

Life After Weight Loss: Design Implications for Community-based Long-term Weight Management

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Abstract. The pervasiveness of online health communities and recent exponential growth of health tracking technologies provide new possibilities for weight management, an important health issue that remains prevalent. To enhance the understanding of how to support them to succeed, we investigate people's practices and experiences over the course of weight management, interviewing users from a well-established online peer-to-peer weight management community that integrates a calorie tracking tool. We find that support for weight loss *maintenance* was surprisingly overlooked, which we identify as a missed opportunity both for recognizing and leveraging individual member's success and for enhancing community development. Our findings further characterize the changes people experience when they have transited from weight loss to weight loss maintenance. These changes of experience converge onto four facets, including motivation, goal recognition, social support, and social presence. We discuss the specific challenges and associated design opportunities these changes of experience afford for supporting long-term success of weight management.

Keywords: Design, Online health communities, Health tracking technology, Weight loss maintenance, Weight management

1. Introduction

Weight management, reaching and maintaining a healthy weight, is of tremendous importance for overall health and wellbeing. It can mitigate the increased risks resulting from overweight and obesity, such as diabetes, hypertension, heart diseases, and cancers (NHLBI Obesity Education Initiative Expert Panel on the Identification, Evaluation, and Treatment of Obesity in Adults (US) 1998). Despite the growing societal attention, weight problems remain highly prevalent. An analysis of the US population in 2009–2010 reveals that 7 out of 10 Americans are overweight, and a third of the adult population (35.5 % men and 35.8 % women) are obese (Fryar et al. 2012).

Weight management often involves a relatively long process of behavior change or lifestyle intervention; its success has been limited. A recent Gallup poll of the U.S. adults showed that 51 % of them want to lose weight and nearly 6 in 10 are heavier than their ideal weight (Brown 2013). However, clinical research has widely reported that the majority of people do not succeed in weight loss; and, even if they do initially

lose some weight, 80 % or more fail to maintain their weight loss (Wing and Hill 2001).

While traditional clinical therapy remains a viable option, the emerging Internet-based innovations are becoming appealing alternatives. Online health communities are one type of those innovations, serving people with various health-related concerns, including weight loss (e.g., SparkPeople, DailyStrength, PatientsLikeMe, LiveStrong.com). Research has characterized types of support these communities provide and evaluated their effects on health outcomes (e.g., (Eysenbach et al. 2004; Coulson et al. 2007; Wright 2009; Hwang et al. 2010; Wang et al. 2012)). Peer-to-peer communities, the primary paradigm for online health support, have been found effective in providing informational and emotional support, even though some research has raised concerns regarding information quality and negative social influences (Frost and Massagli 2008; Wright 2009).

Recently, infrastructures for online health communities, as for all online communities, have shown significant development, incorporating advances in social media, persuasive technology, mobile and wearable devices, as well as various health tracking applications. The majority of those tools rely on strategies of improving data capture and encouraging personal motivations to support or even persuade people to change their unhealthy diets or sedentary lifestyles (e.g., MyFitnessPal, FitBit, UbiFit Garden (Consolvo et al. 2008)), Wellness Diary (Mattila et al. 2008), PmEB (Tsai et al. 2007)). Aside from the focus on individuals, a growing number of researchers and practitioners have also experimented to integrate social sharing into their designs (e.g., (Consolvo et al. 2006; Lin et al. 2006)). Yet, these efforts that attempt to collect, record and analyze personal health information at large scale and beyond the conventional qualitative and narrative form are still exploratory. Our study is tasked to understand the practices and experiences of people engaged with those novel technological affordances, which allows us to discover design opportunities to advance such efforts.

Distinct from the focus on behavioral or weight-related outcomes, our primary goal is to unfold people's experiences over the fairly long term of weight management, especially what facilitates and what hinders their managing process as well as how the infrastructures are being appropriated. This goal distinguishes our study from the ones assessing interventions' effectiveness (e.g., clinical studies) and the ones using technology probes to elicit user needs and field-test technologies within a relatively short period (e.g., (Consolvo et al. 2008)). To this end, we interviewed members of an established peer-centered weight management community that provides a calorie tracking tool. The community and the tool were chosen because they are highly relevant—both the community spaces and the tracking tool have received, and are still engaging active and extensive uses—and they have implemented the common design strategies adopted in most existing research prototypes and commercial products. Our participants' reflections upon their practices and experiences revealed a lack of support for weight loss maintenance, an issue that has received disproportional research efforts to its acknowledged importance from the medical

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field, and has been largely overlooked in the Human-Computer Interaction (HCI) community. This is associated with the changes people experience over the course, which we hypothesize would entail specific socio-technical designs to accommodate. We synthesize and characterize these changes into four facets, motivation, goal recognition, social support, and social presence. We further articulate three specific design challenges and associated opportunities for weight management community to better support weight loss maintenance, including reframing progress, evolving identities, and leveraging tracking data.

Our study contributes to research and design in three ways, (1) characterization of the changes people experience over the long term of weight management, (2) identification of three challenges in designing socio-technical infrastructures to support long-term weight management success, and (3) articulation of a design perspective that supports weight loss maintenance.

2. Background

2.1. Long-term Success of Weight Management

Weight loss is challenging, but maintaining weight loss is even harder and ultimately determines the long-term success of weight management. Losing 10 % of initial body weight is commonly defined as weight loss success because clinical evidence suggests that a 10 % weight loss frequently entrains substantial beneficial change in health risk factors, even in the case of extreme obesity (NHLBI Obesity Education Initiative Expert Panel on the Identification, Evaluation, and Treatment of Obesity in Adults (US) 1998). Success in weight loss maintenance has a less standard criterion; maintaining the loss of 10 % weight for at least 1 year is often used as a measure, though 5-year maintenance follow-ups are more desirable (Jeffery et al. 2000; Wing and Hill 2001). About 20 % of participants are able to maintain a weight loss of at least 10 % of initial body weight for over 5 years, but the vast majority fail to maintain their weight loss for even 1 to 2 years after the initial loss, and some rebound to an even higher weight than their starting baseline (Wing and Hill 2001).

Despite its importance, maintenance of weight loss has received very limited attention from the relevant research communities (Jeffery et al. 2000; Fjeldsoe et al. 2011). The existing efforts were mostly focused on identifying the differential factors between successful weight loss maintenance and weight regain. They suggest that a variety of behavioral, psychological, and social factors are associated with successful weight loss maintenance, including maintaining a physically active lifestyle, regular and healthy meals, self-monitoring, good coping strategies and ability to handle life stress, self-efficacy, and social support (Wing and Hill 2001; Elfhag and Rössner 2005; Chambers and Swanson 2012; Reyes et al. 2012). In contrast, people who regained lost weight exhibited a lack of vigilance regarding weight control, tended to evaluate self-worth in terms of weight and shape, were inclined to use eating to regulate mood, and adopted a dichotomous (black-and-white) thinking style (Byrne

et al. 2003; Elfhag and Rössner 2005; Chambers and Swanson 2012; Reyes et al. 2012). Additionally, failure of weight loss maintenance was attributed to the low level of pleasure relative to effort in weight loss maintenance (Klem et al. 2000).

Aside from comparison between people who succeed in maintaining weight loss and who fail, differences between initial change and long-term maintenance remain ambiguous, leaving uncertainty of whether and how to design different support strategies (Jeffery et al. 2000; Fjeldsoe et al. 2011). Rothman (Rothman 2000) pointed out the distinction between initiation and maintenance of health behaviors, and the need to specify factors that differentially affect initial change and long-term maintenance. A recent survey outlined several behavioral differences between weight loss and weight loss maintenance, suggesting that practices of eating low-fat sources of protein, following a consistent exercise routine, rewarding oneself for adherence to one's diet or exercise plan, and reminding oneself of the original intention of managing one's weight were associated with weight loss maintenance but not initial weight loss (Sciamanna et al. 2011).

