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With a little help from my friends: How social networks help college students trying to lose weight

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UNIVERSITY OF CALIFORNIA, SAN DIEGO

SAN DIEGO STATE UNIVERSITY

With a little help from my friends:
How social networks help college students trying to lose weight

A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy

in

Public Health (Health Behavior)

by

Gina Clara Merchant

Committee in Charge:

University of California, San Diego

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San Diego State University

       Professor Guadalupe X. Ayala
       Professor Linda C. Gallo

2015

The Dissertation of Gina Clara Merchant is approved, and it is acceptable in quality
and form for publication on microfilm and electronically:

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                                                                    Chair

University of California, San Diego

San Diego State University

2015

DEDICATION

To my best friend and husband Derek Bradley. Your unconditional love, and support over the past four years has played a profound role in my success in graduate school. Here is to years of love and friendship, and our growing family. Also, here is to never taking ourselves too seriously, always making time for sending one another emojis we design ourselves, and making up silly inside jokes like "Rrrrrr!!!!" #GoTeamFuzz

EPIGRAPH

'Why did you do all this for me?' he asked. 'I don't deserve it. I've never done anything for you.' 'You have been my friend,' replied Charlotte. 'That in itself is a tremendous thing.'

E.B. White, Charlotte's Web

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LIST OF ACRONYMS AND INITIALISMS

BMI   Body Mass Index

HAL   Healthy Active Living

HALss   Healthy Active Living social support

SMART   Social and Mobile Approach to Reduce Weight

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ACKNOWLEDGMENTS

Aunt for being my most ardent supporter throughout the years. And thank you husband for always being by my side, and keeping my spirits high through the many trials and tribulations that graduate school brings.

Chapter 2, in full, is being prepared for submission to Health Education Research. Co-Authors include Pina, Laura; Weibel, Nadir; Griswold, William G.; Fowler, James H.; Ayala, Guadalupe X.; Gallo, Linda C.; Hollan, Jim D.; Patrick, K. The dissertation author is the primary author of this material.

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Degree: Master of Arts in Experimental Psychology (2011)*
Dean's Outstanding Graduate Award for the College of Arts and Sciences

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CURRENT PROFESSIONAL POSITIONS

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RESEARCH PUBLICATIONS

REFEREED PUBLICATIONS UNDER REVIEW

1. Kerr, J., Takemoto, M., Bolling, K., Atkin, A., Carlson, J., Rosenberg, D., Crist, K., Godbole, S., Lewars, B., Pena, C., **Merchant, G**. Two-arm randomized pilot intervention to decrease sitting time and increase sit-to-stand transitions in working and non-working older adults. *Submitted to PloS One (August, 2015).*

REFEREED PUBLICATIONS

12. **Merchant, G.,** Buelna, C., Castaneda, S. F., Arredondo, E. M, Marshalll, S. J., Strizich, G., Sotres-Alvarez, D., Chambers, E. C., McMurray, R. G., Evenson, K. R., Stoutenberg, M., Hankinson, A. L., Talavera, G. A. Accelerometer-measured sedentary time among Hispanic adults: Results from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). *Preventive Medicine Reports (publication in progress).* doi: 10.1016/j.pmedr.2015.09.019

11. Qi, Q., Strizich, G., **Merchant, G**., Sotres-Alvarez, D., Buelna, C., Castaneda, S., Gallo, L., Cai, J., Gellman, M., Isai, C., Moncrieft, A., Sanchez-Johnson, L., Schneiderman, N., Kaplan, R. Objectively-measured sedentary time and cardiometabolic biomarkers in U.S. Hispanic/Latino adults: The Hispanic Community Health Study/Study of Latinos (HCHS/SOL). *Circulation.* doi: 10.1161/CIRCULATIONAHA.115.016938

10. Vásquez, E., Strizich, G., Gallo, L., Marshall, S. J., **Merchant, G**., Moncrieft, A. E., Murillo, R., Penedo, F. J., Salazar, C. R., Sotres-Alvarez, D., Shaw, B. A., Isasi, C. R. The role of stress in understanding differences in sedentary behavior in Hispanic/Latino: Results from the Hispanic Community Health Study/ Study of Latinos Socio-cultural Ancillary Study. *Journal of Physical Activity and Health.* doi: http://dx.doi.org/10.1123/jpah.2014-0608

9. Gupta, A., Calfas, K., Marshall, S. J., Robinson, T., Rock, C., Epstein, M., Servetas, C., Donohue, M., Raab, F., Fowler, J., Griswold, W., Norman, G., Fogg, B. J., **Merchant, G**., Patrick, K. (2015). Clinical trial management of participant recruitment, enrollment, engagement, and retention in the SMART study using a Marketing and Information Technology (MARKIT) model. *Contemporary Clinical Trials.* doi: 10.1016/j.cct.2015.04.002

8. Hill, L., Rybar, J., Styer, T., Fram, E., **Merchant, G.,*** Eastman, A. (2014). Prevalence and attitudes about distracted driving in college students. *Traffic Injury Prevention.* doi: 10.1080/15389588.2014.949340

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7. **Merchant, G.,** Weibel, N., Patrick, K., Fowler, J., Norman, G., Gupta, A., Servetas, C., Griswold, W., Calfas, K., Raste, K., Pina, L., Donohue, M., Griswold, W., Marshall, S. (2014). Click 'Like' to change your behavior: A mixed methods study of college students' exposure to and engagement with Facebook content designed for weight-loss. *Journal of Medical Internet Research 16 (6), e158.* doi: 10.2196/jmir.3267

6. Marinac, C. **Merchant, G.,** Godbole, S., Chen, J., Kerr, J., Clark, B., Marshall, S. (2013, November). The feasibility of using SenseCam to measure the type and context of sedentary behavior. Paper presented at the International SenseCam & Pervasive Imaging Conference, San Diego, CA and published in the Proceedings of the 4th International SenseCam & Pervasive Imaging Conference through ACM Digital Library.

5. Patrick, K., Marshall, S., Davila, E., Kolodziejczyk, J., Fowler, J., Calfas, K., Huang, J., Rock, C., Griswold, B., Gupta, A., **Merchant, G.,** Norman, G., Rabb, F., Donohue, M., Fogg, BJ, Robinson, T. N. (2013). Design and implementation of a randomized controlled social and mobile weight loss trial for young adults

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2. Kolodziejczyk, J., **Merchant, G.,** Norman, G. (2012). A Systematic Review: Reliability and Validity of Child/Adolescent Food Frequency Questionnaires that Assess Foods and/or Food Groups. *Journal of Pediatric Gastroenterology and Nutrition, 55 (1), 4-13.* doi: 10.1097/MPG.0b013e318251550e

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REFEREED PRESENTATIONS

19. **Merchant, G.,** Carlson, J., Godbole, S., Black, M., Kerr, J. (2014, May). Take a stand: Targeting psychosocial mediators of change to reduce older adults' sedentary behavior. Poster presented at the International Society for Behavioral Nutrition and Physical Activity Conference, San Diego, CA.

18. Godbole, S., Wang, L., **Merchant, G.,** Wing, D., Marshall, S., Kerr, J. (2014, May). Predicting Energy Expenditure from a wrist-worn ActiGraph GT3X+ accelerometer. Poster presented at the International Society for Behavioral Nutrition and Physical Activity Conference, San Diego, CA.

17. Johnson, E., Wang, L., **Merchant, G**.,***** Marshall, S., Kerr, J. (2014, May). Objective measurement of screen time in overweight women with different working status. Oral presentation at the International Society for Behavioral Nutrition and Physical Activity Conference, San Diego, CA. ******Mentored first author*

16. **Merchant, G**., Pina, L., Black, M., Bales, E., Weibel, N., Griswold, B., Fowler, J., Patrick, K. (2014, April). Online and face-to-face: How do ad-hoc and existing networks support weight-related behavior change in young adults? Poster presented at the Society of Behavioral Medicine Conference, Philadelphia, PA.

15. Gupta, A., Calfas, K., Marshall, S., Fowler, J., Norman, G., Robinson, T., Huang, J., Epstein-Corbin, Gross, C., **Merchant, G**., Raab, F., Griswold, W., Rock, C., Fogg, BJ, Weibel, N., Donohue, M., Kolodziejcyk, J., Patrick, K. (2014, April). 12-Month retention and engagement in the social mobile approaches to reduce weighT (SMART) study: A 2-year RCT of a technology-based intervention for

weight-loss. Poster presented at the Society of Behavioral Medicine Conference, Philadelphia, PA.

14. Marinac, C. **Merchant, G.,** Godbole, S., Chen, J., Kerr, J., Clark, B., Marshall, S. (2013, November). The feasibility of using SenseCam to measure the type and context of sedentary behavior. Oral paper presentation at the International SenseCam & Pervasive Imaging Conference, San Diego, CA.

13. Davila EP, Patrick K, Marshall S, Fowler J, Kansagara AG, Servetas C, **Merchant G.** (2013, May). A social and mobile weight control program for young adults, project SMART. Oral presentation presented at the International Society for Research on Internet Interventions, Chicago, IL.

12. **Merchant, G.,** Pulvers, K. (2013, March). Ready to exercise? Exercise-specific cognitions and emotions of young women. Poster presented at the Society of Behavioral Medicine Conference, San Francisco, CA.

11. Gupta, A., **Merchant, G**., Marshall, S., Fowler, J., Calfas, K., Patrick, K. (2013, March). Applying theory-driven behavior change principles to Facebook campaigns for weight loss. Poster presented at the Society of Behavioral Medicine Conference, San Francisco, CA.

10. **Merchant, G.,** Davila, E., Marshall, S., Gupta, A., Patrick, K. (2013, March). Patterns of sedentary behavior among overweight/obese college students recruited to a weight-loss intervention. Poster presented at the Society of Behavioral Medicine Conference, San Francisco, CA.

9. **Merchant, G.,** Parada, H., Marshall, S. J. (2012, May). Convergent validity of self-reported sedentary behavior and accelerometry: Comparing multiple cut points. Poster presented at the American College of Sports Medicine Conference, San Francisco, CA.

8. **Merchant, G.,** Pulvers, K., Hood, A., Carillo, J. (2012, April). Measurement issues within the stages of change for exercise. Poster presented at the Society of Behavioral Medicine Conference, New Orleans, LA.

7. Kolodziejczyk, J., **Merchant, G.,** Norman, G. (2012, April). A systematic review: reliability and validity of child/adolescent food frequency questionnaires that assess foods and/or food groups. Poster presented at the Society of Behavioral Medicine Conference, New Orleans, LA.

6. Pulvers, K., Limas, L., **Merchant, G.,** Hood, A. (2012, April). Hope is linked with positive affect during nicotine deprivation. Poster presented at the Society of Behavioral Medicine Conference, New Orleans, LA.

5. **Merchant, G.,** Brooks, R., Edwards, J., Pulvers, K. (2011, April). Effective strategies for coping with the urge to smoke. Poster presented at the Western Psychological Association Conference, Los Angeles, CA.

4. Pulvers, K., Hood, A., Carillo, J., **Merchant, G.** (2011, April). Positive traits linked less pain through lower pain catastrophizing. Poster presented at the Western Psychological Association Conference, Los Angeles, CA.

3. Ramirez, E. I., Norman, G. J., **Merchant, G**., Sallis, J. F., Calfas, J. K., Patrick, K. (2011, April). Multi-behavioral determinants of weight loss in men and

women. Poster presented at the Society of Behavioral Medicine Conference, Washington, DC.

2. Pulvers, K., **Merchant, G.,** Pandzic, I., Potter, R., Carlson, J., Thode, L. (2010, June). Cognitive and affective correlates of distress tolerance and smoking relapse. Poster presented at the American Psychological Association Conference, San Diego, CA.

1. Shepard, A., **Merchant, G**.,***** Pulvers, K. (2010, June). Does affect mediate the relationship between hope and nicotine dependence? Poster presented at the American Psychological Association Conference, San Diego, CA. ******Mentored first author*

FELLOWSHIPS

Integrated Cardiovascular Epidemiology Fellowship -- Training Grant (T32)
Primary mentor: Dr. Matthew Allison, M.D., M.P.H.
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- Recipient of the Ruth L. Kirschstein National Service Award (NRSA) Institutional Training Grant. Funded by the National Heart, Lung and Blood Institute of the National Institutes of Health & managed by UCSD (Program Director: Dr. Michael Criqui, M.D., M.P.H)

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TEACHING EXPERIENCE
Instructor:
Introduction to Psychology Section instructor
30 students (CSUSM; Undergraduate; Fall, 2011)

Teaching Assistant:
Epidemiology & Biostatistics (part B)
40 students (UCSD; Undergraduate; Spring, 2014)

Primary Care & Public Health
80 students (UCSD; Undergraduate; Winter, 2014)

Advanced Statistics
32 students (CSUSM; Undergraduate; Fall, 2011)

Psychological Testing Methods
40 students (CSUSM; Undergraduate; Spring, 2010)

Teacher training:
Center for Teaching Development's College Classroom course
UCSD in affiliation with CIRTL; 2013

Teaching of Psychology course
CSUSM; 2010

Invited workshops/presentations:
What are social network methods and analyses? How to use them in your research
Half-day workshop; Chair
Audience: Society of Behavioral Medicine attendees (N = 17) comprised of faculty, clinicians, and students
SBM Annual Conference; spring, 2015

On grant writing & writing well
Half-day workshop
Audience: 2nd year MPH students
SDSU; spring, 2014

Using accelerometers to measure physical activity & sedentary behavior
Half-day workshop
Audience: Junior faculty/post-doctoral investigators from around the country taking part in the Programs to Increase Diversity Among Individuals Engaged (PRIDE) workshop to enhance research skills in cardiovascular health disparities
IBACH/SDSU; Summer, 2013

Guest lectures:
- **Using social media to promote and understand health behavior change**
  Course: Digital Health (SDSU; Masters; Fall, 2015)
- **Measurement considerations in social-media based interventions**
  Course: Health Behavior Measurement (SDSU; PhD; Fall, 2014)
- **Critical concepts in behavioral measurement**
  Course: Behavioral Measurement (SDSU; PhD; Fall, 2014)
- **Overcoming barriers to exercise**
  Course: Cardiopulmonary Therapeutics (SDSU; PhD; Fall, 2014)
- **Remotely delivering interventions using social media**
  Course: Health Communication (SDSU; Masters; Fall, 2014)
- **Understanding adherence in studies using technology to change health behavior**

Course: Health Behavior Practicum Part I (UCSD; PhD; Fall, 2013)

- **Using theory-driven behavior change techniques in health behavior interventions**
  Course: Theoretical Foundations of Health Promotion (SDSU; Masters; Fall, 2013)
- **Using accelerometers to objectively measure sedentary behavior**
  Course: Physical Activity & Public Health Practice (SDSU; Masters; Spring, 2013)
- **The role of promotoras in promoting weight-related behavior change**
  Course: Health Promotion (SDSU; Masters; Spring, 2012)

AWARDS / HONORS

- **Chancellor's Doctoral Incentive Program Conference Grant**
  (University of California, San Diego 2013)
- **California State University Chancellor's Doctoral Incentive Program**
  San Diego State University (2011 – 2014)
- **Dean's Outstanding Graduate Award, College of the Arts & Sciences**
  California State University San Marcos (2011)
- **Student Research Competition Finalist**
  California State University San Marcos (2011)
- **California State University Pre-Doctoral Scholarship Runner-up**
  California State University San Marcos (2010)
- **Big East & New England Scholar-Athlete**
  University of Connecticut (2003)
- **Gelfenbien Family Academic Achievement Award**
  University of Connecticut (2003)

PROFESSIONAL SERVICE

- Co-leader of the Human Nature Group (HNG): http://hng.ucsd.edu. A methods-focused multidisciplinary group of social and health science students and faculty (*2014 – present*)
- Invited panelist at the Southern California Forum for Diversity in Higher Education *(2012-2014)*
- Peer nominated to be Student Representative for the Health Behavior Track of the Joint Doctoral Program in Public Health *(2012-2013)*

Peer reviewer:
- American Journal of Preventive Medicine
- Journal of Medical Internet Research

Professional organization membership:

- Society of Behavioral Medicine: Junior Chair elect for the special interest group 'Theories & Techniques of Behavior Change Interventions' *(2013-2015)*

COMMUNITY SERVICE
- Volunteer Graduate Assistant Coach: California State University Women's Soccer *(2009-2011)*
- Volunteer for the Vicalli Community Outreach Center: Monterrey, MX *(Fall 2005)*
- Volunteer for the California Public Interest Research Group (CALPIRG): University of California San Diego *(2004)* & University of Connecticut *(2002)*

PERSONAL ACTIVITIES
- Founder of a San Diego adult running team, Prado Racing Team: www.runprt.com
- University of California San Diego Track and Field 2005: 2005 CCAA Conference Champions
- University of Connecticut Women's Soccer 2002–2003: 2003 Division I National Semi-finalists & 2002 Big East Conference Champions
- Cuesta College Women's Soccer 2000–2002: 2001–2002 season Team Captain

ABSTRACT OF THE DISSERTATION

With a little help from my friends:
How social networks help college students trying to lose weight

by

Gina Clara Merchant

Doctor of Philosophy in Public Health (Health Behavior)

University of California, San Diego, 2015

San Diego State University, 2015

Professor Kevin Patrick, Chair

Most young adults gain weight while attending college, setting the stage for long-term weight gain, and associated chronic disease. Interventions that use social and mobile technologies, and leverage social network support may help students adopt health-enhancing habits such as regular exercise.

