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Is There Evidence that Friends Influence Body Weight? A Systematic Review of Empirical Research

Solveig A. Cunningham,

Hubert Department of Global Health, Emory University, United States

Elizabeth Vaquera,

Department of Sociology, University of South Florida, United States

Claire C. Maturo, and

Hubert Department of Global Health, Emory University, United States

K.M. Venkat Narayan

Hubert Department of Global Health, Emory University, United States

Abstract

Researchers and policymakers from diverse fields are engaged in efforts to understand the biological and social causes of obesity in order to develop policies, interventions, and recommendations to stop or reverse increases in obesity. One potentially promising approach is to harness influence from social contacts. An important foundation for this approach involves critically analyzing available data regarding whether and how body weight can be affected by close social contacts, especially friends. This systematic review examines evidence from published studies addressing the influences of friends on body weight. The majority of the sixteen studies conclude that there is evidence of influence: six reported that friends influence body weight and ten reported evidence of influence in some circumstances or specifications. However, this literature sheds little light on mechanisms of influence. There is limited evidence that friends' communication about weight is associated with weight status and no compelling evidence that friends' behaviors affect one's weight. Many of the studies best designed to examine influence were the ones that did not explore mechanisms of influence. A priority for future research is to understand how, when, and how much friends affect the risk of obesity.

Keywords

social networks; obesity; overweight; BMI; peers; friendship; influence

Introduction

Obesity is a major public health concern, with almost 1 in 10 adults globally estimated to be obese in 2005 (Kelly et al., 2008). In the United States, about one in three adults and one in five children and adolescents are obese (Flegal et al., 2012; Ogden et al., 2012). Extensive research efforts have been dedicated to exploring the possible reasons for the increasing

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Corresponding author. Solveig A. Cunningham. sargese@sph.emory.edu.

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prevalence of obesity over the past 30 years. An emerging interest is the possible role of social influences. Social scientists have demonstrated that interpersonal contacts are important for several aspects of wellbeing. Social contacts can promote, discourage and sanction attitudes and behaviors (Crosnoe et al., 2003; Hallinan & Williams, 1990; Urberg, 1992) and thereby may influence health and health behaviors (Bahr et al., 2009; Schlundt et al., 1990). Pressure and behavior modeling from social contacts are predictive of smoking, delinquency, and substance use in adolescence (Glaser et al., 2010; Simons-Morton & Farhat, 2010; Simons-Morton & Haynie, 2003). Previous research also suggests that social contacts may influence participation in organized sports (Kohl & Hobbs, 1998), dieting (Haines & Neumark-Sztainer, 2006) and food choices (Cullen et al., 2004).

Influences from peers and other close contacts can manifest as social pressure, social modelling and imitation, social comparison and behavior approximation (Brechwald & Prinstein, 2011), or a combination of these. However, not all social contacts are equally important: the closer and stronger the connection, the broader and stronger the possibilities for influence (Duncan et al., 2000; Lin, 2001). The signalling and information exchanges that occur between friends -as individuals who know each other, trust each other, and have each other's well being at heart -require special attention. Messages transmitted through this kind of connection are expected to be more clearly understood and more likely to be internalized, making friends potentially more influential for health behaviours than other social contacts (Berten & Rossem, 2011; Crosnoe & Muller, 2004; Schofield et al., 2007; Urberg, 1992). Close or best friends have been shown to be more important than cliques, crowds, and peer groups (Hallinan & Williams, 1990; Urberg, 1992; Wilkinson, 2010). Friends are more likely to set norms, for example, about what and how much to eat through their own behavior than are other social contacts (Carbery & Buhrmester, 1998; de Castro, 1994; Giordano et al., 2003; Matsumoto et al., 1999; Reisman & Shorr, 1978). Consequently, the study of friends is of theoretical importance and of potential relevance for interventions, as friends are especially capable of understanding the individual and creating normative pressure for behavior change throughout life (Brechwald & Prinstein, 2011). While many studies have focused on friendships in adolescence, when social relations shift focus from family to friends, there is long-standing evidence that friendships are also important in adulthood.

The notion that friends can be a central social resource in obesity interventions underscores the importance of assessing what is known about friendship influences on body weight. A major challenge to this area of research is posed by the difficulty of distinguishing influence from associations and from similarity among friends. Homophily, or the tendency to associate with others who are similar, is itself theoretically important and potentially noteworthy for intervention development, but the potential of friends to influence each other beyond the similarities between them would be especially salient for research and practice. Many studies have not taken this distinction into account. The purpose of this systematic review of the literature is to examine the empirical evidence of friendship influences on weight published to date, the strength of these findings, and the possible mechanisms through which friendship influences may occur.

Methods

We conducted searches of public health, social science, and medical peer-reviewed journals in February 2012 using PubMed, EconLit, and Sociological Abstracts. Each search used a combination of key words denoting friendship indicators (friend* or peer*) and weight indicators (obesity, overweight, body weight, BMI, body mass index). We included the word peer in our search because it is sometimes used to mean 'friend'. However, we only retained the articles where 'peer' referred to friends rather than general peer groups or schoolmates.