With respect to strategies to support weight management or behavioral change in general, the National Cancer Institute (NCI) suggested integrating theories in health promotion practice (Rimer and Glanz 2005). In its guide, the transtheoretical model (Prochaska and Velicer 1997) is the theory that directly acknowledges maintenance as a distinct stage. The model posits that as a person attempts to change a behavior, s/he moves through five stages (six if the termination stage is included), precontemplation, contemplation, preparation, action, and maintenance. These descriptions of stages, as a core contribution of the model, indicate when particular shifts in intentions and behaviors between stages occur. The other key component in the model, the processes of change, describes how these shifts occur. In particular, progressing from the action stage to the maintenance stage is mediated by counter-conditioning, helping relationships, contingency management, and stimulus control. Another health theory discussed in the NCI's guide, the health belief model, is also widely applied to designing and evaluating health interventions (Janz and Becker 1984). It was developed in 1950s by a group of U.S. Public Health Service social psychologists to explain when people are ready to act on their problem behaviors. Specifically, six main constructs influencing people's decisions include perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cue to action, and self-efficacy.

In contrast to the existing health/behavior change theories, our investigation has a different pursuit, as to complement the understanding with the perspective of personal experiences. Theories like the health belief model and the transtheoretical model are important foundation of designing and evaluating health interventions. They explain or predict the changes of health behaviors. Different from the transtheoretical model's focus on triggering shifts or transitions between stages, we attempt to understand the support people need for their overall journey beyond the "transiting" moments. In addition, we do not restrict the definition of stage boundary between action and maintenance, given its ambiguity and controversy critiqued by

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other researchers (e.g., (Bandura 1998)). Instead, we take into consideration of people's perception—achieving targeted weight as reaching the state of weight loss maintenance.

In regard to supporting mechanism design, interventions leveraging social interactions have shown some promise for weight loss maintenance, but are largely limited to follow-up contacts with health professionals and involvement of family in the medical field (Jeffery et al. 2000; Fjeldsoe et al. 2011). The development of social media, persuasive technology, mobile devices, and various wearable or tracking technologies allow interactions with a much larger group of people, whose engagement is voluntary and autonomous compared to formal clinical intervention (Orleans 2000) and stages of health conditions are diverse. Our study aims at inspiring new ways of design that leverage those technology advancements.

2.2. Online Health Communities and Support Groups

Online health communities (OHCs) and computer-mediated support groups enable people to connect with peers sharing similar health-related concerns or interests, mostly supporting with relatively conventional communication tools like discussion forums, emails, chats, and blogs, while others incorporating the recently emerged social networking features. Although the involvement of professionals, family, and friends in OHCs has its own benefits (e.g., (Mamykina et al. 2008; Maitland and Chalmers 2011; Newman et al. 2011)), we are particularly interested in peer-centered ones, a common type for wellness issues and chronic conditions. Previous research has pointed out that peer expertise differs from and complements clinician expertise; it is personal and experiential, comprised of action strategies and perspectives in narrative style (Hartzler and Pratt 2011).

Researchers have articulated many benefits of OHCs for various health conditions, primarily as an extended support network to families and friends (Eysenbach et al. 2004; Wright 2009; Hwang et al. 2010). Advantages include access to a large group of peers with diverse backgrounds and perspectives, but sharing similar health concerns and experiences, relaxed time and space constraints, mitigated stigma and privacy protection through relative anonymity, and social accountability (Wright 2009). Social support is regarded as the cornerstone of online health communities. It has been found to be positively associated with people's well-being, which can be attributed to its buffering effect (i.e., protecting people from potentially adverse effects of stressful events) and its main or direct effect on well-being of social support (Cohen and Syme 1985). Accordingly, studies have focused on examining the content of social support, such as emotional, informational, and instrumental, and their varying compositional characteristics for different health conditions (e.g., (Coulson et al. 2007; Hwang et al. 2010)). Besides distributed in more conventional discussion forums, conversations also take place in the comments on self-reported personal health information (Frost and Massagli 2008). Frost et al. observed that people find and offer answers for solving specific health-related questions as well as

build and maintain relationships with peers. To obtain pertinent support, especially information and knowledge for solving individualized problems, patients in diabetes support groups were found to operationalize their experiences, share illness trajectories, and develop common understanding towards diabetes management (Huh and Ackerman 2012). Compared to informational support, increased exposure to emotional support was more positively associated with member commitment in OHCs (Wang et al. 2012). Overall, meta-analyses have not identified negative effects of OHCs despite concerns about issues such as misinformation propagated by peers (Eysenbach et al. 2004).

Drawing on the content of user discussions, a recent study on a weight loss community by Li et al. (Li et al. 2014) described different transient states people experienced, including “Binged”, “Frustrated” and “Milestone”, and the mindsets of community members. It reported that when people declare their Milestone state, the community often reaches out to celebrate and acknowledge their achievements, but for many people the milestone is fleeting, as it is time to set another goal. The authors also extrapolated that people in the community often consider the community forum either “a static repository of information to be searched” or “a place to work through an issue or question”. These interpretations indicate that people who lose weight may just leave the community. Overall, research on OHCs has largely emphasized affordances of peer networks rather than online communities, resulting in the understatement of identity commitments, roles, norms, learning, and sense of community. However, research investigating community affordances of OHCs showed that online communities also rely on the norms of reciprocity and support to function (Maloney-Krichmar and Preece 2005; Resnick et al. 2010). Mamykina et al. (Mamykina et al. 2010) also argued that viewing health management from identity construction perspective is important for research and design in technologies for health. Thus, intentional design to support role-based interactions in online health communities may be beneficial.

We follow the community perspective, focusing on people’s involvement with respect to their personal health conditions and their community environment. Most research to date was focused on analyzing the content of postings from users in an online health community without relating that to the progression of their health conditions. They did not consider the changes of the illness experience and personal needs of support as individuals progress along each illness stage and as their involvement in the community increases, which is critical to long-term success of behavioral change.

2.3. Tracking Technologies Related to Weight Management

The design space of leveraging tracking data to support and persuade health-related behavior change is enormous; the main strategies include self-monitoring, goal-setting and feedback, and social sharing, which have all been dedicated to provoking or promoting behavioral changes (Klasnja and Pratt 2012). Due to the limited space

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and our study scope, we primarily cite design examples relevant to weight management, namely the ones with features of tracking dietary and/or physical activities.

Support for self-monitoring is mainly concerned with what to capture, at what level, and in what ways. Tracking tools specifically designed for managing weight often capture weight and activities contributing to calorie consumption and expenditure, including food and nutrition consumption and physical activities. The level of details being captured varies from as simple as overall food quality and energy (e.g., Wellness Diary (Mattila et al. 2008)) to as specific as each food item and its nutrition (e.g., PmEB (Tsai et al. 2007)), providing a tradeoff between ease of use and accuracy. The ways that self-monitoring was achieved were either through manual tracking (e.g., (Tsai et al. 2007; Mattila et al. 2008)) or by sensing technologies (e.g., (Consolvo et al. 2008)).

Another commonly deployed strategy is enabling goal-setting and providing feedback to enhance personal motivation and promote behavioral change. Goal setting theory (Latham and Locke 1991) suggests that a clearly prescribed and challenging yet attainable goal consistently leads to higher performance as long as people are committed to it. Weight management related goals are often defined in terms of weight itself, caloric intake, dietary configuration, and/or exercise level (e.g., (Consolvo et al. 2008; Mattila et al. 2008)). Allowing an optional secondary goal was also found helpful for users to persist during difficult weeks (Consolvo et al. 2008). In addition to comparing variations of goal sources (i.e., who should set the goal) and timeframes (i.e., proximal vs. distal), research has also experimented different ways of feedback and reward provision. Providing feedback about progress towards goals is well recognized as an effective approach to enhance users' self-awareness and the sense of self-efficacy. Feedback presentation ranged from simple charts of raw activity data (e.g., Shakra (Maitland et al. 2006)) to metaphorical abstract representations of activity level (e.g., Breakaway (Jafarainimi et al. 2005)). Most existing applications only reward progress with positive feedback, while some also have punishing mechanisms but evoked mixed feelings (e.g., Fish'n'Steps (Lin et al. 2006)).