The first study explored how overweight/obese college students participa-ting in project SMART (N=404), a remotely delivered 2-year weight-loss trial, engaged their social networks, and used social and mobile technologies

while trying to lose weight. The second study tested whether participants in the treatment (versus control) group talked more about diet and exercise with their Facebook friends, and the third study tested whether this type of online communication, and receiving social support for it was associated with weight loss.

Study One involved qualitative interviews with a convenience sample of participants (n=38), intercepted after one of their measurement visits. Study Two involved building a dictionary of diet and exercise words that was used to classify participants' Facebook posts as being about HAL or not. Study Three quantified the number of likes and comments on posts (i.e., social support), and tested whether posting about HAL or receiving social support for HAL was associated with weight loss.

Study One found that participants in the control and treatment groups used non-study designed apps to help them lose weight and many participants knew one another. Individuals talked about their weight-loss goals with friends and felt accountable to follow through with their intentions. Study Two found that treatment group participants posted more HAL than those in the control from baseline to +6 months of participation (Beta=1.75; $p<0.05$) but this effect did not persist over time. Study Three found no association between HAL posts and weight loss but the association between social support for HAL posts and weight loss (kg) approached significance at +18 months of participation (Beta= −0.20; p=0.07).

Interventions using social and mobile technologies should measure participants' direct-to-consumer technology use and interconnectivity so that treatment effects can be isolated and cross-contamination accounted for. Future work will test how social network connections, and network structure is associated with weight loss among this population.

CHAPTER 1: INTRODUCTION

Gina Merchant

Individuals' behavior and health status are heavily influenced by social relationships and the social conditions in which interpersonal interactions occur (Berkman, 2000). Seminal work such as that of Berkman and Syme (Berkman & Syme, 1979) demonstrated that individuals who were more socially connected were at lower risk for all-cause mortality.

Epidemiologic evidence not only suggests that body mass index (BMI) clusters in social networks (Hruschka, Brewis, Wutich, & Morin, 2011) but that obesity can spread within a network (Christakis & Fowler, 2007). In addition, friends' dieting and physical activity behaviors affect individuals' BMI and even insulin resistance (Henning, Zarnekow, Hedtrich, Stark, Türk, & Laudes, 2014). And evidence from a team-based weight-loss competition found that having an optimal team environment, defined as other teammates losing weight and providing support for weight loss, can predict an individual's likelihood of achieving 5% weight loss (Leahey, Kumar, Weinberg, & Wing, 2012).

SOCIAL NETWORKS

Defined as a web of social relationships and their corresponding properties, social networks exert their influence on individuals' health through a variety of social constructs including social norms, social support, and social capital (Leroux, Moore, & Dubé, 2013). For example, young adults whose friends were trying to lose weight were more likely to report intending to lose weight (Leahey, LaRose, Fava, & Wing, 2011).

This association was fully mediated by social norms for weight loss defined as network members' approval and encouragement for weight loss and sharing of information about weight loss (Leahey, LaRose, Fava, & Wing, 2011). Social norms may also explain why exposure to peers who ate poorly, were physically inactive, and/or who gained weight predicted individuals' weight gain over time (Madan, Moturu, Lazer, & Pentland, 2010).

In addition to normative influence, social networks can influence individuals' weight loss through social support and accountability. For example, having a social contact in a weight loss intervention was associated with greater weight loss and this association was explained by attendance and self-monitoring (Carson, Eddings, Krukowski, Love, Harvey-Berino, & West, 2013). Individuals may be more likely to follow through on their commitment to weight-related behavior change in the presence (real or imagined) of others (Mann, 2008). Additional evidence for social accountability has been observed in individuals seeking health information online and from friends and family: Seeking health information from one's network was positively associated with fruit and vegetable consumption and exercising (Ramírez, Freres, Martinez, Lewis, Bourgoin, Kelly, Lee, Nagler, Schwartz, & Hornik, 2013).

Health information seeking, sharing of behavior change goals, and weight loss intentions are no longer restricted to face-to-face or synchronous interactions. With the advent of the Internet and social media, individuals are increasingly exposed to and influenced by network members in online environments.

ONLINE SOCIAL NETWORKS

Approximately 1.5 billion people use Facebook every month (Groden, 2015) and 4 billion pieces of content are shared on Facebook each day ("The Top 20 Valuable Facebook Statistics—Updated May 2015," 2015) and sharing on Facebook can influence individuals' mood and behavior. There is evidence that happiness spreads among Facebook friends (Coviello, Sohn, Kramer, Marlow, Franceschetti, Christakis, & Fowler, 2014) and that Facebook can work similarly to an online health community where participants with shared goals positively influence one another to achieve significant weight loss (Valle, Tate, Mayer, Allicock, & Cai, 2013). Repeated online communication such as that enabled by Facebook has been shown to increase the strength of relationships among network members, especially among individuals who do not frequently interact through other channels (Burke & Kraut, 2014). Therefore, online social networks may exert similarly positive weight-related behavior change influence as face-to-face networks over time.

DATA SOURCE

The three papers below examined the role of social networks in influencing and providing resources and support to college students trying to lose weight. The over-arching theme under investigation is how face-to-face and online interactions may serve complementary purposes. All three papers utilized data from project SMART (a Social and Mobile Approach to Reduce Weight), a weight-loss intervention that targeted overweight/obese college students. The study was a randomized controlled trial, and the primary outcome was weight loss at 2 years

(Patrick, Marshall, Davila, Kolodziejczyk, Fowler, Calfas, Huang, Rock, Griswold, Gupta, Merchant, Norman, Raab, Donohue, Fogg, & Robinson, 2014).

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Carson, T. L., Eddings, K. E., Krukowski, R. A., Love, S. J., Harvey-Berino, J. R., & West, D. S. (2013). Examining Social Influence on Participation and Outcomes among a Network of Behavioral Weight-Loss Intervention Enrollees. *Journal of Obesity*, *2013*, 1–8. doi:10.1155/2013/480630

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Henning, C. H. C. A., Zarnekow, N., Hedtrich, J., Stark, S., Türk, K., & Laudes, M. (2014). Identification of Direct and Indirect Social Network Effects in the Pathophysiology of Insulin Resistance in Obese Human Subjects. *PLoS ONE*, *9*(4), e93860. doi:10.1371/journal.pone.0093860

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CHAPTER 2: FACE-TO-FACE AND ONLINE NETWORKS:

COLLEGE STUDENTS' EXPERIENCES IN A WEIGHT-LOSS TRIAL

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ABSTRACT

Objective: This study aimed to understand how college students participating in a two-year weight-loss randomized controlled trial (RCT) engaged their social networks, and used social and mobile technologies to try and lose weight (e.g., Facebook, apps, and text messaging).

Methods: Participants (n=20 treatment; n=18 control) from project SAMRT (Social and Mobile Approach to Reduce Weight; N=404) were intercepted after a measurement visit and administered semi-structured interviews. Treatment group participants were asked about their use of intervention tools whereas control participants were asked about their general use of social and mobile technologies. Both groups were asked about how they leveraged their social networks to help them reach their weight-loss goals and their experience in the study. Interviews were analyzed using grounded theory.

Results: Treatment group participants appreciated the timely support provided by the study and the integration of content across multiple technologies. Participants in both groups reported using non-study-designed apps to help them lose weight and many participants knew one another outside of the study. Individuals talked about weight-loss goals with their friends face to face and felt accountable to follow through with their intentions. Although seeing others' success online motivated many participants, there was a range of perceived acceptability in talking about personal health-related information on Facebook.

Conclusions: These findings can inform work using social and mobile technologies to promote weight loss. Weight-loss trials should measure participants' use of direct-to-consumer technologies and interconnectivity so that treatment effects can be isolated and cross-contamination accounted for.

INTRODUCTION

Approximately 40% of young adults aged 18–24 years are enrolled in college (U.S. Census Bureau, 2014) and while in college, most experience weight gain and an increase in percent body fat (Fedewa, Das, Evans, & Dishman, 2014). As college students transition from adolescence to young adulthood they often adopt unhealthy behavioral patterns such as regular fast food consumption, and skipping breakfast (Niemeier, Raynor, Lloyd-Richardson, Rogers, & Wing, 2006). Despite the need to prevent unhealthy weight gain among college students, limited research has investigated how to promote healthy weight-related behaviors in this population (Nelson, Story, Larson, Neumark-Sztainer, & Lytle, 2008). The widespread use of social and mobile technologies by college students (Smith & Zickuhr, 2011) suggests that leveraging these technologies may be especially effective.

Approximately 84% of college students use online social networking sites (Smith & Zickuhr, 2011) with Facebook being the most popular (Duggan & Brenner, 2013). Compared to other user groups, young adults more frequently update their status on Facebook, sharing what they are doing and how they are feeling with friends (Hampton, Goulet, Rainie, & Purcell, 2011). Individuals use Facebook to express their self-identity and access their Facebook identities to affirm their sense of self (Nadkarni & Hofmann, 2012; Toma & Hancock, 2013). While working toward health behavior change, individuals may share their experiences on Facebook and friends may provide support, which could reinforce individuals' healthy identities. For some, however, sharing personal health information on general networking sites such as

Facebook is undesirable due to privacy concerns. Users are selective about the health information they communicate, depending on the online audience (Newman, Lauterbach, Munson, Resnick, & Morris, 2011) and the social identity they wish to cultivate (Lampinen, Tamminen, & Oulasvirta, 2009).

Social networks exert their influence on individuals' health through norms, support, and capital (Leroux, Moore, & Dube, 2013). In a cross-sectional study of adults aged 18–25 years, participants were more likely to report trying to lose weight if their friends were also trying to lose weight (Leahey, Kumar, Weinberg, & Wing, 2012). This association was mediated by norms for weight loss defined as network members' approval and encouragement for weight loss and sharing of information about weight loss (Leahey, Kumar, Weinberg, & Wing, 2012). Norms may also explain why college students who were exposed to peers who ate poorly, were physically inactive, and/or gained weight over time, also gained weight (Madan, Moturu, Lazer, & Pentland, 2010).

Social networks can also influence individuals' weight-loss efforts through accountability (Hwang, Ottenbacher, Green, Cannon-Diehl, Richardson, Bernstam, & Thomas, 2010b; Kiernan, Moore, Schoffman, Lee, King, Taylor, Kiernan, & Perri, 2012; Pagoto, Schneider, Evans, Waring, Appelhans, Busch, Whited, Thind, & Ziedonis, 2014). Having a social contact in a weight-loss intervention was associated with greater weight loss and this association was explained by attendance and self-monitoring (Carson, Eddings, Krukowski, Love, Harvey-Berino, & West, 2013). Individuals may be more likely to follow through on their commitment to weight-

related behavior change in the presence of others (Mann, 2008) and qualitative research suggests that feeling accountable to others helped adults maintain weight loss (Metzgar, Preston, Miller, & Nickols-Richardson, 2014). Enlisting a friend to join a weight-loss program has also been shown to be beneficial, provided that the friend also loses weight (Gorin, Phelan, Tate, Sherwood, Jeffery, & Wing, 2005). Further, weight-loss program participants perceive themselves to be positively influencing friends outside the program and feel good about helping others lose weight (Bishop, Irby, Isom, Blackwell, Vitolins, & Skelton, 2013; Hwang, Ottenbacher, Green, Cannon-Diehl, Richardson, Bernstam, & Thomas, 2010b).

ONLINE SOCIAL NETWORKS

Facebook has been used to promote smoking abstinence (Struik & Baskerville, 2014), weight loss (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswald, &Marshall, 2014; Napolitano, Hayes, Bennett, Ives, & Foster, 2013a), physical activity (Cavallo, Tate, Ries, Brown, DeVellis, & Ammerman, 2012a; Valle, Tate, Mayer, Allicock, & Cai, 2013), and good sexual health practices (Gold, Pedrana, Stoove, Chang, Howard, Asselin, Ilic, Batrouney, & Hellard, 2012). Remotely delivering intervention content via Facebook is a promising approach because Facebook supports public and private interactivity among users, and encourages content creation across a variety of features (Loss, Lindacher, & Curbach, 2014). However, maintaining user engagement can be especially problematic with online interventions (Eysenbach, 2005), and engagement is highly variable within and across Facebook-based studies. Merchant and colleagues

found that the most active users (16% of the intervention sample) accounted for 81% of all interactions on the study's Facebook page (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswald, &Marshall, 2014). Low observed engagement is influenced by the high prevalence of "lurking," a behavior in which users passively consume content without contributing or interacting (Rafaeli, Ravid, & Soroka, 2004; Sun, Rau, & Ma, 2014).

It is unknown whether social networking sites are an appropriate setting for health promotion (Loss, Lindacher, & Curbach, 2014) or, specifically, weight loss (Chang, Chopra, Zhang, & Woolford, 2013). However, research to date indicates that young adults accept physical activity promotion (Cavallo, Tate, Ries, Brown, DeVellis, & Ammerman, 2012a; Valle, Tate, Mayer, Allicock, & Cai, 2013) and weight-loss interventions (Napolitano, Hayes, Bennett, Ives, & Foster, 2013b; Valle, Tate, Mayer, Allicock, & Cai, 2013) that use Facebook. Further, at least one study found that a brief Facebook-based intervention among young adults led to significant weight loss (Valle, Tate, Mayer, Allicock, & Cai, 2013). There is also evidence that online networks enable the delivery of support for weight loss, although most studies have focused on women (Ballantine & Stephenson, 2011; Hwang, Ottenbacher, Green, Cannon-Diehl, Richardson, Bernstam, & Thomas, 2010b; Pagoto, Schneider, Evans, Waring, Appelhans, Busch, Whited, Thind, & Ziedonis, 2014). More research is needed to describe how different populations engage their networks online. Further, given the resource demands of face-to-face interventions and the potential reach of

online alternatives, there is a need to better understand how users engage with social media and mobile technologies that support health promotion.

The present study explored how overweight/obese college students participating in a remotely delivered randomized controlled trial (RCT) of a social and mobile media-based weight-loss program interacted with study tools and engaged their social networks. This investigation used grounded theory (Glaser & Strauss, 1967) to discover how participants (1) used social and mobile technologies for weight-related behavior change, and (2) leveraged their social networks online and face-to-face while working toward their weight-loss goals.