Searches were not restricted by publication date. We identified 2,875 articles: 71 in EconLit, 356 in Sociological Abstracts, and 2,448 in PubMed. Titles and abstracts were initially screened for relevance and 176 articles met the inclusion criteria. These studies were then reviewed independently by two authors according to the following criteria: (1) published in English; (2) presented findings from analysis of primary or secondary data; (3) included a measure of body weight or weight change as an outcome variable; (4) measured friends separately from other social contacts such as family or neighbors, and (5) proposed to identify the influence of the friendship indicators on the weight indicators. Studies of the influence of obesity on friendships were excluded. Hand searches of the references of these articles were performed and search criteria were adapted subsequently to ensure that they captured all relevant articles. Following these steps, sixteen articles met the inclusion criteria.

A data extraction spreadsheet was used to assess whether articles met inclusion criteria and to compare across studies. For each study, the following information was collected: author(s) and year of publication; data source, study design, sample size and age; weight related variables; friendship variables; control variables; estimated effect sizes and significance levels. The included articles were assessed on the measures of friendship influence and body weight and the extent to which the data and methods could distinguish influence based on study design. Due to the variety of measures and study designs employed across studies, with multiple measures of body weight and of friendship in diverse populations, it was not possible to perform a meta-analysis.

Results

Findings from the sixteen studies that met the inclusion criteria are summarized in Table 1 and details of the studies are presented in Table 2. The earliest study was published in 1994, and 14 of the 16 studies have been published since 2006. Six studies reported significant associations consistent with friendship influences on body weight and ten reported mixed results depending on the relationship under study or the model specification. To gain a clearer understanding of the possible mechanisms through which influence may occur, we classify the studies based on the measures of friendship influence used as a predictor: 1) friends' own weight status; 2) friends' weight-related behaviors, such as eating and physical activity; and 3) friends' communication about weight and weight-related behaviors, such as encouragement or discouragement of healthy or unhealthy behaviors.

The strongest and most consistent support for friendship influences on body weight was provided by the studies that investigated the relationships between *friends' own body weight* and respondents' weight and obesity risks. The majority of studies taking this approach used longitudinal analyses, extensive controls and multiple robustness checks. The magnitude of the association ranged from null to significant odds of obesity 3.5 times higher if a friend was obese compared with not obese.

Most studies did not present compelling evidence that *friends' weight-related behaviors* affected weight; few studies explored these relationships and the ones that did showed contradicting results. Similarly, evidence that *friends' communication* about weight was associated with weight status was mixed. Most studies exploring communication relied on cross-sectional data and many did not control for possible confounding factors, which may include education, family, and socio-economic environment, and thus were unable to address causal relationships.

Friends' body weight

The strongest evidence for friends' influences on body weight comes from studies that examined the relationships between ego's and friends' weight (Christakis & Fowler, 2007; Fowler & Christakis, 2008b; Halliday & Kwak, 2009; Leahey et al., 2010; Renna et al., 2008b; Trogdon et al., 2008; Valente et al., 2009). These studies tested the relationship between ego's and friends' BMI, obesity, and weight change without testing specific pathways of influence. They used complex statistical analyses, with seven using an extensive set of controls for confounding characteristics, and six using multiple robustness checks. Five studies used longitudinal data. All studies reported significant associations between friends' and ego's body weight in at least some model specifications.

The five longitudinal studies were able to partly account for homophily by examining weight change after a friendship was established. Results indicate that adolescents and adults whose friend was obese had between 50 and 80% higher odds of also being obese, depending on the model selected (Christakis & Fowler, 2007; Cohen-Cole & Fletcher, 2008a). The magnitude of this relationship varied by gender and depended on the reciprocal nature of the relationship between the two individuals. Among same-sex friends, adults with an obese male friend faced double the odds of being obese, even after accounting for their own weight history, while the risk increase associated with an obese female friend was not significant (Christakis & Fowler, 2007). The relationship was not significant for friendships that the ego did not acknowledge or for opposite-sex friendships. Six studies found that ego's BMI increased significantly with the BMI of friends: for each additional BMI point of the friend, an ego's BMI was estimated to increase, by about 0.05 BMI points (Christakis & Fowler, 2007; Cohen-Cole & Fletcher, 2008a; Renna et al., 2008b). Studies that considered mean BMI in the ego's friend group yielded similar results, with an increase of 0.16 to 0.30 BMI points for each additional BMI point in the average friend (Halliday & Kwak, 2009; Renna et al., 2008b; Trogdon et al., 2008). Results were robust to multiple model specifications, but were not significant in some models with individual fixed effects, especially if ego was not allowed to select new friends over time. Additionally, a study that attempted to explicitly disentangle homophily from influence using stochastic actor-oriented models reported that most of the associations observed were the result of homophily rather than influence (de la Haye et al., 2011).