A growing number of projects introduced social sharing in their system design for social support, social comparison, social influence, and learning. Social support was implemented by enabling sharing with other users of the system, other members in the OHC (e.g., MyFitnessPal), or family and friends, among which people deliberately select to manage impression and meet health needs (Newman et al. 2011). Social comparison consists of cooperative and competitive strategies. Cooperative mechanisms associate individual performance with collective outcomes to make individuals accountable and committed to their health goals (e.g., (Lin et al. 2006)). For competitive designs, prior research has not reached a consensus about their effectiveness (e.g., enjoyment (Maitland et al. 2006), discouragement (Lin et al. 2006)). Social influence from successful peers, as social cognitive theory (Bandura 1986) suggests, facilitates behavioral change through role-modeling. Sharing experiences and tracking data also provides opportunities of social learning from others,

such as members in the same local community (e.g., EatWell (Grimes et al. 2008)) and from medical professionals (e.g., MAHI (Mamykina et al. 2008)).

Despite the rapid growth of health tracking technologies for supporting behavioral change, the existing literature in HCI has not accounted for maintaining the change after users achieve their targeted health goals, which is critical to the long-term success of weight management. This is partly due to the difficulty in evaluating long-term effects and users' experiences of the early-stage and error-prone systems developed in HCI (Klasnja et al. 2011). Additionally, most of the tracking technologies aiming for behavioral change do not yet have an effective strategy to leverage the larger social and community context that user activities are situated in (Huh et al. 2012), but have rather focused on the individual usage and interpersonal interactions. As He et al. (He et al. 2010) pointed out in their design proposals for changing energy consumption behaviors, "one-size-fits-all" solutions are not effective because the readiness, willingness and competence develop during the behavioral change process. Our study attempts to address these gaps and understand how to design for long-term success of weight management through investigating practices and experiences of long-time users of an OHC that integrates a tracking tool with the aforementioned common design strategies. This effort not only extends work like He et al.'s (He et al. 2010) to the context of weight management, but more importantly, it moves beyond the strategy of motivational feedback to encompass broader social and contextual factors.

3. Method

3.1. Study Design and Context

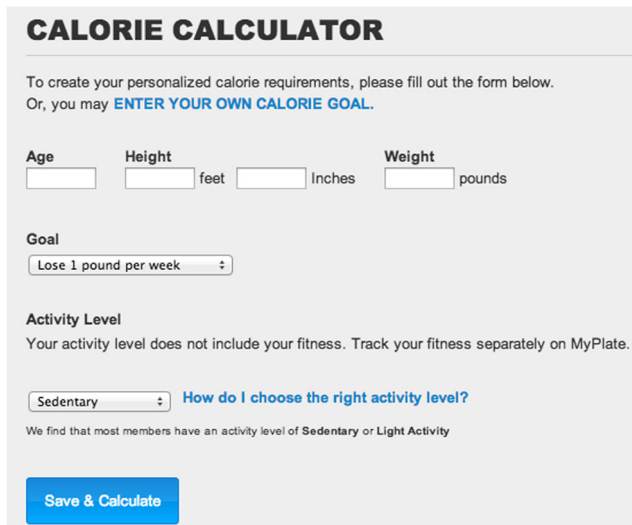
To understand how people leverage online health communities and tracking tools to manage weight, we conducted interviews with users of LiveStrong.com, a well-established online weight management community that provides a widely-adopted tracking application, MyPlate calorie tracker, available in both desktop and mobile versions. Although OHCs are not necessarily effective in health support, they are persuasive in people's daily lives. For LiveStrong.com, it has over four million registered users (as of 2011) since its launch in 2008, and its tracking application for weight management has been installed more than a million times according to XYO.net. People are likely to have many weight management practices beyond LiveStrong.com, but our study was focused on activities directly afforded by the community system.

LiveStrong.com is designed to support healthy living in general through healthy diet and fitness, and most of the active participation has been dedicated to weight management. The MyPlate calorie tracker has incorporated the common design strategies of current tracking technologies summarized in Section 2.3, including self-monitoring, goal setting and feedback, and social sharing. It enables self-monitoring of weight and calorie-related activities as most weight management tools

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do, while at a relatively high level of recording details (i.e., amount and nutrition facts of individual food items, types and lengths of physical activities, weight) and in the form of manual input (i.e., no sensor delivered by MyPlate to automatically capture food or physical activities). Goal setting often involves defining targeted weight, caloric and nutrition intake, as well as types and amount of physical activities. In MyPlate, users can set their weekly weight change goals (i.e., losing/gaining specific amount of weight, or maintaining weight), daily calorie goals, ultimate weight goals, and daily nutrient goals (Figure 1). None of these goals are defined by the system. Instead, users have complete control to configure their goals, or they can adopt system suggestions for some of the goals derived from their other goals or characteristics, including daily calorie goals and daily nutrient goals. Such designs accord with the findings on goal sources, which suggest that self-set goals are more appealing whereas assigned one are not (Consolvo et al. 2009a). MyPlate provides feedback on weight-measured progress. It visualizes users' weight changes with a standard line chart plus a highlighted text-based description, "I've lost <amount of pounds> lbs!".

LiveStrong.com allows social sharing in several ways. One way was to post free-style text messages to LiveStrong.com community groups.¹ Members can create custom groups that are either open to public or private to group members, in addition



CALORIE CALCULATOR

To create your personalized calorie requirements, please fill out the form below.
Or, you may [ENTER YOUR OWN CALORIE GOAL](#).

Age **Height** feet Inches **Weight** pounds

Goal

Activity Level
Your activity level does not include your fitness. Track your fitness separately on MyPlate.
 [How do I choose the right activity level?](#)

We find that most members have an activity level of Sedentary or Light Activity

[Save & Calculate](#)

Figure 1. The interface of MyPlate for setting a weekly weight management goal and a daily calorie goal

¹ This feature was available by the time of our data collection, which was April, 2013.

to the predefined ones. Many active and popular groups have thousands of members. For example, the 100+ Pounds to Lose Group has more than 4000 members. Group spaces are organized in a blog format: they are segmented by dates with members' posts and corresponding comments constituting each segment. Membership is not required to participate in group discussions as long as the group is open to public. Once enrolled as a member of a group, one's calorie tracking data will be aggregated with the data of other group members.

In addition to text-based sharing, LiveStrong.com users can share their structured tracking data of daily calorie goals, calorie consumed, logs of food intake and calorie of each food item and its nutrient breakdown, calorie burned, logs of fitness activities, and net calorie consumed. These records can be presented and shared in two ways. One is called *food diary*, an integral record that consists of tracked food and fitness information and allows other members to comment. Users can configure which items of the tracked data to be shown in the diaries and who can access their diaries (i.e., public, friends only, private, and selected individuals). The other is an aggregate view of group members' daily tracked data, which summarizes part of individuals' data, including calorie goals, calorie consumed, breakdown of nutrient intake, calorie burned, and net calorie consumed. This is similar to the idea of cooperative mechanisms experimented in previous studies (e.g., (Lin et al., 2006)). Both total and average values of these measurements from members who have tracked their activities on that day are shown in a table, which can also be expanded to display data at the individual level (Figure 2). Groups can choose whether to enable this visualization feature in their group space.