METHODS

PROJECT SMART

Students (N=404) were recruited from three Southern California universities to participate in project SMART. Methods, design, and implementation have been described elsewhere (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswald, &Marshall, 2014; Patrick, Marshall, Davila, Kolodziejczyk, Fowler, Calfas, Robinson, Huang, Rock, Griswold, Gupta, Merchant, Norman, Raab, Donohue, & Robinson, 2014). Participants were randomized to either the control (*n*=202) or treatment (*n*=202) group. The treatment group tools included: a study-specific website, which contained a blog and an online library; apps; email; a study-specific Facebook page; text messages; and occasional contact with a health coach based on individual participants' needs. All treatment tools were branded as *ThreeTwoMe*. The study's Facebook page was "open" and non-study participants

could view and engage with its content and participants' friends could see when they interacted with the page. Treatment group participants were encouraged to use the health coach and their peers as sources of support. The control group had access to a static website that contained health information relevant to college students and received quarterly newsletters about healthy living (Patrick, Marshall, Davila, Kolodziejczyk, Fowler, Calfas, Robinson, Huang, Rock, Griswold, Gupta, Merchant, Norman, Raab, Donohue, & Robinson, 2014).

SAMPLE AND DATA COLLECTION

A convenience sample (n=38) of participants was interviewed for the present study, which is estimated to be sufficient to reach theoretical saturation (Starks & Trinidad, 2007). Participants were "intercepted" at the end of a measurement visit. Those that agreed to be interviewed were provided a $25 incentive (gift card to Target). All interviews were conducted in English (see Appendix I for interview questions).

Compared to the overall sample, a larger percentage of participants in the present study were older, male, and Hispanic and the majority of the sample came from the University of California San Diego. Participants were consented prior to each interview, and agreed to have their data recorded. The Institutional Review Board at the University of California San Diego approved this study. The interviews were semi-structured, and lasted between 30 and 60 minutes. All interviews were digitally recorded and transcribed verbatim. Demographic characteristics of those interviewed are described in Table 2.1.

DATA ANALYSIS

The qualitative approach of grounded theory (Glaser & Strauss, 1967) was used because the goal of the present study was to explain social processes. Using the framework advanced by Strauss and Corbin (Strauss, Corbin, & Strauss, 1990), data were analyzed in three stages: open, axial, and selective coding (Walker & Myrick, 2006). During open coding, the data were examined line-by-line and key concepts and their properties were discovered. Axial coding involved identifying the relationships

Table 2.1. Demographic characteristics of SMART interview sample participants

	Total (*n*=38)	Treatment (*n*=20)	Control (*n*=18)
Age at baseline (years), mean (SD)	25.00 (4.46)	24.55 (4.20)	25.00 (4.86)
Gender, *n* (%)			
Male	17 (45)	11 (55)	6 (33)
Ethnicity, *n* (%)			
Hispanic	12 (32)	6 (30)	6 (33)
Race, *n* (%)			
White	20 (53)	10 (50)	10 (55)
Asian	8 (21)	5 (25)	3 (17)
Black	3 (8)	1 (5)	2 (11)
Other	7 (18)	4 (20)	3 (17)
Undergraduate, *n* (%)	27 (71)	14 (70)	13 (72)
School,* *n* (%)			
UCSD	27 (71)	15 (75)	12 (67)
SDSU	8 (21)	4 (20)	4 (22)
CSUSM	3 (8)	1 (5)	2 (11)
Visit, *n* (%)			
Final	16 (42)	8 (40)	8 (44)
18 months	16 (42)	8 (40)	8 (44)
12 months	6 (16)	4 (20)	2 (11)

CSUSM, California State University, San Marcos; SDSU, San Diego State University; SMART, Social and Mobile Approach to Reduce Weight; UCSD, University of California, San Diego

among the data, and through selective coding, the data were fully integrated. These processes were documented via memos, which provided a roadmap of analytic decisions(Birks, Chapman, & Francis, 2008). Audio recordings of the interviews were

listened to as needed. Emerging themes and supporting quotes were discussed in bi-monthly meetings. Data were constantly compared to themes and codes were modified as necessary. Transcripts were blinded during analysis and the final coding framework had 20 codes (see Appendix II for the coding framework).

Transcripts were uploaded into the cloud-based software program Dedoose ("Dedoose, Version 5.1.29, web application for managing, analyzing, and presenting qualitative and mixed method research data," 2014). After coding the transcripts in Dedoose, 429 digital excerpts were created. These transcripts were printed and arranged on large post-its to visually display and interpret the data. These data fit into two broad categories: (1) a process evaluation of the SMART program, and (2) how participants leveraged their social networks online and face-to-face to help with weight loss. Within the SMART process evaluation category, there were three themes; and, within the social networks category, there were two themes. Sub-themes were used to group similar data and define key concepts (Figure 2.1).

RESULTS

PROCESS EVALUATION OF THE SMART PROGRAM

Participants in the treatment group described liking the *ThreeTwoMe* experience because it provided them with timely reminders and information that they could access at their leisure. Participants in both groups disengaged with the program over time and many control group participants knew that they were in the control group. Treatment group participants generally found the Facebook page to be motivating, the challenges fun, the text messaging useful, and the apps difficult to

use. Some individuals wanted more interaction with other participants. Approximately half of the participants interviewed used direct-to-consumer apps to help them meet their weight-loss goals.
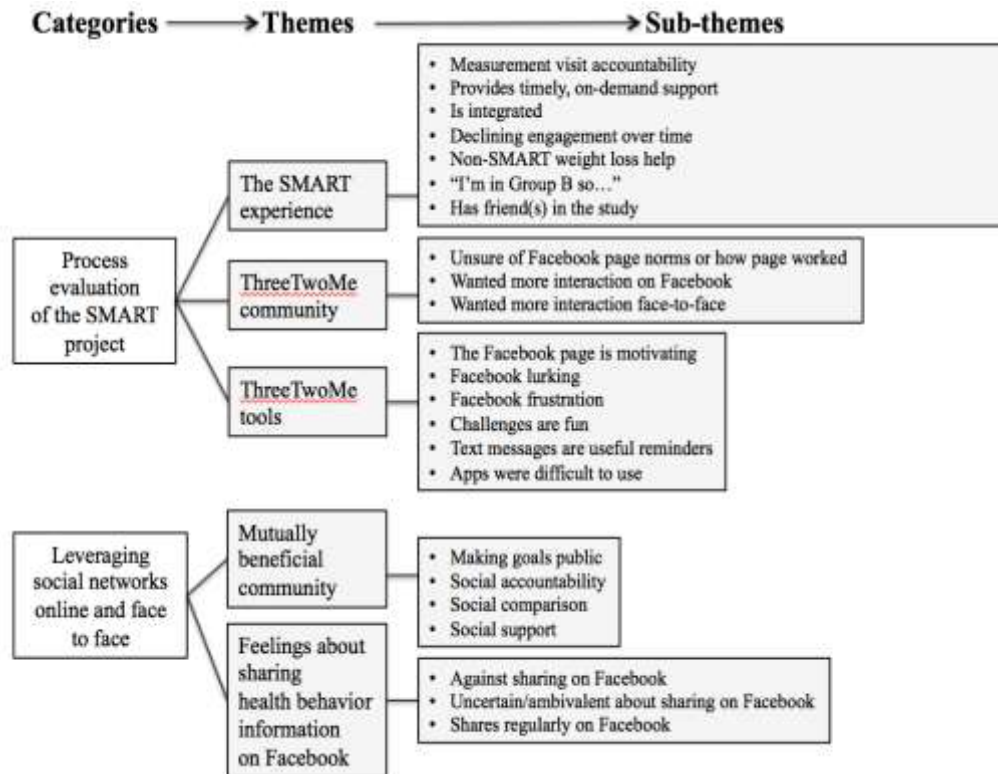
Figure 2.1. Qualitative categories, themese, and sub-themes based on semi-structured interveiw data

THEME I: THE SMART EXPERIENCE

Measurement Visit Accountability: Participants in both groups described how having measurement visits scheduled every 6 months where they knew they would meet staff in person, take surveys about their diet and exercise, and weigh in was helpful in keeping them on track. Some described using the surveys as a self-

monitoring tool that reminded them how much they ate and sat, which motivated them to want to change their habits. Others noted that knowing they had a visit coming up made them feel accountable to lose weight.

> A little bit ashamed if you haven't completed as much or achieved as much as you were hoping for with weight loss.

Provides Timely, On-Demand Support: Participants in the treatment group liked how the tools were something they could access at their leisure with many describing how they digested "news" or entered their data during their bus commute to school, at the end of their day, or on a regular schedule they set for themselves. Participants also described the timeliness of the support and messages they received via text or Facebook, noting that it would remind them that they were in the study and would reach them while they were going about their daily routine.

> I like it, especially when I was in the gym and I got a text like, "Oh, where you at?" "I'm at the gym." Like, it felt good. Um… plus the feedback… just getting, "Thank you. Oh, you're doing great. Keep up the good work."

Is Integrated: Participants in the treatment group talked about how using one of the study's tools prompted them to use others.

> I accessed it when there was usually a related post on Facebook or something that said there was a new contest or something, "come check out the blog…" I admit it wasn't something that I checked regularly on my own, but when I was directed there I would go take a look.

Declining Engagement Over Time: Participants in both groups described accessing the study's tools "at the beginning" but less and less over time. Individuals also talked

about becoming disengaged after the first year due to changing interests in technology over time.

> It's really weird because initially I'm very excited. Excited to use the program so I do it every single day and I wear my pedometer. I weigh myself like religiously, obsessively. But then after a few weeks the excitement sort of died down…when I first, originally, started the study, I was more into Facebook than I am now.

Non-Smart Weight-Loss Help: Participants utilized non-study-specific technologies and programs to help them meet their goals. Two participants joined campus club sports teams while in the study. Other got into activities such as body building, competitive running, hired a personal trainer, or joined a gym-based or online weight-loss program. One control participant started acting as a personal trainer for her friends after she successfully lost 40 pounds. Approximately half of the participants interviewed described using apps that were not part of the study. Control and treatment participants talked about trying out various apps and using some with their friends. The most frequently mentioned app was MyFitnessPal, which one participant liked best because it had a barcode scanner. Another popular app was the Nike Running app, which participants described liking due to the positive feedback it gave.

> I liked Nike because like, at the end of a run they would like do a little cheer song. "Congratulations! You finished your run!"

"I'm in Group B So…": A number of control group participants interviewed discussed how they knew they were in the control group and that this frustrated them.

> I think I'm in the group that's not supposed to have any supplements to help me lose weight so it gives me an incentive to almost try and lose weight.

Has Friend(S) in the Study: Many participants in both groups stated how they knew others in the study. Some heard about the study through a friend and later joined, one participant and her sister joined together, and others later found out that they had friends in the study via Facebook or face-to-face. One person knew "at least three other people."

> I do have other friends who are in the study but they're in a different group I guess… when we found out we were in the same study, we started talking a little bit more… We just sort of were like, "OK, maybe we can work out together and hang out or something like that.

THEME II: THE *THREETWOME* COMMUNITY

Unsure of Facebook Page Norms or How Page Worked: Facebook displays the posts made by fans of the page in a dialogue box to the side of the page's main feed, which displays all content generated by page administrators. However, a number of participants were not sure if it was acceptable for them to reach out to other participants on the study's Facebook page and some thought that participant posts were "hidden" by Facebook. Some participants talked about how interacting with the health coach on the Facebook page may help others as well, since the content is public. Several participants wished they could better see others' posts. One participant described interacting at the beginning but then stopped since not that many others were doing it. One participant was not clear that non-study participants could become a fan of the page, view content, and interact with it.

> I guess no one reached out to me, I didn't reach out to them… It should happen though… I mean, we have the space, we have the group, we have the page, everybody is there. And everybody who is there knows they are a participant. So, I don't know.

Wanted more interaction on Facebook: Several participants wondered how others in the study were progressing and liked seeing the success stories from the blog posted on Facebook. Some wanted more of an interactive Facebook community so that they could feel more of a "sense of a team with *ThreeTwoMe*, rather than by myself." A few participants described comparing themselves to other participants via Facebook, which motivated them to get back on track.

> It's nice to see people changed… I look at them and I'm like, what's my progress? Am I progressing well, as well as them?... It tells me, OK, I've gotta do this, I gotta do something cuz I haven't been doing things in awhile.

Wanted more face-to-face interaction: A number of participants in the control and treatment groups talked about how meeting fellow participants in person would be motivating and how this would provide positive peer pressure. Others said how they knew face-to-face meet-ups might not be for everyone but that the option should be there.

> Maybe if a girl in your building actually is doing it as well, like, and you see her frequently, maybe you can go work out together, you know?

THEME III: *THREETWOME* TOOLS

The Facebook Page Is Motivating: Participants described the Facebook page as motivating and the content as inspirational and encouraging. Some said it reminded

them that they were in the study and helped them learn about resources they hadn't known about previously. Some described the Facebook campaigns as motivating because it got them to be active with their friends; they felt it brought participants together or that they were motivated to win something.

> There was an activity where we would go hiking. And then I was like, "Let's go hiking" [to my roommates]… Um so, we did it. We just went hiking that weekend, you know, just like that.

Facebook Lurking: As described previously (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswald, &Marshall, 2014), many participants "lurked" (Sun et al., 2014) on Facebook. Some participants accessed the *ThreeTwoMe* content by seeing it in their newsfeed because they marked the page as "favorite." Most, however, described going to the actual page because it was "easier" than sorting through the "clutter" on their newsfeed.

> I think I, I look at 90% of stuff and don't comment on it… Unless I really, you know, am moved to comment. And sometimes I'll even write a comment on people's stuff and then delete it. Just like, "Oh my God, I don't want to be part of that conversation.

Facebook Frustration: Some described not being able to easily see the *ThreeTwoMe* content, being tired of having to sort through their newsfeed, or just not liking Facebook anymore.

> The newsfeed on Facebook, it's just gotten to the point where you kind of start filtering it out because there are so many posts. It just kind of turned to background noise more than helpful.

Challenges Are Fun: Participants were exposed to challenges through the BeHealthy app, on the blog and via Facebook. Some challenges were posts designed as part of

Facebook campaigns and others were part of a series of "Daily Be Healthy" messages. Most participants talked about accessing the challenges via Facebook and email, describing them as "fun," and said they were motivated to complete them because they wanted to challenge themselves to try new things.

> I like the challenges 'cause they would pop up and I'd be like, "Oh, I can totally do that."

Text Messages Are Useful Reminders: Participants described the text messages they received from *ThreeTwoMe* as "useful" and helpful in reminding them to "keep on top of the program."

> The fact that the text message is there, it's enough to remind me to keep on top of the program. I like the idea and the consistency which helps me to keep going and makes me think that I don't need too much more than a text message.

Apps Were Difficult To Use: Although a few participants described liking the graph feature of the TrendSetter app, which showed self-reported weight change, steps, and/or calories consumed over time, most participants described frustration using study-designed apps. Participants had difficulty with the user interface and talked about not wanting to log information twice: on a direct-to-consumer app they were already using and a study-designed app.

> It was just too cluttered. It was slow… It took a while to open up. Took a while to get it running and then, it got to be too much of a hassle.

LEVERAGING SOCIAL NETWORKS ONLINE AND FACE TO FACE

Participants described how they often made healthy choices with friends and shared their weight-loss goals with friends and family. Participants felt that their friends held them accountable to meet their goals and that the encouragement and reminders they received from their network was helpful. Many individuals shared their goals with others face to face, and did not feel that Facebook was the appropriate setting to receive support or talk about their progress. Many did, however, report being motivated by seeing others' success on Facebook.

THEME I: MUTUALLY BENEFICIAL COMMUNITY

Overall, participants described their social networks as mutually beneficial communities where social support was exchanged in a nonjudgmental way and they were encouraged to find that there were others like them from whom they could learn.

Making Goals Public: Many participants reported talking openly with their friends about their goals to lose weight, be more active, and eat healthier. Although most described making their goals public face to face with friends, some used online social networking sites to broadcast their intentions and update friends on their goal striving. Participants talked about how making their goals public helped them to be held accountable to their goals. One participant described making her goals public as similar to an "oath" that her friends could hold her to.

> I put this picture on Facebook so that everyone would see it and now it's like I have to do it because I just published it to the entire Facebook community… So everybody's been encouraging me and stuff.

Social Accountability: Most participants emphasized the importance of face-to-face compared to online accountability. Computer-mediated communication was viewed as less effective because it was easier to not follow through and "just shove it aside and go, whatever."