Three of the studies that used data on adolescents and young adults reported larger estimated effects for females than for males on BMI-for-age percentile, BMI, overweight risks, and two-year change in BMI (Halliday & Kwak, 2009; Renna et al., 2008b; Trogdon et al., 2008; Valente et al., 2009).

While estimates were fairly consistent whether the mean, the minimum, the maximum, or the median weight of the friendship group was considered (Renna et al., 2008b), the significance and magnitude of the relationships appeared to vary with the weight of the ego: BMI was not associated with mean BMI of friends for adolescents below the 10th percentile for BMI (Halliday & Kwak, 2009), but significant associations were found at the 25th percentile, with estimated increases of 0.16 BMI points for every 1-point increase in the mean BMI of friends (Trogdon et al., 2008). These associations increased steadily with ego's BMI, reaching an estimated increase of 0.66 BMI points for every 1-point increase in mean BMI of friends for egos who were in the 75th percentile, again with larger estimates for girls than for boys (Trogdon et al., 2008).

Friends' weight-related behaviors

Three studies examined friends' weight-related behaviors and ego's BMI and weight change. One reported that fast food consumption by friends was associated with lower BMI

in the ego and that non-obese individuals more often played sports with friends (Chambers & Swanson, 2006). However, the analysis was cross-sectional and did not account for confounders. In another cross-sectional study, the number of friends who were trying to lose weight was positively associated with BMI (Page & Suwanteerangkul, 2007a), implying either lack of friendship influence, lack of success of dieting, or homophily in weight (that is, both friends are heavy and are struggling to lose weight). The third study involved an intervention design and investigated the effectiveness of involving groups of friends in a weight loss intervention together to promote weight loss and weight-loss maintenance (Wing & Jeffery, 1999). Participants recruited together with three friends had better session attendance and weight loss than those recruited alone. The addition of a social support component that required participants (both those recruited with friends and those recruited alone) to call each other on the phone, work together in class activities, plan a party together, compete together against other groups in weight maintenance, and eat and exercise together at least once during the intervention was associated with greater attendance and weight loss than among those who were not assigned to receive this social support (Wing & Jeffery, 1999). However, among participants recruited with friends, those who gained weight gained more weight, and those who lost weight lost less than those recruited without friends (Wing & Jeffery, 1999).

Communication about weight and weight-related behaviors

Five studies explored whether friends' communication about weight and weight-related behaviors influenced the respondent's weight and weight change (Ball & Crawford, 2006; Epstein et al., 1994b; Page & Suwanteerangkul, 2007b; Shroff & Thompson, 2006b; Thompson et al., 2007a). One longitudinal study found that, among individuals enrolled in a weight loss program as children, those who had been discouraged by a friend from unhealthy eating were significantly more likely to lose weight over 10 years (Epstein et al., 1994a). A cross-sectional study found that sabotage of physical activity, measured as the friend enticing the respondent to participate in unhealthy behaviors, was associated with respondent's higher BMI. However, friends' encouragement of physical activity was not significantly associated with lower BMI after controlling for confounders (Ball & Crawford, 2006).

Three cross-sectional studies focused on other forms of communication among friends: pressure to diet, preoccupation with weight and weight concerns, conversations about appearance, teasing and blaming, and advice about dieting. Adolescents whose friends pressured them to diet were almost 3 BMI-points heavier if they were boys and 3.5 BMI-points heavier if they were girls compared with those not feeling pressure to diet (Page & Suwanteerangkul, 2007a). Similarly, two studies reported that advice to avoid dieting from friends was associated with lower BMI and lower odds of overweight in females (Shroff & Thompson, 2006a; Thompson et al., 2007b). Consistent with these patterns, another study found that extensive discussions about weight among friends, including preoccupation with weight and teasing about weight, were associated with higher BMI (Shroff & Thompson, 2006a).

Most studies that focused on communication found significant but modest associations between communication with friends and BMI (Ball & Crawford, 2006; Page & Suwanteerangkul, 2007a; Shroff & Thompson, 2006a; Thompson et al., 2007b) or BMI changes (Ball & Crawford, 2006; Epstein et al., 1994a). Only two of the studies were longitudinal.

Discussion

This review of the literature provides substantial evidence that friends' body weights are strongly correlated, but evidence for the influence of friends' modelling behavior and communication about healthy weight is generally weak. There was evidence that friends, especially best- and same-sex friends, stand out among social contacts as possibly influential for weight. For example, body weight was more strongly associated between friends than between siblings or partners (Christakis & Fowler, 2007), and was stronger between best friends than casual friends (Leahey et al., 2010). Still, some analyses suggested that associations between friends' weights are driven by homophily or shared environments rather than influence (Cohen-Cole & Fletcher, 2008b; de la Haye et al., 2011).