LiveStrong.com also implements other common infrastructures of online communities for social interactions, such as discussion forums, email-style private personal messages, and a primitive social networking function. Through the networking function one can add other members as friends; depending on friends' privacy setting, one may receive their activity feeds and access their profile information and food diaries but cannot make comments on any single activity entry (e.g., a food item, a physical activity lasting for a specific time period).

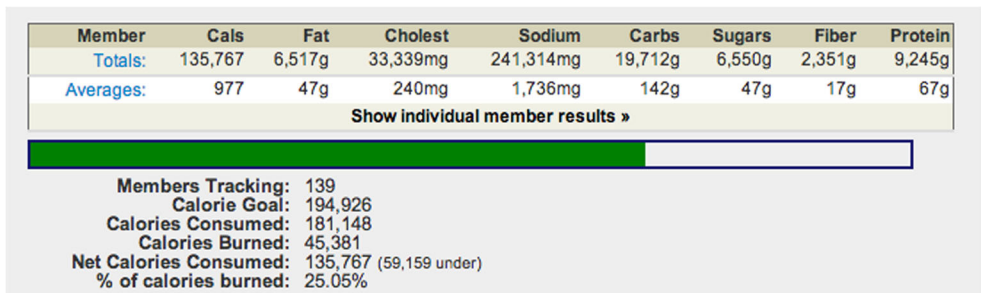


Figure 2. The visualization of aggregate group members' daily tracking data

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The popularity and the focused context of LiveStrong.com provided us a rich environment to study the affordances of online support community integrated with individual tracking data. LiveStrong.com and its tracking tool, MyPlate, also implement the common design strategies in the healthcare support field, which gave us a comparison baseline in our investigation.

3.2. Participant Recruitment and Data Analysis

We recruited and interviewed site users via asynchronous personal message on LiveStrong.com—similar to internal email of the site. Open-ended written response may increase the likelihood of successfully recruiting interviewees, since participants might feel less identifiable than being interviewed in voice. The contact we made with participants was purely through their public information, rather than inquiring about the private phone numbers or other user accounts. As conveyed in written form, these responses did not entail additional transcription. We had acquired IRB approval before we conducted the study. The first author participated in the community as an active participant-observer. The relationship was between the community/community members and the investigator, and it was individually cultivated and included multiple interactions rather than a mass mailing. Furthermore, we did not ask or receive any personal health information from the platform/host. We did not find out anything about the health community members that they did not volunteer, nor did we ask them about health details beyond their community practices.

Our recruitment scripts were sent to users who had posted to a group at least once within the latest month. We also intentionally targeted users who had registered LiveStrong.com for different lengths of time, which enabled us to observe diverse perspectives and experiences and understand community practices comprehensively. We continued our recruitment until a sense of saturation was achieved from our ongoing data analysis, which returned 18 participants in total.

Both interview responses and descriptions in interviewees' public profiles comprised our data sources. Interviews were semi-structured with a set of initial prompts that focused on participants' goal accomplishment, community engagement, and uses of other members' shared tracking data. Specifically, our interview questions asked for reflections with respect to 1) the drivers keeping them motivated and progressing toward their goals, 2) the frustration if they experienced and strategies to cope with it, 3) factors attracting them to join the community and choose a group, 4) reasons for staying in the community, 5) awareness and usage of other users' shared tracking data, and 6) the ways members support each other. We followed up with participants using the personal messages when clarification and elaboration were needed. The method was semi-structured in the way that the interview questions were not completely the same for all the participants. We adapted the flow and a few questions to our observations of individual activities and status. We also asked different follow-up questions, which were contingent on participants' earlier responses. For instance, one participant mentioned she lost 55lbs when she responded

to the question of how she kept herself motivated and progressing towards her goal. Given the significant amount of weight loss, we followed up asking her to elaborate the process of losing that amount. For another participant who reported commenting on others' food diaries as a primary approach to exchange support in the community, we subsequently asked about the purposes and motivations of posting those comments. The final data set consisted of 45 messages in 15,739 words.

The interview responses were analyzed with an open coding approach through an iterative process (Glaser and Strauss 1967). The coding process was not constrained by the structure of interview questions but rather completely open-ended. The first author initially coded all the data collected, which generated 63 codes. Example codes included seeing less visible progress, changing goals for maintenance stage, and joining groups of people with similar goals. The codes were then discussed among all the authors to iteratively merge, refine and identify the most prominent themes. Two rounds of iterations eventually converged onto 4 themes as presented in the result section.

3.3. Participant Overview

Our participants included 12 female and 6 male. We had expected such a skewed distribution of gender, which is a common pattern in online health and weight management communities (Wing and Hill 2001; Eysenbach et al. 2004). As Table 1 shows, all participants frequently logged onto the community and tracked their activities. In the meanwhile, the participants represented a wide range of

Table 1. Participant overview.

	Sex	Time Since Joined	Login and Tracking	Health Goals
P1	F	8 months	2–3 times a day	Maintain weight
P2	F	1 year 2 months	Daily	Maintain weight
P3	F	3 years 7 months	5–6 days a week	Maintain weight
P4	F	5 years 2 months	Daily; not record when traveling	Maintain weight
P5	F	5 years 7 months	Daily	Maintain weight
P6	F	3 years 7 months	5 days a week	Maintain weight
P7	M	9 months	Daily	Maintain weight
P8	M	1 month	>=4 times a day	Lose weight
P9	F	10 months	Daily	Lose weight
P10	M	1 year 8 months	Daily	Lose weight
P11	F	1 month	Daily	Lose weight
P12	M	10 months	Daily	Maintain weight
P13	M	1 year 8 months	Daily	Maintain weight
P14	F	2 years 10 months	3–5 days a week	Lose weight
P15	F	3 years 2 months	Several times a day	Maintain weight
P16	F	3 years 9 months	Several times a day	Lose weight
P17	F	2 years 11 months	Daily	Lose weight
P18	M	9 months	Daily	Lose weight

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characteristics pertinent to their engagement with the online community and its tracking tool as well as their personal weight management goals and status. In regard to different levels of community involvement, our sample included both long-time users and relatively new ones of the site and the tracking application. They had different weight management goals at the time we interviewed them: 8 people were still trying to lose weight; the rest were devoted to maintaining weight, while two of them were focused on being physically active rather than measuring weight. Except these two participants, all had experienced weight loss, ranging from 3 pounds to 155.6 pounds. 7 participants had maintained the loss of 10 % weight for at least 1 year, which is usually considered successful weight loss maintenance. In addition, participants also varied at their ages: 12 people who reported their age ranged from 20s to 60s.

With respect to the use of shared tracking data, nine participants reported having used other individuals' shared food diaries; three mentioned attending to other members' weight progress shared weekly at group weigh-in activities, in which the group moderators collected members' most recent amount of weight loss, ranking their performance and highlighting the best ones. The aggregate view of group members' daily tracking data was found meaningless and irrelevant; only one participant (P7) found it to provide meaningful information and make use of it.

4. Findings

Our analysis found that participants experienced changes with respect to motivation, goal recognition, social support, and social presence when they reached their weight goal and started to maintain their weight loss. In this section, we detail those changing facets and strategies some participants developed to adapt to the changes.

4.1. Motivation

Motivation derived from progress becomes difficult to retain when people are approaching the maintenance stage. The rewarding experiences from the amount of weight lost, the change of physical appearance, and social recognition of the progress all fade away. The excitement and joy from physical activities is replaced with mundane routines.