> Even when I'll come home tired from work and I'll be, "Oh, I really don't…" One of my roommates will come home and be, "Let's go. I've been waiting for you. Let's go to the gym." And we'll go.

Social Comparison: Participants were influenced by their friends' success at healthy living and weight loss, and how they learned by observing others. Several talked about how if their friend can do it, "I can do that too." Participants often compared themselves to others in online and face-to-face networks, and said how seeing others succeed motivated them to try harder. Some participants talked about the difference between online and face-to-face influence, and emphasized how seeing others online was helpful because it afforded a personal connection with "people that kind of looked like me." Online social comparison motivated some to initiate behavior change but the face-to-face accountability was needed for follow through. Despite social comparison and influence largely being discussed as positive, some participants talked about how it was demoralizing because they asked themselves, "Why can't I be there?" Other participants described how their friends had bad eating habits and "all my friends are obese," which made it difficult to make healthy choices.

> The success stories on Facebook were really helpful because… Hey, I'm in this study too… Why am I not at this point? You know? And it kind of motivates me to, to try to get to that point.

Social Support: A number of participants said they often talked with their friends about healthy eating or going to work out, and how friends provided nonjudgmental emotional support. Some described how their friends gave them new ideas for ways to be healthy. Others discussed how their friends were "supportive" and were like a "partner support system" or "buddy."

> Some of my friends, we'll talk about like "damn, I need to go to the gym." "All right, let's go this day" or something. It's really positive. It's not like, "let's cry about my feelings."

THEME II: FEELINGS ABOUT SHARING PERSONAL HEALTH BEHAVIOR INFORMATION ON FACEBOOK

Three groups emerged to describe how participants felt about sharing their healthy-active-lifestyle goals and activities on social networking sites, which was almost always Facebook.

Against Sharing on Facebook: A number of participants expressed distaste for talking about their physical activity exploits and weight-loss goals on Facebook. Most said it was not the right forum because there were too many people in the audience, even "a lot of people that I really don't like and probably don't like me." Others talked about how they didn't want the pressure and how everyone has an opinion on Facebook, whether or not they can truly understand what others are going through. Some participants said that they were careful with what they talked about on Facebook in efforts to manage the impression others may form of them.

> It's more like, the fear that it won't work out. And also, I just don't like telling people I'm trying to lose weight. I feel like it affects their perception of me.

Uncertain/Ambivalent About Sharing On Facebook: Many participants felt that some sharing was acceptable and that "trying to get healthier is a good message." Others said that they did not "see the application" and that Facebook is not the forum for this type of sharing. Some said that they would share more if they had better control over who was in the online audience. Others talked about how their sharing on Facebook was context dependent, and that they were comfortable broadcasting when it was "more of a monumental thing" or after they had reached a goal. Some described how they did not feel like they were "at that point yet" and that sharing workouts and the like were reserved for those who were "really fit already."

> I have recently since I've started losing weight to try to like, share what I've been doing. But I'm only doing that because I've been successful.

Shares Regularly on Facebook: Some participants regularly shared on Facebook, posting about their workouts, new recipes, and pictures related to their weight-loss goals. One participant described this process as making a "live documentary" that prompted her friends to say, "Hey, can I run with you?" Some participants said that they were motivated by online social support.

> I mean, we all do it for the likes… People will be like, "You go girl!" or something because if they previously saw that you didn't really do that, but now you do, they're like, "That's cool."

DISCUSSION

This study used grounded theory to discover how participants used social and mobile technologies, and utilized their social networks while striving for weight loss. The findings reveal a rich set of insights that researchers should consider when

designing social network-based weight-loss interventions for overweight/obese college students, including a high prevalence of use of non-study-promoted tools and cross-contamination between treatment and control groups (see Appendix III for recommendations for future research). The results emphasize how individuals rely on external accountability and commonly engage in social comparison, highlighting the importance of thinking beyond social support in terms of social network influences on weight-related behavior change (Berkman, Glass, Brissette, & Seeman, 2000).

Most of the existing research examining social network influences on individuals' weight loss has focused on social support (Ballantine & Stephenson, 2011; Cavallo, Tate, Ries, Brown, DeVellis, & Ammerman, 2012b; Hwang, Ottenbacher, Green, Cannon-Diehl, Richardson, Bernstam, & Thomas, 2010a; Turner-McGrievy & Tate, 2013). While the present study found that individuals relied on their friends for support, participants also emphasized how they compared themselves to others in their network and how seeing others succeed motivated them to try harder. Social comparison (Festinger, 1954) may be motivated by individuals' desire to evaluate, improve and/or enhance their sense of self (Gibbons & Buunk, 1999), and may lead to more committed goal striving or feelings of self-enhancement. In cases where individuals perceive themselves to be underperforming relative to their peers, they may be motivated to improve, and in cases where they are leading others, they may experience feelings of self-enhancement. Previous research on a large sample of culturally diverse adolescents showed that individuals who compared

themselves to their friends engaged in more physical activity and had better dietary habits (Luszczynska, Gibbons, Piko, & Tekozel, 2004).

Yet it is also possible that social comparison is damaging, leading to feelings of guilt and shame. For example, passive consumption of Facebook feeds has been linked to increased loneliness (Burke, Marlow, & Lento, 2010) and some individuals have reported that social comparison was a barrier to talking about their weight-loss behaviors on Twitter (Pagoto, Schneider, Evans, Waring, Appelhans, Busch, Whited, Thind, & Ziedonis, 2014). However, these examples could reflect the practice of social comparison to others in general online networks where membership is not related to health or shared goals. Social comparison may only be effective when comparing oneself to others working toward similar goals, and when the difference between the individual and the network members, in terms of behavior and goal achievement, is relatively small. When comparing oneself to "nearby" others, individuals may be more readily able to envision their desired future self. Under these conditions, individuals can engage in "mental contrasting" where they can mentally elaborate on how they can reach their goal state (Oettingen & Schwörer, 2013).

In line with earlier qualitative research (Metzgar, Preston, Miller, & Nickols-Richardson, 2014; Pagoto, Schneider, Evans, Waring, Appelhans, Busch, Whited, Thind, & Ziedonis, 2014), individuals in the present study valued social accountability for weight loss. Participants discussed how they felt accountable to the SMART program and their existing networks to follow through on their goals.

Treatment participants may also have felt accountable to the *ThreeTwoMe* virtual health coach, a phenomenon found in earlier work (Watson, Bickmore, Cange, Kulshreshtha, & Kvedar, 2012). Participants emphasized how knowing others were relying on them to show up in person and being confronted by a friend face to face was more influential than computer-mediated accountability.

Participants voiced a range of acceptance for sharing personal healthy/active-lifestyle content via Facebook. Echoing earlier research, individuals regulated with whom they shared their health behaviors and goals (Lampinen, Tamminen, & Oulasvirta, 2009) and balanced self-presentation management and eliciting social support for their health-related goals (Newman, Lauterbach, Munson, Resnick, & Morris, 2011). Given that approximately 75% of college students' Facebook friends are non-close connections (Manago, Taylor, & Greenfield, 2012) and that Facebook is used to cultivate a positive sense of self-worth (Toma & Hancock, 2013), it is unsurprising that individuals are hesitant to share information that might alter how they are perceived by others. However, Facebook use is also motivated by a desire to belong (Nadkarni & Hofmann, 2012) and therefore, as individuals are exposed to new network norms of regular physical activity and healthy dietary habits, they may be more likely to adopt these behaviors (Madan, Moturu, Lazer, & Pentland, 2010) and talk about them online.

The present study is limited in that the individuals interviewed did not constitute a random sample. The extent to which the present study's findings are generalizable to other young adults or demographic groups is also unclear. Further,

individuals talked about how having measurement visits every 6 months made them feel accountable to lose weight, which could be interpreted as observation bias (Adair, 1984) as opposed to social accountability.

Health information seeking, and sharing of behavior change goals and weight-loss intentions are no longer restricted to face-to-face or synchronous interactions. Individuals are increasingly exposed to and influenced by others in online environments and the recommendations provided by the present study can inform future work using technology and social media to promote weight-related behavior change.

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APPENDIX I. Interview Questions

_____

Interview goals:

A.   To understand participant's use of and interaction with SMART.

B.   To understand SMART use in time and space with respect to:

i.   SMART resources

ii.   Other resources

iii.   People, social networks

C.   To learn the situations where participants access SMART tools.

D.   To find out what tools have helped participants with weight loss. What hasn't worked and why?

These questions are to be used in a semi-structured interview, as a guide, not word for word

_____

********* **TREATMENT** *********

[*Ask about major, year, etc. - icebreaker questions*]

1.   Did you do anything to stay healthy before you started ThreeTwoMe (TTM)?

2.   What motivated you to be part of this study?

3.   What has being in the study been like for you?

a.   What do you use SMART ThreeTwoMe for?

4.   What kind of health-related activities are you engaged in currently?

App use/Website

5.   Which apps are you currently using?

a.   Why do you use or not use the TTM apps (or other apps)?

b.   **If app user**, do you share your info with others? Why/why not?

6.   If you use ThreeTwoMe.com what do you use from it? (Blog? Library?)

Facebook use

7.   Do you use the Facebook component of SMART?

a.   Do you see it in your news feed or go to the page?

b.   Have you ever hidden any of the ThreeTwoMe posts? If so, why?

c.   Would you prefer a private page only visible to others in the study?

8.   What do you like about the Facebook component? What do you not like about it?

9.   What is it like seeing other participants in the study on Facebook?

a.   Do you notice them/their posts?

10.   There are Facebook campaigns/themes where participants are asked to pledge to participate (e.g., Eat more mindfully during Thanksgiving; The Pedometer Challenge).

a.   Have you ever participated? Why or why not?

11.   What does it mean when you 'like' something on Facebook?

a.   When do you decide to comment?

12.   Why do you post?

13.   How does using Facebook make you feel?

14.   Do you talk about your health on Facebook? (Physical activity, food, weight loss)

SMS Use

15.   The SMS component of SMART was recently updated (began June 2, 2013), and you are probably getting more texts.

      a.   What was it like before versus how it is now? Is it different? Better or worse?

      b.   What do you like about the new texts and what do you dislike?

Seeking health information:

16.   Do you search for information about your health? If so, when? Where? On your laptop, phone, desktop?

17.   Can you tell me about times you've wished you had information related to what's going on at the moment?

Social support:

18.   How would you describe your relationship with the TTM health coach?

19.   Do you talk about your weight-loss/lifestyle-change goals with your friends and/or family?

20.   What sorts of things do your friends and family do to help? What do they not do?

      a.   How do you connect with them about health stuff? (Phone, in person, casually, planned)

21.   Do you know anyone else in the study?

      a.   How would you feel about that?

Ideas for the future:

22.   What are the top 3 things that have worked for you that you would say should definitely exist in a future version of SMART?

23.   What kind of support do you wish you had to help you meet your weight-loss and/or lifestyle-change goals?

********* **CONTROL** *********

[*Ask about major, year, etc. - icebreaker questions*]

1.   Did you do anything to stay healthy before you started SMART?

2.   What motivated you to be part of this study?

3.   What has being in the study been like for you?

4.   What kind of health-related activities are you engaged in currently?

5.   Are there things you've done in the past that have helped you lose weight?

6.   Do you do health-related things on your own or as part of a group?

7.   Do you talk about your weight-loss/lifestyle-change goals with your friends and/or family?

a.   What sorts of things do your friends and family do to help? What do they not do?

      b.   How do you connect with them about health stuff? (Phone, in person, casually, planned, etc.)

      8.   Do you know anyone else in the study?

      a.   How would you feel about that?

      9.   Do you search for information about your health? If so, when? Where?

      10.   Do you share health/lifestyle information online?

      a.   What about on Facebook? Why or why not?

      b.   Have you ever been part of an online weight-loss or fitness group?

      11.   What kind of support do you wish you had to help you meet your weight-loss and/or lifestyle-change goals?

APPENDIX II. Coding Framework Used to Analyze the Interview Transcripts (N=20 Codes)

Code name	Definition
What SMART program was like to participant	How he/she felt about the program (used when other program codes did not apply).
What didn't work about the program	What he/she found to be unhelpful and/or frustrating about the SMART program.
Non-SMART weight-loss help	Non-SMART apps/online tools and/or weight-loss assistance (e.g., personal trainer).
Has friend in the study	He/she knows other(s) in the study.
Specifically about the health coach	Explicitly about the health coach.
Study Facebook page	About the study's Facebook page.
Study Facebook page campaigns	About the campaigns launched through the study's Facebook page.
Facebook interaction with other participants	Interaction with other participants on Facebook, wanting more interaction and/or discussing how they might feel about it.
Integrated	Tools link to one another; one tool reminds participant to use another tool and/or receive similar messages through multiple tools.
Timely feedback	Communication was timely. For example, a participant posts a question on Facebook and the health coach responds within a day.
Challenge/contest	Felt challenged via challenge/contest pushed out by the study (or other tool/program).
Face-to-face support	Friends, family, and/or acquaintances provide encouragement and face-to-face support.
Online and/or mobile weight-loss help	The SMART program, and/or virtual friends provide encouragement online that the participant positively receives. May be online social support (e.g., emotional support).
Online network sharing/norms	How online networks function, the role they serve in his/her life, and/or how he/she uses them (including norms of online space and feelings about

sharing/self-disclosure).

Lurking online	Reading online content but not visibly interacting.
On-demand support	Support for weight loss can be accessed 24/7 and/or at his/her leisure.
Making goals public	Telling others online or face to face about behavioral goals and/or losing weight. May be broadcasted or told to specific individual(s). A verbal contract/social agreement.
Social accountability	Feels accountable to follow through on stated goals and other commitments shared with his/her network. Different from social support because no resources or materials are exchanged. May also talk about feelings of social shaming or guilt.
Making healthy choices with others	Doing healthy things and making healthy choices alongside others making healthy choices. Participant may also have described liking working out with others and/or wanting opportunity to be healthy with others more. Positive social influence.
Sense of community/group influences individual	His/her behavior helps others and/or others' behavior helps him/her. "We're all in it together" (i.e., shared identity). Could also be social comparison or observing/hearing about other's success that motivates participant to strive for his/her goals (i.e., role models).

APPENDIX III. Recommendations for Future Research

Recommendation 1: Incorporate opportunities for virtual or face-to-face interactions of study participants. Participants emphasized the importance of social accountability in helping them meet their goals and many wanted the opportunity to interact with fellow participants. Approaches that encourage participant interaction via meet-ups on the study's Facebook page, or that challenge participants to be healthy and active with their friends, might be productive. Earlier work has shown that promoting, but not requiring, participants to work out together in a team-based weight-loss competition led to significant weight loss (Leahey, Kumar, Weinberg, & Wing, 2012).

Recommendation 2: Develop fun challenges that can be incorporated into daily routines. Treatment group participants liked that the social and mobile technologies provided timely, on-demand support. In line with earlier work, individuals thought text messaging was useful for weight loss (Fukuoka, Kamitani, Bonnet, & Lindgren, 2011; Patrick, Raab, Adams, Dillon, Zabinski, Rock, Griswold, & Norman, 2009), as was the study's Facebook page (Cavallo, Tate, Ries, Brown, DeVellis, & Ammerman, 2012; Napolitano, Hayes, Bennett, Ives, & Foster, 2013; Valle, Tate, Mayer, Allicock, & Cai, 2013). Participants emphasized that the challenges delivered through the study's Facebook page and other technologies were fun and helped them to challenge themselves. An example includes embedding challenges into long-term goals such as achieving 10,000 steps per day (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswald, &Marshall, 2014).

Recommendation 3: Measure passive participation in social network–based interventions. It is well established that lurking—passively consuming information but not visibly interacting with it or creating new content—is highly prevalent in online communities (Sun, Rau, & Ma, 2014). Measuring lurking behavior objectively (e.g., through server logs; [Burke, Marlow, & Lento, 2010]) or via self-report (Valle, Tate, Mayer, Allicock, & Cai, 2013) is important because without capturing it, metrics of user engagement will be underestimated (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswold, & Marshall, 2014). In addition, measuring lurking behavior will allow for testing whether lurking is negative for weight loss. Although individuals who lurk have reported receiving comparable amounts of social support for weight loss compared to those who contribute content (Ballantine & Stephenson, 2011), lurking may not be as productive for weight loss because the user is less engaged with the community.