If we are to believe that it is possible for friends to influence each other's body weight, as opposed to individuals simply selecting friends who look like them or who are similar in their health trajectories, then we must have models for how influence occurs. Guiding theoretical and empirical questions emerge from the literature. Most importantly, how is information and behavior shared between friends in ways that could affect behavior? We examined the pathways through which friends could influence each other's body weight and proposed that they can be categorized as joint engagement in and modeling of weight-related behaviors and communication of ideas and information about weight and weight-related behaviors.

Friends' behaviors may be influential as friends model behavior for each other and engage in activities together, including meals and physical activity. In childhood, physical activity at school and after school is closely tied with friendship (Schaefer et al., 2011); in adulthood many joint activities focus on food and drink consumption. As individuals engage in these activities, they may influence each other through the habits and preferences each brings to the relationship. For example, if two friends are having lunch together, one friend's decision to get an extra portion, to eat dessert, or to skip the vegetables, may mean that the other is encouraged, or perhaps pressured, to do the same (Wansink, 2004). When adults perform physical activity with friends, they work out for longer periods but the level of activity is less vigorous (Dunton et al., 2009); children engage in more vigorous physical activity when they are active with friends (Salvy et al., 2008). Decisions to alter one's activities in the presence of friends can be purposeful but at times are not conscious (Wansink, 2004). In spite of these observations, in this review, we found almost no evidence consistent with friends influencing body weight through their own weight-related behaviors. This lack of evidence may be a product of the limiting design of the studies that have explored this pathway, so it will be important for future studies to explore it further.

Communication from friends may influence body weight because it creates shared norms and beliefs (Brechwald & Prinstein, 2011; Corsaro, 1992; Hartup, 1996). Through conversations, friends share with each other ideas and expectations about what is appropriate, normal, beautiful, desired. Casual discussions about others' and each other's health, appearance, and desirable or undesirable weight-related behaviors create shared norms and values, which individuals then project back upon themselves, their characteristics, and their habits. Weight-related behaviors are affected by perceptions about friends' beliefs and behaviors and by fear of social sanctions for violating norms (Brechwald & Prinstein, 2011; Busse et al., 2010). Further, friends may bolster in each other confidence about their ability and willingness to change a behavior and may affect personal beliefs about the barriers to and benefits of weight-related behaviors (Kohl & Hobbs, 1998). Still, some cross-sectional studies found that pressure to diet for weight loss was actually associated with being heavier (Page & Suwanteerangkul, 2007b; Shroff & Thompson, 2006b). This review found limited evidence that friends' communication about weight and

weight-related behavior influence weight. The weak evidence may be due to limitations in study design and inadequate measurement of the communication mechanisms, so this possible pathway of influence should be explored further.

The strongest evidence that friends can influence each other's body weight was provided by studies comparing friends' and respondent's *weight*. However, these studies did not explore the pathways or mechanisms through which influence can occur. Furthermore, distinguishing between social influences and homophily, meaning that individuals select friends at least in part based on their physical similarity and reject others as potential friends based on dissimilarities, is a major challenge faced by this literature. Significant associations between friends' and ego's weights do not necessarily indicate influence. This concern has been raised previously, urging researchers to actively seek to determine whether influence exists (Brechwald & Prinstein, 2011). Still, most study designs cannot distinguish association from causality and tend to overestimate social influence (Bauman & Ennett, 1996; Kobus, 2003; Mercken et al., 2007). With recent advances in statistical computing and the availability of large, well-designed longitudinal studies to which a few key questions could be added, there is promise for identifying and understanding the temporal order of hypothesized influences. Among the studies reviewed, several research designs were used to try and discern influence from homophily, including utilizing longitudinal data to assess how respondents' behaviors change after the initiation of friendships, taking into account the differences between reciprocal and non-reciprocal friendships, examining averages among a respondent's friends, and accounting for previous body weight. Even with these strong study designs, questions remain based on alternative approaches to disentangling influence (Cohen-Cole & Fletcher, 2008b; de la Haye et al., 2011) and our inability to assign friends in the natural social environment.

A limitation of many of the studies included in this review was reliance on the ego's reports about his or her friends, introducing the potential for projection bias, that is, attributing their own preferences and behaviors to their friends and thus overestimating similarities with friends. Still, eight of the sixteen studies used data collected directly from friends themselves, including objective measurements of weight and height (Christakis & Fowler, 2007; Cohen-Cole & Fletcher, 2008a; de la Haye et al., 2011; Fowler & Christakis, 2008b; Halliday & Kwak, 2009; Renna et al., 2008b; Trogdon et al., 2008; Valente et al., 2009). In fact, the strongest associations were observed in studies that relied on direct measures of the ego's and friends' weight.

