a great deal of variation in physical development and associated changes in BMI, which may have hindered the detection of an influence effect over the short duration of the study. Replicating this study design and analytic strategy using a large representative sample over a longer time frame would therefore be fruitful.

Despite no evidence that friends influence the weight of adolescents in this study, it seems plausible that this effect may emerge over time. In a peer context where excess weight is salient to the formation of relationships, it is likely that these friends act as referents for norms around weight, affecting future weight management [7]. Moreover, adolescent friends have also been found to engage in similar weight-related behaviors [8], a further mechanism by which their BMIs could assimilate. The negative effect of weight-based stigma on adolescents' emotional and physical wellbeing is also substantial [27], and this shared experience of marginalization among overweight friends could result in parallel changes in BMI [30,31]. Should additional research provide stronger evidence of a "contagion" effect on weight, understanding the underlying mechanisms will be crucial for addressing this in health policy and interventions. However, an important first step will be to address mechanisms driving the marginalization of overweight adolescents that is initially shaping young people's friendship networks and peer environments.

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