Recommendation 4: Explore new research methods that acknowledge the quality and quantity of consumer-facing technologies for weight loss. The traditional approach of asking individuals to not enroll in outside weight-loss programs while participating in a weight-loss trial may be insufficient given the wide availability of

online tools. Most participants reported using other social and mobile technologies such as apps and/or pursuing alternative means to help them lose weight. Instead of investing in internal app development, future work should consider encouraging participants to use existing direct-to-consumer technologies and measure their use. Similarly, researchers should collect self-report data on participants' involvement in other weight-loss activities. Individuals enrolling in weight-loss trials may be sensitive to control group assignment or frustrated by not losing weight using treatment tools and experiment with alternative means to achieve their goals. Future work may also consider alternative designs, which would minimize these social threats to internal validity (Horner, Rew, & Torres, 2006).

Recommendation 5: Capture comprehensive data on participants' social networks so that analyses can take their effects into account. Many participants reported knowing one another, which exposed cross-contamination between the treatment and the control groups. We suspect that this happens in many RCTs, particularly of weight loss. Investigators should capture data on participants' networks (either online or face-to-face, see Perry & Pescosolido, 2010) so that cross-contamination can be assessed and accounted for in the measurement of treatment effects. By having access to participants' Facebook data, the SMART project captured each participant's online friendship network, and the effect of cross-contamination will be assessed in future work.

REFERENCES FOR APPENDIX III

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CHAPTER 3: YOUNG ADULTS TRYING TO LOSE WEIGHT:

TALKING ABOUT DIET AND EXERCISE ON FACEBOOK

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ABSTRACT

Objective: This study tested whether a remotely delivered 2-year randomized weight-loss trial (N=404) changed the frequency with which participants talked about healthy-active living (HAL) with their Facebook friends.

Methods: Build a dictionary of unigrams (N=351words) to classify Facebook posts as being about HAL (yes/no). Test whether treatment, versus control, group participants increased their HAL posting over time, and whether engagement with the study's Facebook page led to more HAL posting over time.

Results: Participants made 155,518 posts, and 4.9% were classified as HAL. A random sample of baseline posts (5%, n=2410) was manually coded and showed that the dictionary had poor sensitivity (55%) but good specificity (98%). The difference between treatment and control group participants HAL postings was significant from baseline to +6 months (Beta=1.75, p<0.05). Treatment group participants who were more, versus less, engaged with the study's Facebook page did not post more HAL content over time.

Conclusions: A remotely delivered weight-loss intervention marginally increased the frequency with which participants talked about HAL with their Facebook friends but this difference did not persist over time. Future work will improve upon the dictionary classifier, which missed classifying a substantial percent of true positives, and test whether communication about HAL predicts weight loss.

INTRODUCTION

Digital health interventions are increasingly using open social networking sites such as Facebook to remotely engage participants and push messages designed to promote health behavior change (Laranjo, Arguel, Neves, Gallagher, Kaplan, Mortimer, Mendes, & Lau, 2015). Open networks are defined as large virtual communities that support various forms of social interactions but are not explicitly designed for health care or health needs (Centola, 2013). Conversely, intentionally designed networks serve specific health-related purposes such as social support for chronic illness and weight loss (Centola, 2013).

A major advantage of behavioral interventions using open versus intentionally designed networks is that content can be pushed to participants in a social space where existing friendship networks also exist. Compared to that from intentionally designed networks such as Patients Like Me (Swan, 2009), exposure to and engagement with intervention content in an open network may more profoundly influence what participants' talk about with their friends online because the social interactions are occurring on the same digital platform. Also, harnessing a platform individuals' regularly use could improve participants' chances of long-term behavior change by ameliorating the problem of non-usage attrition in digital health interventions (Eysenbach, 2005) and facilitating social support from existing relationships as opposed to strangers (Maher, Lewis, Ferrar, Marshall, De Bourdeaudhuij, & Vandelanotte, 2014). Receiving social support for behavior

change, however, is largely predicated on the user sharing behavioral goals and related content.

The extent to which individuals are comfortable sharing personal health information on open networks varies, with some citing privacy concerns such as managing their identity across multiple friendship groups (Lampinen, Tamminen, & Oulasvirta, 2009; Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswold, & Marshall, 2014). Sharing, however, does benefit goal achievement. In one experiment, ensuring individuals shared their commitment to be more physically active via Facebook increased the likelihood of goal follow through (Munson, Krupka, Richardson, & Resnick, 2015). And a different study, using Twitter, demonstrated that individuals who tweeted specific goals about quitting smoking had higher odds of achieving smoking abstinence (Pechmann, Pan, Delucchi, Lakon, & Prochaska, 2015).

Distinct from explicit goal sharing, individuals may talk about their health with friends in open networks inasmuch as these behaviors are examples of everyday activities (e.g., eating) and/or accomplishments (e.g., working out). Also, online posting behavior varies based on the digital content to which an individual is exposed (Coviello, Sohn, Kramer, Marlow, Franceschetti, Christakis, & Fowler, 2014; Kramer, Guillory, & Hancock, 2014). For example, one Facebook experiment demonstrated users' positive posting decreased when the amount of positive posts they were exposed to was reduced, and negative posting decreased when the amount

of negative posts they were exposed to decreased (Kramer, Guillory, & Hancock, 2014).

FACEBOOK AND ONLINE COMMUNICATION

Facebook is a promising platform for studying online health communication because it commands a rich set of features for content sharing and social interactions (boyd & Ellison, 2007), and because it has been widely adopted. Approximately 1.5 billion people use Facebook every month (20% of the world's population) (Groden, 2015) and 4 billion pieces of content are shared on Facebook each day ("The Top 20 Valuable Facebook Statistics – Updated May 2015," 2015).

Facebook enables users to connect with their friends through direct messaging, providing feedback/support, and broadcasting social news. Broadcasting is defined as undirected communication wherein the user posts content to a public page visible to the social network (Burke & Marlow, 2011). Facebook's *status update* feature enables broadcasting whereby the user posts content to his/her page (the Timeline). Similarly, users can post content to a friend's page that will also be visible to the network. This content is then aggregated into a stream of news (the Newsfeed) that users can interact with at their leisure. For example, a user may post, "Finished my first 5K today!" and the user's friends can comment or like the post when they see it in their Newsfeed or on the user's Timeline.

Many studies have examined motivations for Facebook use and concluded that users are generally motivated by a desire to keep in touch with friends, gain social acceptance, cultivate their identity, and affirm their sense of self (Nadkarni &

Hofmann, 2012; Toma & Hancock, 2013; Wilson, Gosling, & Graham, 2012). For example, one study examining motivations for Facebook use among college students found that "expressive information sharing" predicted use of the *status update* feature (Smock, Ellison, Lampe, & Wohn, 2011) with expressive information sharing defined as providing information about something personally relevant, sharing information that the user thought would be of interest to others, and, talking about oneself (Smock, Ellison, Lampe, & Wohn, 2011).

Additional research has examined how users connect with similar others in defined user communities such as Facebook groups for breast cancer survivors (Bender, Jimenez-Marroquin, & Jadad, 2011) and patients with chronic diseases (Greene, Choudhry, Kilabuk, & Shrank, 2011). However, little research has empirically explored what health-related content users share with members of their existing friendship networks. Given the popularity of using Facebook in digital health interventions, it is of interest to understand the extent to which users share health-related content with their friends outside of defined user communities. Also, it remains untested whether exposure to health-related content while participating in a behavioral trial affects posting behavior with existing friendship networks.

PURPOSE OF THE PRESENT RESEARCH

This study explored the broadcasted Facebook communication of overweight/obese college students participating in a remotely delivered weight-loss trial.

Treatment group participants had access to diverse relationships on the same platform (i.e., Facebook) including those with their existing friends, fellow participants, and the study's health coach, which provided complementary and synergistic exposure to critical resources known to help with weight loss such as feedback, social support, and social capital. Further, participants were exposed to theoretically designed and scientifically sound weight-loss content via the study's Facebook page including trustworthy information (e.g., tips for making healthy food choices), opportunities for self-comparison (e.g., viewing the success/failures of others), motivational messages, and timely feedback (e.g., likes and comments from fellow participants and the health coach).

The primary aim of the present study was to develop a method to identify participants' broadcasted Facebook posts that related to healthy-active living (HAL) and analyze how this posting behavior varied over time. We hypothesized that compared to those in the control, treatment group participants would broadcast more HAL content over time, and that treatment participants who were more engaged with the study's Facebook page would broadcast more HAL content than those less engaged over time.

METHODS

PARTICIPANTS

From May 2011 to May 2012, 404 students were recruited from three Southern California universities to participate in project SMART. SMART was one of seven studies funded by the National Heart, Lung and Blood Institute to target

weight loss/weight control in young adults. The primary outcome of SMART was weight-loss at 24 months from baseline. Participants attended a measurement visit at baseline and every 6 months for 24 months, conducted at the students' university. Participant compensation increased by $5 after each completed clinic visit, from $20 at baseline to $50 at 24 months. At the baseline measurement visit, participants underwent written informed consent.

Inclusion criteria were: (1) aged 18 to 35 years; (2) body mass index (BMI) 25–40 kg/m^2; (3) owns a personal computer; (4) owns a mobile phone and uses text messaging; and (5) a Facebook user or willing to join. Exclusion criteria were: (1) comorbidities of obesity that require clinical referral (e.g., diabetes); (2) psychiatric or medical conditions that could prohibit study compliance (e.g., bipolar disorder); (3) taking weight-altering medications; (4) pregnant or intending to get pregnant over the next 2 years; and (5) enrolled in or planning to enroll in another weight-loss program.

INTERVENTION

The intervention has been described in detail elsewhere (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswold, & Marshall, 2014; Patrick, Marshall, Davila, Kolodziejczyk, Fowler, Calfas, Huang, Rock, Griswold, Gupta, Merchant, Norman, Raab, Donohue, Fogg, & Robinson, 2014). Briefly, eligible participants were randomized into one of two groups: social and mobile intervention (*n=202*) or online education-only control (*n=202*).

The intervention group had access to a study-specific website, blog, apps, Facebook page, text messaging component, and a health coach. Upon entering the study, all intervention participants were asked to 'like' the Facebook page. After liking the page, users are considered 'fans' of the page and could see all posts in their news feed. Because the Facebook page was open, non-study participants could also view and engage with its content. A health coach (a registered dietitian) remotely delivered all intervention content to the 202 intervention participants. The control group received access to a static website and quarterly newsletters about healthy living.

MEASUREMENT

By consenting to participate, individuals granted the study access to their Facebook data, which included all communication between participants and their friends from the perspective of the participant. Facebook query language was used to retrieve data from Facebook's social graph. Data were downloaded in JSON (JavaScript Object Notation) format and cleaned in R version 3.1.2 (Team, 2014).

Dependent variable: Participants' broadcasted Facebook posts were extracted from the corpus of Facebook data. Broadcasted communication was defined as participants' published content (posts) of any record type (i.e., status update, link, photo, video or check-in) provided it included text. Activity on the study's Facebook page was excluded, as were likes, comments, and posts made by participants' friends (Figure 3.1).

For user i and time period t, u_{it}^h is the number of posts that contain at least one HAL unigram and u_{it} is the total number of posts. Therefore, y_{it} is the fraction of posts that contain at least one HAL unigram defined as

$$y_{it}^h = \frac{u_{it}^h}{u_{it}}$$

and $u_{it} \neq 0$. Also, $0 \leq y_{it}^h \leq 1$.
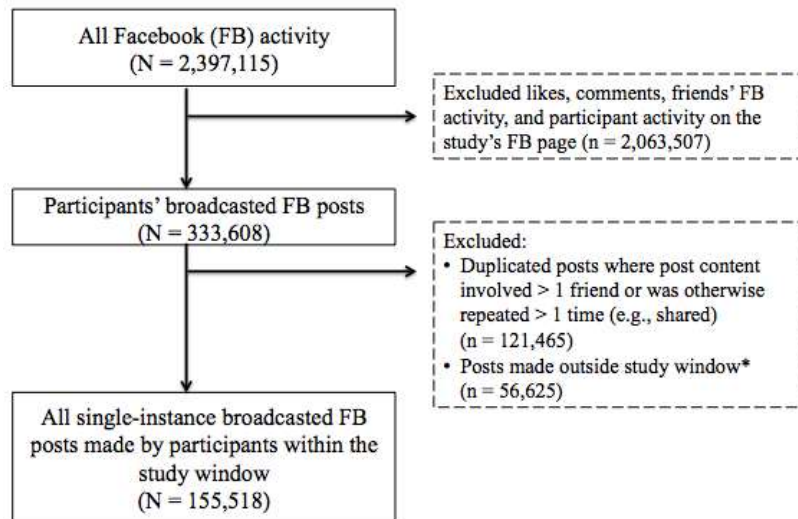
Figure 3.1. Processing of Facebook (FB) data for HAL dependent variable
*Study window was defined as posts made 6 months prior to study entry (i.e., baseline) up to +26 months (i.e., study exit). All post data were anchored to participants' study start date.

Independent variables: For Hypothesis One, the primary predictor variable was group assignment (treatment/control). For Hypothesis Two, the primary predictor variable was engagement with the study's Facebook page defined as the number of interactions with the page for user i at time period t. Interactions included directed (e.g., likes, comments) and broadcasted communication (i.e., posts to page). Covariates included self-reported age (at baseline) and sex.

TEXT ANALYSIS

We took a supervised approach to classify the text of participants' Facebook posts as being about healthy-active-living (HAL) or not. The classifier used to flag posts was a dictionary consisting of diet and exercise unigrams. The text of each Facebook post was stripped of punctuation and case before being passed to the dictionary classifier. Posts that contained ≥ 1 HAL dictionary word were classified as being about HAL.

To create the initial word pool for the dictionary classifier, words were scraped from three sources: USDA websites (United States Department of Agriculture, n.d.), the Physical Activity Compendium (Ainsworth, Haskell, Herrmann, Meckes, Bassett Jr, Tudor-Locke, Greer, Vezina, Whitt-Glover, n.d.), and the study's Facebook page (https://www.facebook.com/threetwome). Unigrams were included if they met the criteria of purposeful physical activity (e.g., running) and eating well (e.g., blueberries). To capture various contexts of word use, different forms of the same root word were included such as plural, infinitive, gerund, present, and past tense (e.g., run, ran, running, runner). Bigrams (e.g., sit up), household chores, and leisure activities were excluded.

The dictionary was iteratively built through reliability and validity testing. A random sample of baseline posts was independently coded by two raters and used as the ground truth for diagnostic validity. The two raters' manually coded posts were compared to one another, and inter-rater reliability was assessed (see Appendix I at the end of this chapter for manual coding instructions). After achieving consensus on

the ground truth, the manual codes were compared to results from the classifier, and sensitivity and specificity was assessed. Based on these results, words were added/removed from the dictionaries.

PLAN OF ANALYSIS

The outcome variable used to test both hypotheses was the percentage of participants' broadcasted posts that contained ≥ 1 HAL unigram. Posts were analyzed in 6-month intervals anchored to participants' start date from baseline up to study exit (a maximum of +26 mos). Time points were defined as follows: broadcasted posting behavior 6 months prior to study entry up to study start (T0); posting from 1 to 6 months (T1); posting from 7 to 12 months (T2); posting from 13 to 18 months (T3); and, posting from 19 to 24 months (T4). These cut-offs matched participants' measurement visits, which occurred every 6 months.

Data were analyzed using linear mixed effects models from the R package nlme (Pinheiro, Bates, DebRoy, Sarker, & Team, 2014). A random intercept was used to address the nesting of repeated observations within person. A modified intent-to-treat analysis was used whereby participants had to contribute broadcasted Facebook data from baseline and at least one other time point to be included in the analyses. Hypothesis Two was restricted to treatment group participants, as the control group was not exposed to the study's Facebook page.