A challenge of synthesizing this literature is the multitude of measures of friendship influence, body weight, and control variables used across studies. Another consideration is the age of study populations. We did not restrict inclusion criteria based on age, but, because few datasets are designed to permit research on friendship influence, many studies relied on one of the few datasets that does so, the National Longitudinal Study of Adolescent Health (Cohen-Cole & Fletcher, 2008b; Fowler & Christakis, 2008a; Halliday & Kwak, 2009; Renna et al., 2008a; Trogdon et al., 2008), and so focused on adolescence and early adulthood. Few studies have focused on adults (Ball & Crawford, 2006; Chambers & Swanson, 2006; Christakis & Fowler, 2007; Leahey et al., 2010; Wing & Jeffery, 1999) and none on early or middle childhood. In the studies of adults, patterns of association did not differ by age, and two studies had similar effect estimates in adult and adolescent populations (Christakis & Fowler, 2007; Fowler & Christakis, 2008b). It will be important for future studies to examine the possibility of friendships as influential for health across ages and life stages.

Findings from several studies suggested that the importance of friends is not equal across types of friendships. The significance of the associations often hinged on the definition of

friends selected by the researcher or available in the data: the strongest empirical support for possible influences was for friendships reported by the respondent and reciprocal friendships (reported by both members of a friendship dyad). In studies that distinguished friends' gender, only the BMIs and obesity of same-sex friends were strongly associated (Christakis & Fowler, 2007; Fowler & Christakis, 2008b; Renna et al., 2008b). These patterns are consistent with homophily but not necessarily with influence.

Having made some preliminary advances in understanding the scope and nature of friendship influences on body weight, an important step will be to consider how this information may inform recommendations and interventions. The two intervention studies (Epstein et al., 1994b; Wing & Jeffery, 1999) provided some evidence that friends can engage and motivate each other in ways that increase the success of weight-loss interventions. Even if we are dubious about the influence of friends and believe that observed similarities between friends are the result of homophily, involvement of friends or social engagement with new acquaintances in a weight-management program could improve healthy weight maintenance. Still, the evidence from these studies is only suggestive, as it includes some contradictory findings, so the efficacy of involving friends in weight-loss interventions should be explored further.

While recognizing the potential of friendship to change behavior, it is important to consider the nature of friendships - duration, frequency of contact and quality - to maximize intervention outcomes. For example, given the findings reported, it is likely that involving same-sex friends in interventions can be more effective than including opposite-sex friends. Additionally, since individuals tend to associate with others of similar weight status, pre-existing social networks could be used to recruit participants into interventions. As the importance of friends' weight status has been shown to be stronger for heavier individuals, peers could prove especially useful in weight-loss interventions. Consistent with previous literature (Gaughan, 2006; Riegle-Crumb et al., 2006), several studies indicated that females may be more affected by their close friends than are males.

Research on social influences on body weight has provided some insights into the possible existence of influences and their potential usefulness in programs. At the same time, there is much to learn about how friends influence each other, under what circumstances, the mechanisms through which influences can occur, and the ways in which programs can involve friends to promote healthy weight.

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Highlights

- Sixteen peer-reviewed studies examined whether friends influence body weight, obesity and weight change.
- All studies reported significant associations between friends in body weight by at least one measure.
- Most studies are not able to establish causality between friends' body weights
- There is only weak evidence for the pathways through which friends may be influential.
- The majority of studies are based on data from adolescents, with limited information on other ages.

Table 1
Summary of evidence of friendship influence across studies with indicators of study quality

Friend indicator	Respondent's weight measure ¹	Respondent objective weight measures	Friend direct assessment	Longitudinal design	Findings consistent with influence ⁴	Study
<i>Friends' own weight status</i>						
Friends underweight	BMI		X	X		Halliday & Kwak 2009
	Overweight/obese		X	X		Halliday & Kwak 2009
Friends overweight or obese	BMI		X	X	X	Halliday & Kwak 2009
	Overweight/obese		X	X	X	Halliday & Kwak 2009
	Overweight/obese	X	X ²	X	X	Christakis & Fowler 2007
	Overweight/obese		X		X	Trogdon, Nonnemaker & Pais 2008
	Overweight/obese			X	X	Leahey et al 2010
Best friend is overweight	Overweight/obese			X	X	Leahey et al 2010
Reciprocating friend is obese	Overweight/obese	X	X ²	X	X	Christakis & Fowler 2007
Non-reciprocated friend is obese	BMI	X	X ²	X		Fowler & Christakis 2008
	Overweight/obese	X	X ²	X		Christakis & Fowler 2007
Same-sex friend is obese	Overweight/obese	X	X ²	X	X	Christakis & Fowler 2007
	Overweight/obese	X	X ²	X	X	Cohen-Cole & Fletcher 2008
Opposite-sex friend is obese	Overweight/obese	X	X ²	X		Christakis & Fowler 2007
Same-sex friend's BMI	BMI	X	X ²	X		Cohen-Cole & Fletcher 2008
Friend's BMI	BMI	X	X ²	X	X	Fowler & Christakis 2008
	BMI	X	X ²	X		de la Haye et al. 2011
Minimum BMI of friends	BMI		X		X	Renna, Grafova & Thakur 2008