The majority of participants considered the affordance of self-monitoring and the perception of their own achievement pivotal drivers that kept them motivated to attain their weight management goals. They were rewarded physically, psychologically, and socially for their achieved progress—from experiences of chronic diseases becoming under control, enjoyment from physical activities, the ability to fit into smaller clothes, past achievement of overall weight loss, to high rank of weekly weight loss progress among group members. Such mastery experience, joy, as well as social recognition and comparison motivated participants both intrinsically and extrinsically to persist. These motivators are consistent with social cognitive theory

(Bandura 1986), goal setting theory (Latham and Locke 1991), social comparison (Maitland and Chalmers 2011), and other design guidelines (e.g., (Consolvo et al. 2009b)). LiveStrong.com directly supports some of these incentives, including displaying past weight loss progress within any time period and ranking weekly weight loss progress within some groups through weigh-in activities organized by group moderators.

As participants accomplishing their weight loss goals and entering the maintenance stage, the motivations derived from weight loss progress significantly decreased. Seven participants cited maintaining weight loss as the barrier of their long-term weight management success. In fact, five of them had experienced different degrees of weight regain and had to resume their weight loss goals. Frequent or severe relapses further suppressed participants' motivation. P3 had successfully lost 100 pounds but then regained 50 pounds, which made her very frustrated and developed negative attitude towards her goals.

“I am frustrated by the fact that you just have to keep keep keep at it forever to attain your goals and you can never let up. I know to some that statement might seem silly. It's like saying – ‘I'm so frustrated that I have to sleep every day' or ‘I'm so frustrated that I have to bathe every day'... But I'm being honest. It's how I feel sometimes.”(P3)

One of the difficulties participants pointed out in weight loss maintenance was that the progress was not rewarding anymore and the joy eventually diminished as exercises became mundane. Framing progress and goals based on the amount of weight lost and physical appearance—measurements that are easily accessible—made participants' achievements of weight loss maintenance hardly recognizable for themselves or for their peers. Furthermore, routinized physical activities could not provide as much excitement as they initially did.

“The motivating factors that made it easier to lose weight eventually go away. People stop commenting on how great you look and how much you've lost; the number on the scale stops going down; exercise starts to feel dull and stale.” (P2)

Participants suggested several strategies they developed to increase the visibility of their progress and goal achievement, which were not directly supported by LiveStrong.com. One way was to summarize and emphasize their achievement in their personal profile. The achievement usually encompassed both the amount of weight lost in the past and the duration of successful weight loss maintenance.

“April, 2013, have kept 50–55 pounds OFF for six months!

...2010 ends: 33 pounds lighter! Not working off this extra weight super fast, but still tickled with results.” (P15)

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Some participants also proactively added new goals that contributed to weight loss maintenance but afforded more discernable achievement. These goals mostly regarded fitness activities rather than weight-wise measures. Participants could also regain excitement while maintaining their adherence to the behavior changes they initially made.

“I want to see what new goals & heights I can reach. I want to get better at kickboxing, I want to start a running program, I want to build upper body strength (because as a kid I couldn’t even do monkey bars I had such wimpy muscles).” (P1)

Aside from exploring new goals, some participants overcame the decrease of motivation by focusing on progress beyond their weight, incorporating measures of body figure and composition as well as physical activities.

“Since I lift, I’ll never be willowy and I’ll always be a touch heavier on the scale. I’ve learned to rely more and more on taking measurements and less what the scale tells me my ‘weight’ is. This has evolved over the years, definitely, as I wonder and try to work out what it really means to lose ‘weight’ vs. ‘fat’.” (P6)

“Knowing that fitness wise, I am daily exceeding my own expectations and that’s exciting.” (P4)

4.2. Goal Recognition

As approaching their goal weight, individuals are losing their prior identities defined by their weight loss goals, turning into weight loss maintainers. Lack of recognition of the goal of weight loss maintenance and support for the evolved identity from weight losers to weight loss maintainers discourages member commitment and complicates the meaning of aggregate tracking data.

Weight management goals not only drove participants’ efforts; community recognition of these goals also facilitates their identification with and commitment to the community. Ten out of the eighteen participants chose groups pursuing appealing and suitable goals, such as losing a large amount of weight (e.g., “more than 100 pounds to lose”) and keeping a type of lifestyle (e.g., “eating real food, as unprocessed as possible”). These specific goals defined shared identity, legitimizing member participation and indicating member commitment.

Lack of recognition of the goal of weight loss maintenance discouraged participants from staying in the community when they achieved their weight loss goals. Goal-defined identities were easy for participants to relate to and remain engaged in the community during the pursuit of their personal health goals, because such identities explicitly align personal development with the social environment. However, goal-defined identities were ephemeral; participants might not be aware of the

importance of maintaining weight or lose their legitimacy in the community in which the goal of weight loss maintenance was not recognized. P2 shared her observation of the resignation of other members, attributing that to achievement of weight loss goals. She found it difficult to remain engaged in her weight loss group after reached her weight loss goal.

“Additionally, many members on this site tend to stop logging in and interacting once they reach their goal... and now that I’m only trying to maintain my weight loss, I don’t feel as if I have as much to add to the conversation.” (P2)

Even if weight loss maintainers chose to stay in their initial weight loss groups, not being recognized of their different identities from weight losers increased the ambiguity of the group tracking data. The level of daily calorie and nutrient intake of weight loss maintainers was likely to deviate from that of weight losers in the same group, creating difficulty in comparing with peers and evaluating one’s own performance. For example, P7 was concerned with aggregating data from someone like him at the weight loss maintenance stage with others in the process of weight loss.

“In general, my diet is lower in carbs than the aggregate. I suspect that my exercise has been above the average, but I’m less certain of that. ... [M]y data is included in the conglomerate data, and since I’m no longer interested in losing weight, my calorie intake will somewhat skew the data for the rest of the group.” (P7)

Another reason for the difficulty of using aggregate group data was lack of accountability among group members. Although group membership implied individual commitment to the identity defined by shared goals, participants still did not perceive these goals as joint enterprise requiring interdependence, but rather as independent personal pursuit. This perception was articulated when participants explained why they found the aggregate group data—discrepancy between the total of members’ calorie goals and the actual total of net calorie intake—to be not very useful. Despite the design intention of making group members accountable to each other in not exceeding their calorie goals, participants found it to be too difficult and not important to establishing such accountability for all the other members.

“It only works if all members are logging on and tracking faithfully.” (P3)

“I don’t bother with it. These people are trying to find out what works for them, in their life.” (P6)

Compared to aggregate group data, participants found individual-level data shared within a smaller network of members with whom they had developed relationship to be more effective and feasible at establishing accountability.

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“[Members helped each other through] constant accountability by tracking together and posting weekly weigh-ins.” (P14)

“Most helpful part is the accountability to the relationships I have established.” (P13)

4.3. Social Support

The sources of social support people rely upon, especially peers with similar experiences, significantly fall short when people evolve from weight losers into weight loss maintainers, because many successful weight losers left the community. Other members who are still pursuing weight loss goals constitute the main support sources for maintainers, reminding them of the risks of weight regain and the fulfillment of community leadership.

One of the key benefits of OHCs lies in social support from a large network that is not constrained by physical proximity and is competent to offer empathy and pertinent informational support (Maloney-Krichmar and Preece 2005; Frost and Massagli 2008). All of our participants indicated having received social support from other LiveStrong.com members for their weight loss efforts. However, sources of such support significantly decreased as participants hit the maintenance stage.

In addition to peers with shared goals and interests, peers with similar health-related experiences and attributes were another important source of social support identified by eight participants. Although personal traits were evident classifiers, the experiences that participants could relate to, empathize, and were knowledgeable of were the underlying similarities that enabled effective exchange of social support. For instance, P1 initially joined a group with similar height and had to shift to another one defined by age (40s), in which she could receive better support.