Assumptions of mixed effects linear regression were checked. For the final adjusted models of both hypotheses, the error structure of the fixed effects was approximately normal and homoschedastic, and the random effects approximately

normally distributed. Although model fit (AIC) and regression diagnostic testing results improved by square root transforming the positively skewed dependent variable (percent HAL), the transformation did not change the results. Therefore, to maintain interpretability, non-transformed results are presented here.

RESULTS

HAL DICTIONARY CREATION

Participants (N=358) made 155,518 broadcasted Facebook posts to their existing network between 6 months prior to study entry and up to study exit (Figure 3.1). A random sample of baseline posts (5%, n=2410) was manually coded by two raters and used as the ground truth for diagnostic validity. The dictionaries had low power to detect true positives (sensitivity=55%) but identified few false positives (specificity=98%). Inter-rater reliability was 75% for posts about diet and 62% for exercise. Most disagreements were due to generous vs. conservative coding in classifying HAL for past, current, and planned exercise as well as requests for support.

The final dictionary contained 165 (exercise) and 186 (diet) words (see Appendix II at the end of this chapter for full dictionaries). Diet words included fruits, vegetables, food descriptors (e.g., organic), proteins, grains, and nutrients. Exercise words included activity descriptors (e.g., aerobic), activities, activity tools (e.g., bicycle), and races/competitions (e.g., 5K). Following the manual coding exercise, some words were excluded because they were frequently used out of context included dancing (as in "with the stars" TV show) and pea (as in the band

Black Eyed Peas). Differently, some words were added based on knowledge of the population such as ToughMudder (a popular running event) or based on further discussion/expert consensus (e.g., lbs).

Of the 155,469 broadcasted posts, 4.85% were classified as HAL (n=7540). Percent of posts classified as HAL was greater at later time points compared to baseline (T0=4.42%; T1=4.88%; T2=5.12%; T3=5.03%; T4=5.01%). Participants more commonly talked about exercise on Facebook with 3.32% of posts (n=5166) being classified as exercise-HAL, and 1.74% (n=2702) flagged as diet-HAL (percent sum is > overall percent HAL because some posts contain both diet *and* exercise words). Among the HAL posts, 4.35% (n=328) contained both diet and exercise words. The maximum number of HAL words found in a single post was 18 wherein a participant posted about a new yoga studio, and the mean number of words in each HAL post was 1.28 (SD=0.78). Table 3.1 contains a random sample of posts classified as HAL.

SAMPLE

There were 329 participants who met the criteria of contributing broadcasted Facebook data at baseline and at least one other time point for the modified intent-to-treat analysis. Table 3.2 shows their demographics by intervention group. There were no demographic differences between participants contributing Facebook data for the present study (n=329) and the total participant sample from project SMART (N=404) at baseline. There was also no difference in the number of participants contributing data between the treatment and control groups at any time point; nor

was there a difference in the total number of Facebook posts made by participants

between groups at any time point (data not shown).

Table 3.1. Random sample of posts classified as HAL with HAL words in bold (*n*=10)

Record Type	Record Content*	Comment
Check-in	Day 7: All **Cardio**	Completed workout
Status update	Where you at gorrrrrl! Make sure you find me after you **walk**, I'm here at your grad :))))	False positive
Status update	HAPPY HAPPY BURRRDAYY!! Ahhhh I MISSSHUUUU! It's been foreva and a day but hopefully I'll **run** into you soon! Hahaha enjoy your special day and make it the best one eva lovely! <3333	False positive
Photo	**Active** Amina was tagged in Brittany Huntridge's album Camera+ Photos.	Context unclear
Status update	Anyone want to go **hiking** with Henry and I?	Request for support
Status update	"By the Universe deserted, she'd tell it to go to hell, and she'd find a body of **water**, on a mirror, on which to dwell" Stunning performances by everyone in Palimpsest tonight! Congratulations to John for a wonderful premiere of his "colla voce". It is always such a profound pleasure to perform with all of you and hear your work. What a program. #elliottcarter #palimpsest #ucsdmusicgrads	False positive
Video	So the (still nameless) hamster finally learned how to **run** on his wheel!....sort of	False positive
Status update	somebody inspire me to go **run**! im lazy!!	Request for support
Status update	Jackie: **Gym**, tanning, and find out who johns texting behind kellys back!!! lmfao! I love Eric! He's hilarious	Completed workout
Status update	GUHHHHH delicious sweet organic **strawberries** from the MMHS farmers market, I've just inhaled 5 and I still want more FFFFFFFFFff	Eating healthy food episode
*Names have been changed or removed.		

Table 3.2. Participant characteristics by intervention group (N=329)

	Total (N=329)	Control (*n* = 167)	Treatment (*n* = 162)
Age (years), mean (SD)	22.6 (3.8)	22.7 (3.8)	22.4 (3.7)
Race, *n* (%)			
White	135 (41.0)	66 (39.5)	69 (42.6)
Other/Multiple	96 (29.2)	51 (310.54)	45 (27.8)
Asian	80 (24.3)	41 (24.6)	39 (24.1)
Black	12 (3.6)	7 (4.2)	5 (3.1)
American Indian Alaskan/ Pacific Islander	6 (1.8)	2 (1.2)	4 (2.5)
Ethnicity, *n* (%)			
Hispanic	103 (31.3)	54 (67.7)	49 (30.4)
Undergraduate (yes), *n* (%)	162 (49.2)	87 (52.1)	75 (46.3)
Anthropometrics, mean (SD)			
Body mass index (BMI)	28.9 (2.8)	28.9 (2.7)	28.9 (2.9)
Waist circumference (cm)	87.4 (8.9)	87.6 (8.8)	87.3 (8.9)

CHANGE IN PERCENT HAL POSTING OVER TIME BETWEEN GROUPS

We hypothesized that treatment group participants would broadcast more HAL content over time than those in the control group. In Model One, percent HAL was regressed onto time, participant group (treatment vs. control), and the interaction group*time. A random intercept for person was used to account for the nesting of posts within the individual. Time and participant group were handled as factors.

From study start to +6 months of participation individuals in the treatment group posted more HAL content than those in the control group (Beta=1.75; *p*<0.05). The model estimated predicted values indicate that treatment group participants increased their HAL posting by approximately 2% from baseline (predicted value=3.95%) to +6 months of participation (predicted value=5.70%). A significant difference between groups did not persist over time. Results held in Model Two, which adjusted for age and sex. Additionally, for every year increase in participants' age, HAL posting increased by 0.20% (*p* < 0.001) (Table 3.3).

Table 3.3. Coefficients for the linear mixed models testing for change in % HAL between the treatment and control participants over time (N=329)

	Model 1			Model 2		
	Beta	CI	p	Beta	CI	p
Intercept	4.44	(3.51, 5.36)	0.00	0.15	(−2.50, 2.80)	0.91
T1	−0.69	(−1.87, 0.50)	0.26	−0.67	(−1.86, 0.51)	0.27
T2	−0.03	(−1.22, 1.17)	0.96	−0.01	(−1.21, 1.19)	0.99
T3	−0.42	(−1.61, 0.78)	0.49	−0.40	(−1.60, 0.79)	0.51
T4	0.40	(−0.8, 1.61)	0.51	0.41	(−0.79, 1.62)	0.50
Group treatment	−0.49	(−1.81, 0.82)	0.46	−0.45	(−1.76, 0.85)	0.50
T1*treatment	1.75	(0.06, 3.44)	**0.04***	1.74	(0.05, 3.43)	**0.04***
T2*treatment	0.95	(−0.75, 2.65)	0.27	0.94	(−0.76, 2.64)	0.28
T3*treatment	0.78	(−0.92, 2.48)	0.37	0.78	(−0.92, 2.48)	0.37
T4*treatment	−0.17	(−1.89, 1.56)	0.85	−0.18	(−1.91, 1.55)	0.84
Sex female				−0.17	(−1.04, 0.70)	0.70
Age				0.20	(0.09, 0.30)	**>0.0001***
The reference categories are control (for group) and baseline/T0 (for time)						

PERCENT HAL POSTING WITHIN THE TREATMENT GROUP BY FACEBOOK ENGAGEMENT

We hypothesized that treatment participants who were more engaged with the study's Facebook page would broadcast more HAL content than those less engaged over time. Treatment engagement with the study's Facebook page declined over time, and engagement varied among participants (Table 3.4). Minimally engaged participants were defined as those who interacted with the study's Facebook page less than once per month for any given time point. Engaged participants were defined as those who interacted with the study's Facebook page at least once per month for any given time point.

Table 3.4. Engagement* with the study's Facebook page over time^

	T1	T2	T3	T4
Mean (SD)	18.09 (40.09)	11.35 (17.23)	14.30 (20.31)	8.66 (14.19)
Median	5	3	5	2
Range	1−285	1−84	1−92	1−68
*Engagement was quantified as participants' observable activity on the study's Facebook page (e.g., likes, posts to page) summed over each time point. These data describe those who engaged ≥ 1 time. ^All Facebook data were anchored to individual participants' study start and end dates.				

In Model One, percent HAL was regressed onto time, engagement group (minimally engaged vs. engaged), and the interaction group*time. A random intercept for person was used to account for the nesting of posts within the individual. Time and engagement group were handled as factors. Given that participants could not interact with the study's page until after joining the study, there were no baseline data for these analyses. Instead, the reference category for time was participants' first 6 months of study participation.

The difference in HAL posting between participants who were more, versus less, engaged with the study's Facebook page approached significance from study start to +6 months of participation (Beta=1.56; p=0.09). However, as participation in the study progressed, this relationship reversed such that more engaged participants posted *less* HAL content relative to those minimally engaged (Table 3.5).

Table 3.5. Coefficients for the linear mixed models testing for change in % HAL among treatment participants by study Facebook engagement status over time (N=162)

	Model 1			**Model 2**		
	Beta	CI	*p*	Beta	CI	*p*
Intercept	4.60	(3.62, 5.58)	0.00	−3.15	(−7.06,0.77)	0.12
T2	0.13	(−1.04, 1.29)	0.83	0.15	(−1.02,1.31)	0.80
T3	−0.03	(−1.21, 1.15)	0.96	0.00	(−1.18,1.18)	0.99
T4	−0.45	(−1.63, 0.72)	0.45	−0.45	(−1.62,0.73)	0.46
Group: engaged	1.56	(−0.25, 3.37)	**0.09**	1.54	(−0.26,3.34)	**0.09**
T2*engaged	−0.82	(−3.4, 1.75)	0.53	−0.86	(−3.43,1.71)	0.51
T3*engaged	−2.73	(−5.22, −0.25)	**0.03***	−2.85	(−5.34,−0.37)	**0.03***
T4*engaged	−1.13	(−4.20, 1.93)	0.47	−1.24	(−4.3,1.82)	0.43
Sex female				0.27	(−1.02,1.56)	0.68
Age				0.34	(0.18,0.49)	**>0.0001***
Minimally engaged (<1 interaction on the study's Facebook page / month) is reference category for group T1 (baseline) is reference category for time point						

DISCUSSION

The SMART intervention caused treatment group participants to talk more about healthy-active-living (HAL) with their friends on Facebook for the first 6 months of study participation although differences between groups did not persist over time. Talking about personal health on networking sites, such as striving for weight-loss, is known to elicit social support and accountability (Ballantine & Stephenson, 2011; Hwang, Ottenbacher, Green, Cannon-Diehl, Richardson, Bernstam, & Thomas, 2010) and may lead to weight-related behavior change and/or weight loss. Earlier work has found that talking about personal health with online networks is associated with better behavioral outcomes. For example, sharing the commitment to be more physically active lead to the accumulation of more physical activity (Munson, Krupka, Richardson, & Resnick, 2015), and sharing details about working toward the goal of quitting smoking such as overcoming barriers to quitting was associated with greater odds of achieving abstinence (Pechmann, Pan, Delucchi, Lakon, & Prochaska, 2015). Other work has demonstrated that posting about weight-related topics is associated with greater weight loss (Hales, Davidson, & Turner-McGrievy, 2014; Valle, Tate, Mayer, Allicock, & Cai, 2013).

However, the aforementioned studies (Hales, Davidson, & Turner-McGrievy, 2014; Munson, Krupka, Richardson, & Resnick, 2015; Pechmann, Pan, Delucchi, Lakon, & Prochaska, 2015; Valle, Tate, Mayer, Allicock, & Cai, 2013) analyzed online communication within a restricted social network. Participants of these studies were sharing with either a pre-defined network of users on Facebook (Munson,

Krupka, Richardson, & Resnick, 2015) or Twitter (Pechmann, Pan, Delucchi, Lakon, & Prochaska, 2015), or were sharing with fellow research participants striving toward the same behavioral goals on study-designed Facebook page (Hales, Davidson, & Turner-McGrievy, 2014; Valle, Tate, Mayer, Allicock, & Cai, 2013). There is a need to extend this work to users' existing online friendships in open networks (Centola, 2013).

Broadcasting health-related goals and activities with existing, as opposed to restricted, networks may have broader health implications because it affords complementary support and accountability to face-to-face interaction. Further, sharing within the broader online network may lead to contagion, or viral spread, impacting the health of individuals beyond those targeted in a behavioral trial. Although yet to be demonstrated with health-related posts, talking more about healthy-active-living with one's online social network could influence others in the network to talk more about healthy-active-living. For example, there is evidence that emotional contagion happens on Facebook whereby the valence of network members' posts affects the posting behavior of other users (Coviello, Sohn, Kramer, Marlow, Franceschetti, Christakis, & Fowler, 2014; Kramer, Guillory, & Hancock, 2014).

This study did not find evidence to support the hypothesis that engagement with the study's Facebook page was associated with talking more about HAL. Restricting the analyses to the treatment group, those more, versus less, engaged with the study's Facebook page posted marginally more HAL at +6 months of study

participation but this difference was not significant. However, the association reversed over time such that those minimally engaged posted significantly more HAL than those engaged at 18 months of study participation.

These findings are likely explained, in part, by a high prevalence of lurking: users' passively reviewing content without visibly interacting with it (Rafaeli, Ravid, & Soroka, 2004; Sun, Rau, & Ma, 2014). For example, the 90–9–1 principle suggests that 90% of online community members read content only, 9% edit or comment on the content of others, and just 1% are responsible for contributing new content (Arthur, n.d.). An earlier investigation of project SMART Facebook activity found that 23% of treatment participants were responsible for posting 91% of the new content on the study's intervention page, and that lurking was a common phenomenon (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswold, & Marshall, 2014). Further, treatment group participants' observable engagement with the study's Facebook page declined over time (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswold, & Marshall, 2014) and at least some participants reported limiting their activity on the page because they did not see a lot of other participants being consistently active (Paper 1).

STRENGTHS AND LIMITATIONS

This study took a supervised approach to classify participants' broadcasted Facebook posts as being about HAL or not. Although the dictionary classifier, which contained unigrams about diet and exercise, was iteratively built through validity

testing, its poor sensitivity may have limited the study's findings. The dictionary classifier missed posts about HAL that contained slang, typos, or content such that more a single unigram was needed to correctly classify the post. That is, the dictionary classifier could not account for unigrams/bigrams/classifier rules that were not pre-specified. For example, it may be that participants in the treatment group talked significantly less about unhealthy diet behaviors (e.g., McDonalds) compared to control group participants, but this was not observed using a dictionary containing only healthy diet-enhancing words.

Unsupervised approaches such as latent dirichlet allocation (LDA) (Blei, Ng, & Jordan, 2003) have been used to discover topics in large corpa of text data such as that from Facebook posts (Wang, Burke, & Kraut, 2013). An advantage of unsupervised, versus supervised, approaches is that they *infer* as opposed to *assume* what the data are saying, and do not rely on pre-established categories or topics (Roberts et al., 2014). However, supervised approaches contain their own set of limitations such as the somewhat subjective decision-making surrounding LDA model selection (Wang, Burke, & Kraut, 2013), and selecting covariates to include in structural topic models (Roberts, Stewart, Tingley, Lucas, Leder-Luis, Gadarian, Albertsen, & Rand, 2014).

Despite being limited in its scope compared to unsupervised approaches, the dictionary classifier developed in this study was comprehensive and comparable to earlier work that has analyzed the content of Twitter posts in terms of physical activity (Zhang, Campo, Janz, Eckler, Yang, Snetselaar, & Signorini, 2013). Also,

the dictionary identified very few false positives (specificity=98%), which indicates that the results observed here are unlikely due to Type I error (i.e., observing a relationship between treatment effect and HAL posting when there was none).