Friend indicator	Respondent's weight measure ¹	Respondent objective weight measures	Friend direct assessment	Longitudinal design	Findings consistent with influence ⁴	Study
Maximum BMI of friends	BMI		X		X	Renna, Grafova & Thakur 2008
Mean or median BMI of friends	BMI		X	X	X	Halliday & Kwak 2009
	BMI		X		X	Renna, Grafova & Thakur 2008
	BMI		X		X	Trogdon, Nonnemaker & Pais 2008
	BMI	X	X ²	X	X	Fowler & Christakis 2008
Friends' weight-related behaviors	Overweight/obese		X	X	X	Halliday & Kwak 2009
	Overweight/obese	X	X ²		X	Valente et al 2009
	Weight change		X	X	X	Halliday & Kwak 2009
Friends' communication about weight and weight-related behaviors						
Weight-loss program with friends	Weight change	X		X ³	X	Wing & Jeffery 1999
Friends eat fast food	BMI					Chambers & Swanson 2006
Rarely plays sports with friends	Overweight/obese				X	Chambers & Swanson 2006
Friends dieting	BMI					Page & Suwanteerangkul 2007
Friends' communication about weight and weight-related behaviors						
Friends pressure to diet	BMI					Page & Suwanteerangkul 2007
Friends advise against dieting	BMI					Thompson et al 2007
Friends discourage unhealthy eating	Overweight/obese					Shroff & Thompson 2006
Friends discourage unhealthy eating	Weight change	X		X ³	X	Epstein et al 1994
Friends sabotage/discourage healthy eating	BMI			X		Ball & Crawford 2006
	Weight change			X		Ball & Crawford 2006
Friends encourage physical activity	Weight change			X		Ball & Crawford 2006

Friend indicator	Respondent's weight measure ¹	Respondent objective weight measures	Friend direct assessment	Longitudinal design	Findings consistent with influence ⁴	Study
Friends discourage/sabotage physical activity	BMI Weight change			X X		Ball & Crawford 2006 Ball & Crawford 2006
Friends preoccupied with weight and dieting	BMI Overweight/obese					Shroff & Thompson 2006 Thompson et al 2007
Conversations about appearance with friends	BMI Overweight/obese				X	Shroff & Thompson 2006 Thompson et al 2007
Friends perceived as a source of influence	BMI Overweight/obese				X	Shroff & Thompson 2006 Thompson et al 2007
Weight teasing from friends	Overweight/obese					Thompson et al 2007

¹ BMI includes the use of BMI-for-age percentiles or z-scores for children and adolescents.

² Includes objective weight measures on friends.

³ Intervention study.

⁴ Many studies reported several sets of results. The results from the models with the most extensive controls are shown here. Information presented is from articles' tables, text, and, where available, online appendices.

Table 2

Summary of study designs and reported study results

Study	Design, Data Source, Sample size, Ages & Country	Body weight (outcome) variable	Friendship (predictor) variable ^L	Strength of association reported and significance level ^{2,3}
<i>Friends' own weight status</i>				
Valente et al, 2009	Cross-sectional data Original data N=562 Age=11-15 USA	Overweight (weight > 95 th %ile)	Mean BMI of friends	0.26 [*]
		BMI > 85 th %ile	% of friends 90 th %ile for BMI	0.11 ^{***}
			% of friends 85 th %ile for BMI	0.11 ^{***}
			% of friends 75 th %ile for BMI	0.10 ^{***}
			% of friends 10 th %ile for BMI	-0.02
			% of friends 90 th %ile for BMI	1.25 ^{***}
		BMI	% of friends 85 th %ile for BMI	1.11 ^{***}
			% of friends 75 th %ile for BMI	1.03 ^{***}
			% of friends 10 th %ile for BMI	-0.00
				All:0.19 ^{***} ; Males: 0.18 ^{***} ; Females:0.19 ^{***}
Halliday & Kwak, 2009	Longitudinal data Add Health Wave 1 N=4,617 Age=15.11 at baseline Wave 2 N=2,970 USA	BMI > 85 th %ile		All:0.11 ^{***} ; Males: 0.08 ^{***} ; Females:0.13 ^{***}
				All: -0.01; Males: -0.01; Females: -0.02 [†]
		BMI < 10 th %ile		-0.00
		BMI		-0.02
		BMI > 85 th %ile		-0.01
		BMI < 10 th %ile		All: -0.05 [*] ; Males: 0.03; Females: 0.07 ^{***}
		BMI change over 2 yrs		All:0.04 [*] ; Males: 0.02; Females: 0.06 [*]