“I initially joined the 5’2” group because there are constraints for a short person working out that tall people don’t get. However, I quickly veered away from this group because while the group members meet the 5’2” or less criteria, this community is comprised mostly of women in their 20’s who have no idea what it’s like to be short and old and trying to get and stay fit and healthy. 8-)... The [Getting Fit and Fabulous Over 40] group is not constrained by a specific height, but they are all people (primarily women) in their 40’s or thereabouts who share their experiences...” (P1)

Another important source of social support cited by five participants was the personal relationships developed through interactions with community members. Shared personal diaries allowed participants to make comments for exchanging social support and maintaining their relationship with their “friends” at LiveStrong.com.

“...several of us look at each other’s food diaries almost every day to cheer each other on, to point out where things might be getting ‘sloppy’ with calories, etc.” (P15)

“...the diary comment option seems to work for my friends and I to stay in touch. I met all of these ‘friends’ in various groups that I was active in before.” (P3)

As participants approaching their weight loss goals and entering the weight loss maintenance stage, such crucial sources of social support became scarce and even inaccessible. The participants who stayed in the community after reaching the maintenance stage associated the lack of social support with their observation that most peers left the community after successfully achieved their weight loss goals, as described in last subsection.

“The only confusion and frustration that I’ve experienced have been in adjusting to the maintenance period. Figuring out what and how much I can eat now has been more of a challenge than I expected. A lot of attention is paid to the weight loss aspect, but maintaining that weight loss is often neglected. ... it [is] difficult to find support or answers to questions.” (P2)

Despite the lack of peers with weight loss maintenance experiences, participants were supported through helping other members. Interacting with peers who are still trying to lose weight evoked weight loss maintainers’ memory of the struggles, discomfort, and stigma they had experienced, keeping them vigilant against lapsing or regaining.

“...helping others is a reminder to live healthfully myself. Additionally, talking with people who are still trying to lose weight reminds me of what I’ve accomplished.” (P2)

Interacting with peers still in the process of weight loss not only reminded weight loss maintainers of the negative consequences of relapses, but also stimulated them to maintain their performance and contributions for keeping their established visibility or leadership in the community. Such status stimulated them to maintain their performance and contributions. P7 considered himself a leader in the challenge group of losing 100 pounds. After he had reached his goal weight, he still reported his weight regularly in the group weekly weigh-ins, and continued offering help to other members in the group. He believed that the retention would be beneficial for his own weight loss maintenance.

“Remaining active in the challenge keeps me in a visible position which may help me to maintain my weight loss longer”. (P7)

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Another important source of social support cited by five participants was the personal relationships developed through interactions with community members. Shared personal diaries allowed participants to make comments for exchanging social support (e.g., “cheer each other on”, “point out where things might be getting ‘sloppy’ with calories”) and maintaining their relationship with their “friends” at LiveStrong.com (e.g., “stay in touch”).

4.4. Social Presence

As people approaching the maintenance stage, their success of weight loss and their experiences of achieving the success become resources for role modeling and learning. Other community members who are pursuing their weight loss goals can benefit from the weight maintainers’ social presence. Meanwhile, their presence to weight maintainers stimulates efforts of maintaining weight loss. However, the visibility of weight maintainers at LiveStrong.com did not increase because of their superior experiences or significant contributions; instead, they might face even more difficulty in managing their social presence.

Participants evolved from support seekers to support givers when they acquired more experience and competence of losing weight and eventually hit the maintenance stage. Aside from interpersonal interactions, their practices captured in their tracked daily activities and their storytelling constructed a shared repertoire, from which other community members could gain empowerment, inspiration, and knowledge.

Seven participants perceived the presence of members who had succeeded in losing weight as critical drivers of their sustained motivations. Although social cognitive theory (Bandura 1986) has already suggested the positive influence of such vicarious experience and its effects on enhancing self-efficacy, researchers still lack understanding of how to match and maximize the similarity between individuals and the successful models, which determines the degree of influence (Fox and Bailenson 2009).

Besides similar physical characteristics (e.g., (Fox and Bailenson 2009)) or contextual environment (e.g., local communities (Grimes et al. 2008)) suggested by previous studies, our participants emphasized the importance of similar practices—both facilitative and inhibitive to their goal achievement—of role models. For example, members who had lost and maintained a large amount of weight enhanced P17’s confidence in her approaches that were similar to the maintainers.

“...meeting people who have ACTUALLY LOST [100+ pounds] weight and continue to keep it off helps me believe it is possible to do it with good diet and exercise practices and not tricks or fads.” (P17)

Similar practices that impede weight maintainers' goal attainment can also increase participants' confidence in overcoming these obstacles. P4's work schedule required a lot of traveling, which caused difficulty in maintaining the healthy diet that she could usually prepare easily at home. Successful weight loss maintainers who also traveled a lot validated the feasibility of not gaining weight while traveling.

"I see people succeeding at not gaining weight who are working the same schedule, so I know it's possible." (P4)

The presence of weight loss maintainers did not just generate psychological benefits (i.e., enhanced self-efficacy); moreover, their practices captured by their storytelling and their tracked daily activities comprised a shared repertoire, from which other members could gain experiential knowledge that professional medical sources could hardly provide.

"I read thru other success stories on the Forums and just try to relate and incorporate some part of it into my real life." (P18)

Activity tracking and sharing afford new ways to record, organize, and access the practice-based knowledge other than unstructured narratives. A few participants used other members' shared tracking data—daily diaries—to learn how to improve their performance. Diet-related knowledge was one type of information participants attempted to discover. Although MyPlate maintains a large database for identifying calorie and nutrient composition of food items, how such information relates to effective practices and ultimately leads to good weight-related outcomes is not externalized by the current design. Some participants studied the shared diaries of successful members to make such association, learning how to compose their diet plans.

"I like to see how people who are losing consistently are eating." (P4)

In addition to supporting weight losers in the community with their presence, weight loss maintainers also benefited from the presence of weight losers, primarily through direct interactions. Helping people who were still trying to lose weight evoked weight loss maintainers' memory of the struggles, discomfort, and stigma they had experienced, keeping them vigilant against lapsing or regaining.

"...helping others is a reminder to live healthfully myself. Additionally, talking with people who are still trying to lose weight reminds me of what I've accomplished." (P2)

The diverse practices shared by members who attempted to lose weight also enhanced the competence of weight loss maintainers to provide help. P6 reported such experience:

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“Those who share, ... whatever I learn from them might help someone else who is having difficulties. The more I know about what others do, the more varied a response I can offer to people who have questions.” (P6)

Despite the ability to serve as role-models and learning resources, weight loss maintainers had to spend great efforts maintaining their social presence. One reason is that any member's social presence depends on the recentness and intensity of their participation rather than their accumulated contributions. At LiveStrong.com, community conversations are categorized and ordered by the time of the original post. Such design may facilitate support to be provided to the most recent request instead of the last replied one or the most discussed one, preventing a few requests from receiving the major part of community attention whereas many other unattended ones quickly becoming invisible. This characteristic differs from the common forum design of traditional online health communities and is similar to the social interaction designs often deployed in more recent community infrastructures (e.g., social media feeds). Nevertheless, weight loss maintainers had to constantly contribute in order to maintain their leadership, and their presence was also subject to support seekers' participation and needs.

“... now that I'm only trying to maintain my weight loss, I don't feel as if I have as much to add to the conversation.” (P2)

“Remaining active in the challenge keeps me in a visible position which may help me to maintain my weight loss longer”. (P7)

Weight loss achievement of weight loss maintainers motivated themselves to keep good performance for a positive image in the community. However, it sometimes also incurred stress on these maintainers. For example, P7 considered himself a leader in LiveStrong.com community. He described such a scenario, in which he “started freaking out” by a little slip and “took a while to sink in (pride is tough to overcome)”.