CONCLUSION

The present study demonstrated that a remotely delivered weight-loss intervention caused participants in the treatment group to post more about HAL (i.e., diet and exercise) than those in the control group. However, the difference between groups was only significant for the first 6 (out of 24) months of study participation. Although the extent to which this impacts real-world behavior and ultimately weight loss remains to be tested, earlier work suggests online communication with individuals' social networks impact health including physical activity (Munson, Krupka, Richardson, & Resnick, 2015) and smoking abstinence (Pechmann, Pan, Delucchi, Lakon, & Prochaska, 2015).

The mechanism to explain the increase in HAL posting among treatment group participants does not appear to be driven by observable engagement on the study's Facebook page. However, given the common practice of lurking in online forums and on social media (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswold, & Marshall, 2014), it may be that defining engagement solely in terms of interactions (e.g., likes, posts to page) is insufficient and biases the measure.

Future work will test whether posting about HAL, and whether receiving social support for HAL posts (in the form of likes and comments) is associated with

weight loss. Work will also be undertaken to improve the dictionary classifier, which should lead to greater measurement precision and stronger evidence for or against the link between HAL posting and weight loss. Lastly, given the low prevalence of talking about diet, versus exercise, on Facebook, which was found here and in earlier work (Villiard & Moreno, 2012), future studies could consider separately coding for diet and exercise communication.

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APPENDIX I. Human Coding Instructions

Coders will 'flag' the random sample of participant posts as being HAL or not HAL using the following logic. Determinations will be indicated on the excel file that contains the random subset of participant posts.

- Answer the following questions for each participant post.
- 1 = YES
- 0 = NO
- Do not skip any questions.

1. **Does the post describe the poster engaging in past/current/planned purposeful physical activity/exercise?**

    Yes -> HAL (1)
    No -> Not HAL (0)

2. **Does the post describe the poster making past/current/planned dietary choices which we would consider part of a HAL?**
    Yes -> HAL (1)
    No -> Not HAL (0)

3. **Is the post HAL?**
    Yes -> HAL (1)
    No -> Not HAL (0)

4. **Was a *likely* HAL word(s) used but used out of context?** (For example, "Dancing with the Stars Marathon!!!! Can't wait!")
    Yes -> (1) *Put the problematic word(s) in the 'Problem words' column
    No -> (0)

5. **Problem words?**
    Yes -> List each word(s) that was problematic in all lower case, double check spelling, and use a comma to separate multiple words.
    No -> (0)

6. **Comment?**

    Yes -> Write down any additional comments that helped guide your decision or things you think should be considered in future coding decisions. If the post is in another language, write the language. If you don't know the language write "other language."
    No -> (0)

APPENDIX II. Healthy-active-living (HAL) dictionary
Exercise words (N = 165)

10k	cheerleading	horseback riding	raced	soul cycle
5k	climb	intramural	races	Spartan
abs	climbing	jazzercise	racing	spin
active	coach	jet ski	racquetball	squash
aerobic	cricket	jet skiing	racquetballs	squats
anaerobic	CrossFit	jog	rafting	Stairmaster
backpacking	crunches	jogging	ran	stairs
badminton	duathlon	karate	recipes	surf
ballet	elliptical	kayaking	reps	surfboard
baseball	endurance	kettlebell	rock-climbing	surfboards
baseballs	ergometer	kettlebells	rollerblading	surfed
basketball	exercise	kickball	rowing	surfing
basketballs	exercises	kitesurf	rugby	swam
biathlon	fencing	kitesurfing	run	swim
bicep	fitness	lacrosse	runner	swimming
bicycle	football	lbs	running	taekwondo
bicycled	footballs	lunge	sit-up	toughmudder
bicycles	Frisbee	lunges	sit-ups	trainer
bicycling	Frisbees	mudder	skateboarding	training
bike	golf	paddleball	skating	treadmill
biked	gym	paddleboarding	ski	triathlon
bikes	gymnasium	pedometer	skied	ups
biking	gymnasiums	Pilates	skiing	volleyball
bodyboarded	gymnastics	plank	skijump	walk
bodyboarding	gyms	planks	skijumping	walked
bodyboard	hackysac	plyometric	skis	walking
bodyboards	hackysacs	plyos	snowshoe	water polo
bootcamp	handball	pullup	snowshoeing	weights
bootcamps	healthy	pullups	snowshoes	windsurf
boxing	hike	pushup	soccer	windsurfed
cardio	hiking	pushups	softball	windsurfing
cardiovascular	hockey	race	softballs	workout
workouts				
wrestling				
yoga				
Zumba				

Diet words (N = 186)

almond	cherries	lentils	persimmons	tilapia
almonds	cherry	lettuce	pineapple	tofu
antioxidant	chickpea	lowfat	pineapples	tomato
antioxidants	chickpeas	mango	pistachio	tomatoes
apple	coconut	mangoes	pistachios	trailmix
apples	coconuts	mangos	plate	tuna
apricot	cod	melon	plum	vegan
apricots	corn	melons	plums	vegetable
artichoke	cranberries	muesli	pomegranate	vegetables
artichokes	cranberry	mushroom	pomegranates	vegetarian
arugula	cucumber	mushrooms	potassium	veggie
asparagus	cucumbers	nectarine	potato	veggies
avocado	currants	nectarines	potatoes	vitamin
avocados	eggplant	nonfat	protein	vitamins
banana	eggplants	nutrient	prune	walnut
bananas	fiber	nutrients	prunes	walnuts
barley	fig	oat	quinoa	water
bean	figs	oatmeal	radish	watercress
beans	fish	oats	radishes	watermelon
beet	flax	okra	raisin	watermelons
beets	fruit	olive	raisins	wellness
blackberries	fruits	olives	raspberries	wholewheat
blackberry	grain	onion	raspberry	yogurt
blueberries	grains	onions	recipe	zucchini
blueberry	granola	orange	recipes	
bran	grape	oranges	romaine	
broccoli	grapefruit	organic	salad	
cabbage	grapefruits	papaya	salads	
cabbages	grapes	papayas	salmon	
calcium	guava	parsnip	soy	
cantaloupe	health	pasta	soybean	
cantaloupes	healthy	peach	spinach	
carrot	honeydew	peaches	sprout	
carrots	iron	peanut	sprouts	
cashew	kale	peanuts	squash	
cashews	kiwi	pear	strawberries	
cauliflower	kiwifruit	pears	strawberry	
celery	leek	pecan	swordfish	
cereal	leeks	pecans	tangerine	
chard	lentil	persimmon	tangerines	

CHAPTER 4: FACEBOOK AND WEIGHT LOSS:

DOES TALKING ABOUT DIET AND EXERCISE WITH FRIENDS HELP?

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ABSTRACT

Objective: Sharing health behavior change goals and receiving social support for them online has been linked to positive health outcomes. Few studies, however, have examined how Facebook communication among existing friendship networks is associated with weight loss. Utilizing data from a completed 2-year randomized trial (N=404), this study tested whether receiving social support for talking healthy-active-living (HAL) was associated with weight loss among overweight/obese college student participants.

Methods: A dictionary consisting of diet (*n*=186) and exercise (*n*=165) unigrams was used to classify participants' Facebook posts as being about HAL or not. Social support for HAL was defined as the percent of likes and comments on HAL posts.

Results: Linear mixed effects models found that the association between social support for HAL posts and weight loss approached significance at +18 months of study participation (Beta= –0.08; *p*=0.07). Within females in the treatment group, the association was significant at 6 months (Beta= –0.20; *p*< 0.05). For every 20% increase in social support received on HAL posts, women in the treatment group lost 4 kg (9 lbs) from baseline to 6 months.

Conclusions: The dictionary classifier contained single diet and exercise unigrams, which may have limited the study's power. Future work will test how to improve this classifier, and how friendships among network members may influence the relationship between online social support for HAL and weight loss.

INTRODUCTION

    Social networking sites have exploded in popularity over the last decade and researchers are increasingly using them in health behavior interventions. Reviews and meta-analyses have found modest evidence that interventions using these platforms are effective at promoting behavior change and positive health outcomes (Laranjo, Arguel, Neves, Gallagher, Kaplan, Mortimer, Mendes, & Lau, 2015; Maher, Lewis, Ferrar, Marshall, De Bourdeaudhuij, & Vandelanotte, 2014). One mechanism to explain effectiveness is these sites' ability to promote the exchange of social support among online connections. Receiving support and feedback online has been linked to improved health outcomes such as weight loss and weight maintenance (Krukowski, Harvey-Berino, Ashikaga, Thomas, & Micco, 2008), and intervention engagement (Brouwer, Kroeze, Crutzen, de Nooijer, de Vries, Brug, & Oenema, 2011; Cugelman, Thelwall, & Dawes, 2011).

    However, the exchange of social support and other types of social influence have mostly been studied in the context of intentionally designed networks (Centola, 2013) that serve specific health-related purposes such as weight loss (Ballantine & Stephenson, 2011; Hwang, Ottenbacher, Green, Cannon-Diehl, Richardson, Bernstam, & Thomas, 2010; Poncela-Casasnovas, Spring, McClary, Moller, Mukogo, Pellegrini, Coons, Davidson, Mukherjee, & Amaral, 2015), diabetes management (Greene, Choudhry, Kilabuk, & Shrank, 2011; Zhang, He, & Sang, 2013), and quitting smoking (Pechmann, Pan, Delucchi, Lakon, & Prochaska, 2015; Post, Taylor, Sanders, Goldfarb, Hunt, & Augustson, 2013). For example,

researchers have created intentionally designed networks within Facebook (e.g., by creating a private Facebook group for study participants) and found positive health outcomes such as increased physical activity among cancer survivors (Valle, Tate, Mayer, Allicock, & Cai, 2013). Other work has examined existing health-related Facebook networks and found that users exchange information, social support, and cultivate a sense of community to help them manage their diabetes (Zhang, Campo, Janz, Eckler, Yang, Snetselaar, & Signorini, 2013). Facebook is an ideal platform to study social influence and health given its widespread use: 20% of the world's population uses the site every month (Groden, 2015).

Although health-specific networks on Facebook are an important area to research, there is significantly more activity occurring among users and their broader network of friends. Some users are hesitant to share personal health-related content with their Facebook friends because of privacy concerns and a desire to manage how others perceive them (Lampinen, Tamminen, & Oulasvirta, 2009; Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswold, & Marshall, 2014; Newman, Lauterbach, Munson, Resnick, & Morris, 2011). However, sharing is known to help individuals successfully change their behavior and achieve desired health outcomes. For example, sharing the commitment to being more physically active can lead to increased likelihood of goal achievement (Munson, Krupka, Richardson, & Resnick, 2015), and sharing specific goals about quitting smoking can increase odds of smoking abstinence (Pechmann, Pan, Delucchi, Lakon, & Prochaska, 2015).

Sharing with existing friends, as opposed to with new or weak connections formed in health-specific networks, may differ in the extent to which sharing impacts health. First, clustered networks where many friends are shared among individuals have been shown to be more effective at influencing complex behavior change than less dense networks where more connections are among weak ties (Centola, 2013). Although weak ties are important for information diffusion (Bakshy, Rosenn, Marlow, & Adamic, 2012) because the network has low redundancy, clustered social networks with redundant ties may be more effective at propagating health behavior change because these behaviors require multiple sources of social reinforcement to be maintained (Centola, 2013). Second, connecting with stronger, as opposed to weaker, ties online could more profoundly influence behavior change because it complements face-to-face interaction. That is, there may be an exponential and synergistic effect of receiving social support and accountability from the same people in online and face-to-face interactions.

Beyond connecting with others, people use Facebook and other networking sites to create and maintain an online identity, and affirm their sense of self (Nadkarni & Hofmann, 2012; Toma & Hancock, 2013; Wilson, Gosling, & Graham, 2012). Those that talk about their health with their online network may be more likely to be engaged in healthy behaviors, and users may increase the frequency with which they talk about their health and health topics as they increasingly identify as a "healthy person."

PURPOSE OF THE PRESENT RESEARCH

The present study investigated whether talking about eating well and exercising among existing network friends, and receiving online social support for these communications was associated with weight loss over time. The study utilized data from a completed randomized controlled trial that used social and mobile technologies to promote weight loss among overweight/obese college students (Patrick, Marshall, Davila, Kolodziejczyk, Fowler, Calfas, Huang, Rock, Griswold, Gupta, Merchant, Norman, Raab, Donohue, Fogg, & Robinson, 2014). Previous work has described the study's Facebook component in detail (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswold, & Marshall, 2014), which included delivering evidence-based and theory-driven messages on a study-designed Facebook page. In addition to collecting engagement data from the study-designed page, this trial collected data from participants and their Facebook friends.

We hypothesized that talking about diet and exercise on Facebook would be associated with weight loss over time, and that receiving social support for these communications (in the form of likes and comments) would also be associated with weight loss over time. Exploratory analyses tested for differences by sex and between the treatment and control groups.

METHODS

PARTICIPANTS

From May 2011 to May 2012, 404 students were recruited from three Southern California universities to participate in project SMART. SMART was one of seven studies funded by the National Heart, Lung and Blood Institute to target weight loss/weight control in young adults. The primary outcome of SMART was weight-loss at 24 months from baseline. Participants attended a measurement visit at baseline and every 6 months for 24 months, conducted at the students' university. Participant compensation increased by $5 after each completed clinic visit, from $20 at baseline to $50 at 24 months. At the baseline measurement visit, participants underwent written informed consent.

Inclusion criteria were: (1) aged 18 to 35 years; (2) body mass index (BMI) 25–40 kg/m^2; (3) owns a personal computer; (4) owns a mobile phone and uses text messaging; and (5) a Facebook user or willing to join. Exclusion criteria were: (1) comorbidities of obesity that require clinical referral (e.g., diabetes); (2) psychiatric or medical conditions that could prohibit study compliance (e.g., bipolar disorder); (3) taking weight-altering medications; (4) pregnant or intending to get pregnant over the next 2 years; and (5) enrolled in or planning to enroll in another weight-loss program.

INTERVENTION

The intervention has been described in detail elsewhere (Merchant, Weibel, Patrick, Fowler, Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswold,

& Marshall, 2014; Patrick, Marshall, Davila, Kolodziejczyk, Fowler, Calfas, Huang, Rock, Griswold, Gupta, Merchant, Norman, Raab, Donohue, Fogg, & Robinson, 2014). Briefly, eligible participants were randomized into one of two groups: social and mobile intervention ($n=202$) or online education-only control ($n=202$). The intervention group had access to a study-specific website, blog, apps, Facebook page, text messaging component, and a health coach. Unlike earlier work that created closed (i.e., private) Facebook pages/groups to reach participants in weight-loss/physical activity trials (Cavallo, Tate, Ries, Brown, DeVellis, & Ammerman, 2012; Maher, Ferguson, Vandelanotte, Plotnikoff, De Bourdeaudhuij, Thomas, Nelson-Field, & Olds, 2015; Napolitano, Hayes, Bennett, Ives, & Foster, 2013; Valle, Tate, Mayer, Allicock, & Cai, 2013), the SMART intervention created an open Facebook page, which meant that activity on the page was visible to participants' friends when participants interacted on the page. This also meant that non-study participants could become fans of the page, post to it, and interact with its content. The page was monitored throughout the trial to see whether control participants became fans of the page and/or interacted with its content. A health coach (a registered dietitian) remotely delivered all intervention content to the 202 intervention participants. The control group received access to a static website and quarterly newsletters about healthy living.

MEASUREMENT

By consenting to participate, individuals granted the study access to their Facebook data, which included all communication between participants and their

friends from the perspective of the participant. Facebook query language was used to retrieve data from Facebook's social graph. Data were downloaded in JSON (JavaScript Object Notation) format and cleaned in R version 3.1.2 (Team, 2014).

Dependent variable: At each measurement visit participants' weight was taken on a calibrated scale to the nearest quarter kilogram. Height was also measured to the nearest centimeter, and body mass index was calculated from height and weight (BMI=weight (kg)/height^2 (m^2)). Weight and height were measured three times, and the averages taken at each visit (baseline, 6, 12, 18, and 24 months).