Study	Design, Data Source, Sample size, Ages & Country	Body weight (outcome) variable	Friendship (predictor) variable ¹	Strength of association reported and significance level ^{2,3}
Trogonon, Nonnemaker & Pais, 2008	Cross-sectional data Add Health Wave 1 N=2,800 Age=15.7 mean USA	BMI	Mean BMI of friends	All:0.30 ^{**} ; Males: 0.26 ^{**} ; Females: 0.33
			Mean BMI of friends (IV)	All:0.52 ^{**} ; Males: 0.54 ^{**} ; Females: 0.56
			Proportion of friends overweight	All:0.65 ^{**} ; Males: 0.45 ^{**} ; Females: 0.89 ^{**}
			Proportion of friends overweight (IV)	All:1.54 ^{**} ; Males: 0.72 ^{**} ; Females: 2.68
		BMI among those in the 25 th %ile of BMI	Mean BMI of friends	All:0.16 ^{**} ; Males: 0.11 ^{**} ; Females: 0.20
			Mean BMI of friends (IV)	All:0.19 [*] ; Males: 0.21 [*] ; Females: 0.16 [*]
		BMI among those in the 50 th %ile of BMI	Mean BMI of friends	All:0.28 ^{**} ; Males: 0.21 ^{**} ; Females: 0.32
			Mean BMI of friends (IV)	All:0.38 [*] ; Males: 0.37 [*] ; Females: 0.44
		BMI among those in the 75 th %ile of BMI	Mean BMI of friends	All:0.41 ^{**} ; Males: 0.35 ^{**} ; Females: 0.43 ^{**}
			Mean BMI of friends, instrumented with mean friends' birth weight & mean friends' parents' obesity	All:0.66 ^{**} ; Males: 0.54 [*] ; Females: 0.85
Renna, Grafova & Thakur, 2008	Cross-sectional data Add Health Wave 1 N=2,391 Age=15.18 mean USA	BMI		Males: 0.16 ^{**} ; Females: 0.16 ^{**}
			BMI %ile	Males: 0.12 ^{**} ; Females: 0.16 ^{**}
		BMI		Males: 0.17 ^{**} ; Females: 0.16 ^{**}
			BMI %ile	Males: 0.12 ^{**} ; Females: 0.16 ^{**}
		BMI		Males: 0.17 ^{**} ; Females: 0.16 ^{**}
			BMI %ile	Males: 0.12 ^{**} ; Females: 0.15 ^{**}
		BMI		Males: 0.12 ^{**} ; Females: 0.15 ^{**}
			BMI %ile	Males: 0.08 ^{**} ; Females: 0.13 ^{**}

Study	Design, Data Source, Sample size, Ages & Country	Body weight (outcome) variable	Friendship (predictor) variable ¹	Strength of association reported and significance level ^{2,3}
Fowler & Christakis, 2008	Longitudinal data Add Health Waves 1-3 N=4,742 Age=16 mean at baseline USA Longitudinal data Framingham Offspring Study N=2,396 Age=21-70 USA	BMI	Median BMI of friends	Males: 0.16 ^{**} ; Females: 0.17 ^{**}
		BMI %ile		Males: 0.12 ^{**} ; Females: 0.15 ^{**}
		BMI	Maximum BMI of friends	Males: 0.13 ^{**} ; Females: 0.12 ^{**}
		BMI %ile		Males: 0.11 ^{**} ; Females: 0.12 ^{**}
		BMI	Mean BMI of male friends	Males: 0.19 ^{**} ; Females: 0.11 ^{**}
		BMI %ile		Males: 0.11 ^{**} ; Females: 0.11 ^{**}
Cohen-Cole & Fletcher, 2008	Longitudinal data Add Health Waves 2 & 3 N=1,988 Age=16.24 mean USA	BMI	Friend's BMI	0.03 [*]
		BMI	Friend-reported friend is obese (respondent did not report friendship)	0.033 [*]
		BMI	Friend's BMI	0.002
		BMI %ile	Mean BMI of female friends	0.05 ^{**}
Leahey, Larose et al, 2010	Cross-sectional data Original data N=288 Age=18-25 USA	Obese	Same-sex friend is obese	Males: 0.05; Females: 0.17 [†]
		BMI	Same-sex friend's BMI	Males: 0.07 ^{**} ; Females: 0.17 ^{**}
Christakis & Fowler, 2007	Longitudinal data Framingham Offspring Study N=12,067 Age=21-70 USA	Overweight or obese (BMI > 25)	Best friend is overweight (RR)	0.41 ^{**}
		Obese (BMI > 30)	Number of overweight casual friends (RR)	0.033
Christakis & Fowler, 2007	Longitudinal data Framingham Offspring Study N=12,067 Age=21-70 USA	Obese (BMI > 30)	Ego-reported friend is obese	$\chi^2 = 3.90^* (a)$
			Reciprocating friend is obese	$\chi^2 = 6.50^{**} (a)$
		Obese (BMI > 30)	Non-reciprocated friend is obese (respondent did not report friendship)	0.52 [*]
			Same-sex friend is obese	1.19 ^{****}
			Opposite-sex friend is obese	0.11
			Male friend is obese	0.62 ^{**}
				-0.29
				0.84 ^{**}