5. Discussion

Our analysis characterizes people's practices and experiences over the course of pursuing a healthy lifestyle, primarily managing their weight, in an online weight management community with tools for data tracking and sharing. As they transitioned from weight loss to weight loss maintenance, their identities have also been transformed and the four sources supporting their weight management are diminishing. These findings point to the missing opportunity of supporting weight loss maintenance. In this section, we articulate how our findings will enhance the understanding of technology-mediated long-term weight management, and further suggest implications for designing personal and ubiquitous computing systems that integrate social interactions to support long-term success of weight management.

5.1. Understanding Technology-mediated Long-term Weight Management

Our investigation is focused on the perspective of personal experiences, which distinguishes our contributions from the existing theories and empirical studies that emphasize behavioral or weight-defined outcomes. We characterize the changes people experience when they progress from weight loss to weight loss maintenance, including motivation, goal recognition, social support, and social presence. The importance of the four constructs has been acknowledged to different extent by health psychology theories, such as motivation in the transtheoretical model (Prochaska and Velicer 1997), goal recognition in the theory on goal setting (Latham and Locke 1991), and social support in numerous clinical studies (Cohen and Syme 1985). Those theories also provide insights to help explain how these facets affect people's behavior and eventually their health conditions. Our findings confirm the importance of those facets. But more importantly, we point out what those changing facets are, especially the social aspects, all of which have not been articulated in prior research to our best knowledge.

The changed experience with respect to motivation probably relates to the changes of perceived benefits and perceived barriers, two factors in the health belief model (Janz and Becker 1984). Participants' responses indicate that motivation is not just vital for driving people moving through stages as the transtheoretical model (Prochaska and Velicer 1997) suggests, but also affects the entire experience of maintaining weight loss.

Our results also extend the characterization of goal-setting's benefits from personal regulation and control to the broader social context, as the maintenance goal defines people's identities and influences their commitment to the community. Li et al.'s paper (Li et al., 2014) enumerated reasons that may account for people's decision of leaving their community, such as the fleeting milestones and informational/problem-solving view of the community. In contrast, our analysis characterizes the experiences and perspectives of the people who did not leave but stayed in the community after losing weight and how they perceived the leaving of others. These people explained that they felt it beneficial to interact with other community members, who could remind them of the pains they had suffered and make them stay alerted from relapsing. They also interpreted others' people's leaving as a result of achieving the weight loss goal.

Social support is often considered to come from various sources, such as family, medical professionals, and peers with similar health conditions. The changing facet regarding social support provides more nuanced views on social support. It stresses the importance of peers with similar goals, as they are perceived competent to provide pertinent support, whereas personal traits are not necessarily effective indicators for connection. Interestingly, people working on maintenance turn to other sources of social support, peers who are still in the process of weight loss, when the ones with similar goals are not available. Instead of directly receiving emotional or

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informational support from peers, they become supported through offering support to others, who remind them of the consequences of relapse. This perception also differs from downward comparison explained in social comparison theory (Wills 1981). In the situation of downward comparison, people tend to disassociate themselves from the ones in worse conditions; their goal of comparison is to feel good about themselves.

Perceived similarities to peers are also important to social presence, especially role-modeling and learning. While the social comparison theory suggests that people make social comparison to similar others to reduce uncertainties when objective and nonsocial measures of their abilities and opinions are not available (Festinger 1954), our finding on social presence has less to do with self-evaluation but rather awareness, identification and learning. Participants' changed experiences with respect to social presence from weight loss to weight loss maintenance encompass the increased challenge of maintaining others' awareness of their own presence. They started to feel having less to contribute to the conversations, such as posting activity updates and sharing experiences. In the meanwhile, how these weight loss maintainers went through the weight loss process serves as learning resources for other people who are still on the way. Such learning is not for judging their abilities but rather seeking specific answers to their problems.

Our work also sheds light on other health conditions that require long-term management, although maintaining weight loss may be more complex than other behavior change maintenance because maintaining behavior changes (i.e., altering dietary configuration and levels of physical activities) does not necessarily lead to maintaining weight. Ploderer et al. (Ploderer et al. 2013) reported less personal interactions from smoking quitters at later stages in an online smoking cessation community at Facebook, which similarly implies the potential of mobilizing maintainers. We did not observe maintainers broadcasting achievements more than providing support for personal individuals. This may be due to the fact that our context does not involve social networks of family and friends, which often creates tensions of managing impression (Newman et al. 2011).

5.2. Design Implications

Our study highlights the missing support for weight loss maintenance. Support for weight management has largely been designed for short-term weight loss because of various reasons such as resource constraints and high attrition rate, although the importance of weight loss maintenance to its long-term success is widely agreed upon (Jeffery et al. 2000; Wing and Hill 2001). The limited number of interventions for weight loss maintenance was targeting behavior manipulation through clinical trials. A few of them experimented introducing social interactions by medical professionals' follow-up or family's involvement (Jeffery et al. 2000; Fjeldsoe et al. 2011), but interactions between peers was discussed less. In addition, peers in

clinical trials are different from those in a naturalistic setting of an online community, in which peers have various starting time of weight management and are likely to be at different stages.

Our study also complements the current research from the design-related disciplines, such as personal and ubiquitous computing, persuasive technology, and HCI, by characterizing social interactions mediated by advanced technological infrastructures, which consist of tracking tools and features of social media. Such characterization opens up research and practical opportunities of integrating personal tracking activity and data with collaborative practices in a community. Compared to traditional online health communities, structured or semi-structured tracking data captured by mobile or sensor technologies afford new ways of accessing data and applying analytics techniques, which further enable engaging and tailored feedback, flexible configuration of social presence, and various approaches to knowledge discovery. These will in turn enhance user engagement with the technology, facilitating their long-term success of weight management. The increasing ubiquity of conversation posts and activity feeds also deviates from conventional forums; it generates challenges for weight loss maintainers to sustain their social presence and for other weight losers to learn from them. Previous design strategies involving social interactions for persuasive technology and personal and ubiquitous computing tools mainly considered interpersonal exchanges (e.g., Houston (Consolvo et al. 2006), Shakra (Maitland et al. 2006)) and relationships (e.g., (Newman et al. 2011)). In contrast, our study accounts for individual differences with respect to their social roles in the technology-mediated context.

5.2.1. *Reframing Progress*

As motivation derived from progress toward weight loss goals becomes difficult to retain for maintaining weight loss, reframing progress and goals turns into a challenge. Designs for reframing progress and goals can leverage the community to reframe progress that is easy to be perceived by and engaging to the individual and the community. Ultimately, the reframing should transform the progress into a moving variable whose positive direction can be shown as decreasing distance towards a goal contributing to weight maintenance. To determine what are effective framings of weight maintenance progress merits further testing with alternative design solutions.

Aside from guiding individual users to develop broader meaning of progress, designs can also facilitate the importance of weight maintenance to be socially recognized and its progress to be socially re-conceptualized. In addition to the option of setting goals as maintaining weight, showing past achievement of weight loss, progress and accomplishment of other goals as discussed above, and perhaps also recognition and compliment from others in members' public profiles, highlighting them in the community and making them visible when members interact with others, can also provide social rewards for weight maintenance progress. Furthermore, facilitating discussions on weight maintenance at the community level and keeping

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progress framing open to all the members may help reshape attitudes toward maintenance and make the competence in overcoming the challenges of maintaining weight valued.

To address the extinct joy and excitement when fitness activities become mundane, designs can leverage practice-based learning to recommend new workout ideas from other users' shared tracking data. For instance, exercises carried out by other people at the same geographic location would probably be feasible and inspiring for users.