Independent Variables

Talking about healthy-active-living (HAL): Participants' broadcasted Facebook posts were extracted from the corpus of Facebook data, and defined as published content (posts) of any record type (i.e., status update, link, photo, video or check-in) that included text. Activity on the study's Facebook page was excluded, as were likes, comments, and posts made by participants or participants' friends.

A dictionary consisting of diet and exercise unigrams was used to classify posts as being about HAL or not. The dictionary was iteratively built through reliability and validity testing, and has been described in detail elsewhere (Paper 2). Briefly, unigrams were included if they met the criteria of purposeful physical activity (e.g., running) and eating well (e.g., blueberries). To capture various contexts of word use, different forms of the same root word were included such as plural, infinitive, gerund, present, and past tense (e.g., run, ran, running, runner). Bigrams (e.g., sit up), household chores, and leisure activities were excluded.

Following validity testing, some words were excluded because they were frequently used out of context (e.g., dancing as in "Dancing with the Stars" TV show), and some words were added (e.g., lbs) based on discussion/expert consensus.

The final dictionary had 165 (exercise) and 186 (diet) words. Diet words included fruits, vegetables, and food descriptors (e.g., organic). Exercise words included activity descriptors (e.g., aerobic), exercises, exercise tools (e.g., bicycle), and races/competitions (e.g., 5K). The text of each Facebook post was stripped of punctuation and case before being passed to the dictionary classifier.

Posts that contained $\geq$ one HAL word were classified as being about HAL. The percent of participants' broadcasted posts that were about HAL was calculated at each time point (# of posts classified as HAL / total # of posts). Time points were defined to match participants' measurement visits: broadcasted posts 6 months prior to study entry up to study start (baseline); posting from 1 to 6 months (6 months); posting from 7 to 12 months (12 months); posting from 13 to 18 months (18 months); and posting from 19 to 24 months (24 months).

Social Support for HAL: Social support for HAL was defined as the percent of likes and comments on participants' HAL posts at each time point (# of likes and comments on HAL posts / total number of likes and comments on participants' posts). Only likes and comments on posts that contained text were analyzed. This ensured that the numerator and denominator of the social support variable were reflecting the same type of data (i.e., likes and comments on broadcasted posts).

Sex, Age, Condition: Participants' self-reported sex and age at baseline, and randomized group (treatment/control) were also examined as covariates.

PLAN OF ANALYSIS

Linear mixed effects models (R package nlme) (Pinheiro, Bates, DebRoy, Sarker, & Team, 2014) were used to test the hypotheses that talking more about HAL with Facebook friends was associated with weight loss over time, and that receiving online social support for talking about HAL was associated with weight loss over time. Exploratory analyses tested whether these associations were different between males and females, and between participants in the control and treatment group. A random intercept was used to address the nesting of repeated observations within person. Time was fitted as a factor in all models.

Assumptions of linear mixed effects regression were tested and met for fully adjusted models. The error structure of the fixed effects were normally distributed and homoschedastic. The random effects were normally distributed.

RESULTS

Participants' demographic and anthropometric characteristics at baseline are presented in Table 4.1. Participants with available Facebook data (N=358) made 155,469 broadcasted Facebook posts between 6 months prior to study entry and up to study exit (i.e., the study window). Of these, approximately 4.93% were classified as HAL (N=7540). There was no difference in the number of participants contributing data across groups (treatment/control) or in the total number of Facebook posts made over time between groups (data not shown).

Participants' friends (N=97,143) made 381,334 likes and 303,105 comments on participants' posts in the study window, and 0.07% of these (N=44,181) were classified as social support on HAL posts. Social support scores per participant and time point were highly varied. At baseline, the average social support score for participants was 4.91% (SD=5.52%), and the Median was 3.86% (range: 0% to 47%). Percent of social support on HAL posts and percent of posts classified as HAL was strongly correlated across all five time points (Pearson r correlations ranged from 0.68 to 0.84)

Table 4.1. Participant characteristics by intervention group

	Total (N=404)	Control (*n*=202)	Treatment (*n*=202)
Age (years), mean (SD)	22.66 (3.77)	22.83 (3.80)	22.49 (3.75)
Race, *n* (%)			
White	169 (41.83)	83 (41.09)	86 (42.57)
Other/Multiple	118 (29.21)	58 (28.71)	60 (29.70)
Asian	96 (23.76)	50 (24.75)	46 (22.77)
Black	15 (3.71)	9 (4.46)	6 (2.97)
American Indian /Alaskan/ Pacific Islander	6 (1.49)	2 (0.99)	4 (1.98)
Ethnicity, *n* (%)			
Hispanic	125 (30.94)	62 (30.69)	63 (31.34)
Undergraduate (yes), *n* (%)	206 (50.99)	106 (52.48)	100 (49.50)
Anthropometrics, mean (SD)			
Body mass index (BMI)	28.98 (2.78)	29.04 (2.72)	28.92 (2.83)

CHANGE IN WEIGHT ASSOCIATED WITH POSTING ABOUT HAL

We hypothesized that talking about diet and exercise on Facebook would be associated with weight loss over time. Weight was regressed onto time, percent of posts that were classified as HAL (%HAL), and the interaction time*%HAL. There was no association between posting about HAL and weight loss over time (data not shown).

CHANGE IN WEIGHT ASSOCIATED WITH RECEIVING SOCIAL SUPPORT FOR POSTING ABOUT HAL

We hypothesized that receiving social support for talking about HAL on Facebook would be associated with weight loss over time. In Model One, weight was regressed onto time, percent of social support on HAL posts (%HALss), and the interaction time*%HALss. The association between receiving social support for HAL posts and weight loss approached significance at 18 (Beta= -0.08; p=0.07) months.

In Model Two, adjusting for participants' HAL posting (i.e., %HAL), and in the fully adjusted model, adjusting for %HAL, age, sex, and group, the results were similar (Table 4.2). To check whether the association between %HALss and weight loss was driven by total social support (i.e., the denominator of %HALss), weight was regressed onto total social support. There was no association between total social support and weight loss (data not shown).

EXPLORATORY ANALYSES

Exploratory analyses tested for differences by sex and between the treatment and control groups. Regressing weight onto time, %HALss, condition, the 3-way interaction time*%HALss*condition and adjusting for %HAL, sex, and age did not show support for a difference in the association between weight loss and %HALss by group (data not shown). There was also no support for moderation by sex (data not shown).

To explore whether there were differences within intervention groups, stratified analyses were run. Within the treatment group, the association between

%HALss and weight loss at 6 months approached significance (Beta= −0.12; *p*=0.07). No significant associations were found within the control group (data not shown).

Table 4.2. Coefficients for the linear mixed models testing for association between receiving social support for talking about HAL on Facebook and change in weight (kg) over time

	Model 1			Model 2			Model 3		
	Beta (CI)		*p*	**Beta (CI)**		*p*	**Beta (CI)**		*p*
Intercept	80.40	(78.96, 81.84)	0.00	80.43	(78.99, 81.87)	0.00	82.98	(75.44, 90.52)	0.00
T2	0.08	(− 0.65, 0.80)	0.84	0.08	(− 0.64, 0.80)	0.83	0.05	(− 0.67, 0.77)	0.89
T3	− 0.25	(− 0.96, 0.45)	0.48	− 0.23	(− 0.94, 0.48)	0.53	− 0.25	(− 0.96, 0.46)	0.49
T4	0.49	(− 0.24, 1.22)	0.19	0.50	(− 0.23, 1.23)	0.18	0.48	(− 0.25, 1.21)	0.20
T5	0.96	(0.23, 1.69)	0.01	0.97	(0.24, 1.70)	0.01	0.94	(0.21, 1.66)	0.01
% HAL SS	0.06	(− 0.02, 0.14)	0.13	0.07	(− 0.01, 0.16)	0.09	0.07	(− 0.01, 0.16)	0.10
T2 * % HALss	− 0.08	(− 0.18, 0.02)	0.11	− 0.08	(− 0.18, 0.02)	0.11	− 0.08	(− 0.18, 0.02)	0.13
T3 * % HALss	− 0.04	(− 0.13, 0.05)	0.38	− 0.04	(− 0.13, 0.05)	0.34	− 0.04	(− 0.13, 0.05)	0.37
T4 * % HALss	− 0.09	(− 0.18, 0.01)	**0.07**	− 0.09	(− 0.19, 0.01)	**0.06**	− 0.09	(− 0.18, 0.01)	**0.07**
T5 * % HALss	− 0.04	(− 0.13, 0.05)	0.41	− 0.04	(− 0.13, 0.05)	0.38	− 0.04	(− 0.13, 0.06)	0.44
% HAL				− 0.03	(− 0.09, 0.04)	0.44	− 0.03	(− 0.10, 0.03)	0.36
Sex female							− 14.88	(− 17.43, − 12.34)	0.00
Age							0.38	(0.07, 0.68)	0.02
Group treatment							− 0.77	(− 3.06, 1.51)	0.51
The reference categories is baseline/T1 (for time)									

A final exploratory analysis tested for an association between weight loss and %HALss among treatment participants, stratifying the models by sex. Among females, there was a significant association between weight loss and %HALss at 6 months (Beta= −0.20; *p*< 0.05). For every 20% increase in social support received on HAL posts, females in the treatment group lost an additional 4 kg (9 lbs) from baseline to 6 months. No significant associations were found among males in the treatment group (Table 4.3).

Table 4.3. Coefficients for the linear mixed model testing for association between receiving social support for talking about HAL on Facebook and change in weight (kg) by sex in the treatment group

	Female treatment group			Male treatment group		
	Beta (CI)		***p***	**Beta (CI)**		***p***
Intercept	68.14	(53.92, 82.35)	0.00	86.31	(70.82, 101.79)	0.00
T2	**0.12**	**(− 1.02, 1.26)**	**0.84**	**− 1.98**	**(− 3.97, 0.00)**	**0.05**
T3	− 0.17	(− 1.31, 0.96)	0.76	− 2.88	(− 4.86, − 0.89)	0.01
T4	0.59	(− 0.56, 1.74)	0.31	− 0.87	(− 3.17, 1.43)	0.46
T5	1.35	(0.13, 2.57)	0.03	− 0.44	(− 2.41, 1.54)	0.66
% HAL SS	0.16	(0.00, 0.32)	0.05	0.04	(− 0.15, 0.23)	0.70
T2 * % HALss	− 0.20	(− 0.37, − 0.04)	**0.02***	0.01	(− 0.20, 0.22)	0.92
T3 * % HALss	− 0.13	(− 0.28, 0.03)	0.12	0.07	(− 0.14, 0.28)	0.51
T4 * % HALss	− 0.13	(− 0.30, 0.03)	0.11	− 0.08	(− 0.33, 0.17)	0.55
T5 * % HALss	− 0.11	(− 0.28, 0.07)	0.22	− 0.03	(− 0.22, 0.15)	0.72
% HAL	− 0.07	(− 0.21, 0.08)	0.36	− 0.06	(− 0.22, 0.11)	0.50
Age	0.36	(− 0.28, 1.00)	0.27	0.22	(− 0.42, 0.85)	0.51
The reference categories is baseline/T1 (for time)						

DISCUSSION

This study found no significant association between posting about healthy-active-living (HAL) and weight loss. There was also no significant association between receiving social support for posting about HAL and weight loss among all participants. However, the direction of the relationship between receiving social support for HAL and weight loss was consistently negative over time and approached significance at 18 (*p*=0.07) months of study participation. Further, although there was no significant difference between intervention groups, exploratory analyses revealed a significant association within females in the treatment group at 6 months.

Although previous work demonstrated that individuals who shared about their health behaviors and goals in online social networks were more likely to

achieve desired health outcomes (Munson, Krupka, Richardson, & Resnick, 2015; Pechmann, Pan, Delucchi, Lakon, & Prochaska, 2015), these studies examined highly specified online communication. For example, Pechmann and colleagues (Pechmann, Pan, Delucchi, Lakon, & Prochaska, 2015) manually coded tweets about smoking, assigning them to one of 15 categories such as "countering roadblocks to quitting." This approach to understanding what social media chatter

was related to health differs from the approach used here, which was significantly broader and more inclusive, using language more loosely associated with the health outcome of interest (i.e., weight loss). It is possible that by using single unigrams (e.g., oatmeal, 5K) to classify Facebook posts as being about HAL versus not, this study introduced measurement error and was unable to correctly classify a large proportion of true positives that would have required a more nuanced classification/coding tool for identification.

Also different from earlier work, which surveyed communication among restricted audiences from the social network (Munson, Krupka, Richardson, & Resnick, 2015; Pechmann, Pan, Delucchi, Lakon, & Prochaska, 2015), the present study tested whether sharing about and receiving social support for HAL with users' entire social network was associated with weight loss. The prevalence of sharing about personal health on social media is known to vary based on users' concerns about privacy, managing others' impression of the self, and feelings such as Facebook not being an appropriate platform for this type of communication (Lampinen, Tamminen, & Oulasvirta, 2009; Merchant, Weibel, Patrick, Fowler,

Norman, Gupta, Servetas, Calfas, Raste, Pina, Donohue, Griswold, & Marshall, 2014; Newman, Lauterbach, Munson, Resnick, & Morris, 2011) (Paper 1). Among college students, an estimated 75% of Facebook network connections are between weak ties (Manago, Taylor, & Greenfield, 2012). Compounded by the fact that many college students are in a state of life transition and establishing a self-identity as an independent young adult, many students may be hesitant to share their behavioral goals with their entire Facebook network. A low prevalence of posting about HAL, and subsequent low prevalence of receiving social support for HAL posts, suggests that a larger sample size than what was used here may be needed to detect the association between social support for talking about HAL on Facebook and weight loss. Further, including a survey measure identifying the extent to which users are willing to share about HAL may explain variance in the relationship between social support for HAL posting, and weight loss.

Despite the present study not finding support for a difference between the control and treatment groups in terms of HAL communication and weight loss, exploratory findings indicated that among females in the treatment group, receiving social support for HAL posts was associated with weight loss at 6 months of study participation. Receiving social support for weight-related behavior change may be especially important for females in behavioral interventions. Previous work has found that women are more likely than men to report using Facebook to receive social support from their network (Smith, 2014).

STRENGTHS AND LIMITATIONS

This study took a novel approach to testing how Facebook users' communication was related to weight loss by building a dictionary classifier to categorize posts as being about HAL versus not. Although this dictionary was iteratively built and underwent validity testing, it was limited in that it missed classifying a large number of true positives (poor sensitivity) (Paper 2). As such, the present study may have been underpowered to observe the hypothesized effects between posting about and receiving social support for HAL and weight loss. In addition, it may be that exercise and diet related posts ought to be considered separately rather than combined into a single dictionary classifier.

The present study also may be limited in that it defined social support as the sum of likes and comments, thereby giving these different types of feedback equal weight. Given that Facebook comments represent a deeper level of communication or connection than likes (Burke & Kraut, 2014) , it may be that these two modes of communication should be evaluated separately.

Finally, this study is limited in that it cannot conclude causality. The results do not indicate whether losing weight causes people to share more about HAL, and receive correspondingly more social support for HAL, or if receiving social support for HAL causes people to lose weight. Nevertheless, it is likely that this relationship is cyclical and mutually reinforcing. Users likely post about HAL to elicit social support for behavior change efforts and weight loss goals and, receiving social support for these posts likely motivates individuals to engage in health-enhancing

behaviors. As individuals begin to see results, they are likely to post more about HAL and receive further social support.

CONCLUSION

This study found limited evidence for the relationship between receiving social support for posting about healthy-active-living (HAL) on Facebook and weight loss. The dictionary used to classify posts contained single diet and exercise unigrams, which may have limited the study's power to detect a significant relationship. However, among female participants in the treatment group, there was a significant association between receiving social support for HAL posts and weight loss at 6 months of study participation. Future work will test whether intervention engagement explains this finding.

Future work will also test how to improve the dictionary classifier, and how friendships among network members may influence the relationship between online social support for HAL and weight loss.

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