Study	Design, Data Source, Sample size, Ages & Country	Body weight (outcome) variable	Friendship (predictor) variable ¹	Strength of association reported and significance level ^{2,3}
de la Haye et al., 2011	Longitudinal data Original data N=156 Age=12.3–15.6 Australia	BMI	Female friend is obese Male reciprocating friend is obese Female reciprocating friend is obese Friend's BMI	0.30 ^{**} 1.28 [*] 1.09 ^{***} No effect size reported
<i>Friends' weight-related behaviors</i>				
Page & Suwanteeangkul, 2007	Cross-sectional data Original data N=2,519 Age= 16.2 mean Thailand	BMI	Number of friends dieting to lose weight (none, some, half, most/all) (RR)	Males: Mean BMI=19.6, 20.59, 20.47, 20.43 ^{**} respectively; Females: Mean BMI=19.06, 19.5, 19.91, 19.96 ^{**} respectively
Chambers & Swanson, 2006	Cross-sectional data Original data N=80 Age=19–73 Scotland	BMI	Friends' frequency of eating fast food (RR)	correlation = -0.23 [*] (a)
		Obese	"rarely" or "almost never" play sports with friends	$\chi^2 = 11.4$ ^{**} (a)
Wing & Jeffery, 1999	Longitudinal, intervention trial Original data N=166 Age=25–55 USA	Weight change in intervention 0–4 mo.	Recruited into weight-loss program with friends & given social support	-0.7 kg (mean difference from social support)(a)
		Weight change in intervention 10 mo.		-0.1 kg (mean difference from social support)(a)
		Weight change after intervention 4–10 mo.		0.4 kg (mean difference from social support) (a)
		Gained weight vs. lost/maintained in 4–10 mo. after intervention		66% vs. 24% maintained weight loss in full (mean difference from friend recruitment) (a)
		Weight change in intervention 0–4 mo.		-2.1 kg ^{**} (mean change for those recruited with vs. without friends) (a)
		Weight change in intervention 10 mo.		-2.9 kg ^{**} (mean change for those recruited with vs. without friends) (a)
Weight change after intervention 4–10 mo.	1.5 kg ^{**} (mean change for those recruited with vs. without friends) (a)			

Study	Design, Data Source, Sample size, Ages & Country	Body weight (outcome) variable	Friendship (predictor) variable [†]	Strength of association reported and significance level ^{2,3}
<i>Friends' communication about weight & weight-related behaviors</i>				
Page & Suwanteeerangkul, 2007	Original data N=2,519 Age=16.2 mean Thailand	Gained weight vs. lost/maintained in 4-10 mo. after intervention	Number of friends who pressure to diet (none, some, half, most/all) (RR)	Males: Mean BMI=19.8, 22.22, 22.21, 22.74 *** respectively Females: Mean BMI=18.94, 20.57, 21.65, 22.55 *** respectively (a)
Epstein et al, 1994	Longitudinal, intervention trial Original data N=158 Age=6-12 at baseline USA	Change in percent overweight over 10 yrs	Friends discourage unhealthy eating (RR)	-0.73*
Ball & Crawford, 2006	Longitudinal data Sub-study within Australian Longitudinal Study on Women's Health N=790 women Age=18-23 Australia	BMI	Friends encourage unhealthy eating (RR)	No effect size reported
			Friends discourage physical activity (RR)	No effect size reported
			Friends encourage unhealthy eating (RR)	No effect size reported
			Friends encourage physical activity (RR)	No effect size reported
Shroff & Thompson, 2006	Cross-sectional data Original data N=344 women Age=14-17 USA	BMI	Friends discourage physical activity (RR)	0.14**
			Friends preoccupied with weight & dieting (RR)	correlation = .21 *** (a)
			Has conversation about appearance with friends	correlation = 0.003 (a)
			Friends are a source of influence (RR)	correlation = 0.11* (a)
Thompson et al, 2007	Cross-sectional data Original data N=325 women Age=14-17 USA	Overweight/at risk for overweight	Friends give anti-dieting advice	correlation = -0.16** (a)
			Friends preoccupied with weight & dieting (RR)	0.00 [‡]
			Has conversation about appearance with friends	-0.08***
			Friends are a source of influence (RR)	0.00
			Friends give anti-dieting advice	-0.06**
			Friends tease about weight (RR)	1.13***

[‡] p 0.10,

* p 0.05,

**
p 0.01,

p 0.001.

¹ RR indicates respondent-reported, that is, information on friends was collected from the respondent rather than directly from friends.

² Strength of association indicates a regression coefficient estimate of the relationship between the friendship independent variable and the body weight dependent variable in all but the studies marked with (a). Strength of association was taken directly from the results reported in each study (in tables, text, or online appendices) in the models with the most extensive controls. To make the findings from various studies more easily comparable, we have converted odds ratios to coefficient estimates where applicable.

³ Readers are encouraged to refer to the original publications of these studies to fully understand the summaries in this table.