5.2.2. *Evolving Identities*

In the course of approaching their weight loss goals, individuals reciprocate social support to the community and serve as successful role models and learning resources to other members. Meanwhile, they are losing their prior identities defined by their weight loss goals, which in turn causes insufficient social support for themselves because of the dropout of their similar peers. Dropping off the community does not necessarily lead to weight management failures for individual weight maintainers; however, their leave is a failure for the community, and a loss of a critical human resource in sustaining community practices, and developing all community members. Evolving goal-defined identities from weight losers to weight loss maintainers as well as role-based identities from help recipients to help providers becomes a challenge at LiveStrong.com, in which the goal of weight maintenance is not specifically supported and the role of help providers is only implicitly recognized based on their actions. Identity-based commitment is an important way of retaining old-timers (Ren et al. 2012), thus supporting evolving identities can help retain the members who have achieved their weight loss goals. This can further increase the number of their peers with shared goals and similar experiences, which affords a large network for them to receive support.

Retention of members approaching weight loss maintenance was found beneficial for both these members themselves and others in the community. Despite the difficulty in locating peers at the maintenance stage, participants perceived benefits of staying as motivating themselves to maintain their weight. Providing empathy to others who were still trying to lose weight evoked their memory of the struggles, discomfort, and stigma they had experienced, which sustained their motivations of adhering to their new lifestyles. Providing help and being engaged in other activities were also important for maintaining leadership in the community, which would reinforce their incentives to continue their self-management efforts. Furthermore, they were perceived by other community members as successful role models and learning resources that are critical to keeping others motivated and making progress.

To support the evolved identities, communities can make the identity of weight maintenance explicit, such as assigning a social space for weight maintainers and creating an identifier that shows the uniqueness of this identity and accompanies with the individual when interacting with other community members.

Other than simply showing members with maintenance goals are different from others, externalizing role-based identity—coaches—may further legitimate the importance of maintenance and sustain member commitment. Explicitly assigning the role of coaches acknowledges advanced members' values in the community and enhance their sense of responsibilities to initiate interactions with other members in the community, which will reinforce their own motivations to sustain their weight as well. Moreover, such externalization affords that other members aspire to acquire this role, motivating them to make progress. Presenting a group of mentors instead of a single one may also prevent conflicts arising from one person dominating a group and information bias from a single source. Additionally, some flexibility should also be allowed when these members occasionally do not perform well, so that they will not be discouraged from serving the coaching role.

5.2.3. *Leveraging Tracking Data*

Although LiveStrong.com allows users to share their personal tracking data, the actual sharing remained very limited and barely associated with social interactions among users. Our discussion here is focused on how the shared data are used when the decision of sharing them has already been made, rather than with whom and what people would like to share their health data, which Newman et al. have examined (Newman et al. 2011). The limited social uses of others' shared tracking data include failing to interpreting average group data for social comparison, discarding aggregate group data as social accountability of behavior tracking, commenting on food diaries to maintain social relationships and exchange social support, and analyzing tracking food diaries of successful cases (i.e., weight loss maintainers) to model their behaviors or learn food and exercise ideas. The low level of usage indicates the challenge of enacting social interactions with tracking data. However, the current uses of food diaries still suggest their potential to mediate social presence of weight loss maintainers, facilitating interactions between people at different stages of weight management.

The failure of establishing accountability through aggregating group tracking data was similar to Lin et al.'s report regarding people's reactions to cooperative and competitive mechanisms (Lin et al. 2006). As achieving collective goals is not consequential to people of a large and weakly connected network, like the system-defined groups at LiveStrong.com, members are unlikely to commit to the collective goals. Our interpretation may not generalize to other contexts because of LiveStrong.com's specific way of data aggregation. A possible solution is to reduce the group size and externalize a social contract of fulfilling individual responsibilities to reach the goal.

The ambiguity of average group tracking data indicates the complexity and multidimensionality of weight management data, of which an individual's present stage is an overlooked index. Interpreting other individuals' health records often requires access to other personal information that is often difficult to obtain (Huh et al. 2012). In contrast, stage as a grouping index does not require the disclosure of sensitive

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personal identity information. Thus, data averaging may consider capturing this information and implementing it in the calculation.

The mutual awareness of social presence between weight losers and weight loss maintainers is beneficial for both sides, which is partly mediated by shared tracking data. For weight loss maintainers, merely presenting their weight loss achievements is probably not sufficient to facilitate role modeling for weight losers; what is more important is their practices of attaining weight loss goals. People who attempt to lose weight match their similar practices with weight loss maintainers to maximize the effects of role modeling. Furthermore, these people do not just want to know what they did and what was not working, as the design for supporting reflection attempted to address (Mamykina et al. 2008), but also how to do it effectively in a prescriptive way and learn experiential knowledge from successful peers. They seek resources for divergent thinking of lifestyle configuration, such as food ideas. Designs can help users plan their daily activities by recommending them with weight loss maintainers' when the practices of the two parties show some similarity. For instance, when a user logged a food item, the tool can display a list of other items successful weight loss maintainers paired with this food on a day. Privacy may not be a big concern in these circumstances because successful members do not have the problem of stigma but high self-efficacy, and they are often more willing to be recognized by their achievement.

In contrast to the social presence of weight loss maintainers to weight losers, the social presence of weight losers to weight loss maintainers is primarily mediated by conversations on soliciting support. The direct interpersonal interaction keeps maintainers from lapses and relapses. However, they cannot become aware of such solicitations when they just track their own behaviors without checking into the community spaces. Designs that enhance their awareness may facilitate those interactions. Additionally, acknowledging receiving support may further enhance social recognition and role identities of weight loss maintainers, encouraging them to interact more with the rest of the community. The acknowledgement may even create opportunities for weight loss maintainers and weight losers to build connections. It can be as simple as informing weight loss maintainers of who has viewed their recommendations, while features of rating, commenting and highlighting in the community may also help. In the future, when the volume of shared tracking data and public conversations grows exponentially and rapidly as the health support technologies become more ubiquitous, it may present additional challenges for weight loss maintainers to maintain their social presence. Stable identifiers and highly visible profiles indicating accumulated contributions may be a first step to address such challenges.

Our design suggestions on leveraging tracking data extend beyond general interpersonal interactions among peers, stressing the importance of interactions between people in the process of weight loss and people in the process of weight loss maintenance with particular similarities (e.g., work schedule, diet entry). Furthermore, PatientsLikeMe, which Frost and Massagli analyzed (Frost and Massagli

2008), implemented weight loss in a primitive form, suggesting that weight management differs a lot from other diseases. Patients can hardly report their conditions in the structured ways of other health problems, which have relatively clear symptoms and diagnosis. Therefore, our design implications are promising to fill the gap in the design of PatientsLikeMe.

5.3. Limitations

Our study was subject to participants' self-selected bias. People who responded to our interview invitations were likely to have stronger internal motivations, more psychological strength and stability, and more social-oriented to achieve their weight loss and weight loss maintenance goals than the ones who did not respond. Thus, they may perceive fewer barriers and react to social interactions differently. Although people at the weight loss maintenance stage only constitute a part of the weight management community and the needs of support for weight loss maintenance may not be evident to people who have not experienced the stage yet, they are still important for the entire population because weight loss maintenance is an inevitable stage for long-term success of weight management. The challenges we identified may also be limited to our study context; other communities and applications in the field may have addressed some of the issues we have raised, though we are not aware of any research prototypes that did. More importantly, we are proposing a design perspective to complement current design thinking of online health communities.

6. Conclusion

High pervasiveness of online health communities as well as exponential growth of emerging technologies afford new and novel ways of integrating social interactions to the designs for supporting weight management. To explore the emerging opportunities, we studied users' practices and experiences in an established online weight management community with a widely adopted tracking application. Our analysis characterizes the social sources that are decreasing during long-term weight management, including motivation, goal recognition, social support, and social presence. Our findings highlight the overlooked opportunity for supporting weight loss maintenance. We further articulate design implications to leverage social interactions to support long-term success of weight management. Our next step is to develop prototypes that implement our design proposals to test our hypotheses.

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