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Support or competition? How online social networks increase physical activity: A randomized controlled trial☆

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ABSTRACT

To identify what features of online social networks can increase physical activity, we conducted a 4-arm randomized controlled trial in 2014 in Philadelphia, PA. Students ($n = 790$, mean age = 25.2) at an university were randomly assigned to one of four conditions composed of either supportive or competitive relationships and either with individual or team incentives for attending exercise classes. The social comparison condition placed participants into 6-person competitive networks with individual incentives. The social support condition placed participants into 6-person teams with team incentives. The combined condition with both supportive and competitive relationships placed participants into 6-person teams, where participants could compare their team's performance to 5 other teams' performances. The control condition only allowed participants to attend classes with individual incentives. Rewards were based on the total number of classes attended by an individual, or the average number of classes attended by the members of a team. The outcome was the number of classes that participants attended. Data were analyzed using multilevel models in 2014. The mean attendance numbers per week were 35.7, 38.5, 20.3, and 16.8 in the social comparison, the combined, the control, and the social support conditions. Attendance numbers were 90% higher in the social comparison and the combined conditions (mean = 1.9, SE = 0.2) in contrast to the two conditions without comparison (mean = 1.0, SE = 0.2) ($p = 0.003$). Social comparison was more effective for increasing physical activity than social support and its effects did not depend on individual or team incentives.

1. Introduction

Physical inactivity significantly increases the risk of chronic disease (Lee et al., 2001; Sattelmair et al., 2011) and mortality (Nocon et al., 2008; Wen et al., 2011). Low levels of physical activity among young adults remains a serious nationwide problem, with 69% of Americans 18 to 24 years of age failing to meet the federal guidelines for physical activity in 2014 (National Center for Health Statistics, 2015). Among all the social and environmental factors affecting physical activity (Addy et al., 2004; Martin and Savla, 2011), interpersonal social networks are one of the most prominent targets for cost-effective interventions (Maher et al., 2015). Online social networks, in particular, have become a highly attractive target for large scale health initiatives (Centola, 2013; Cobb and Graham, 2012); however, there is insufficient knowledge about why online networks might be effective sources of social influence for improving physical activity levels. One prominent argument in the literature on networks and health suggests that online relationships improve physical activity through supportive interactions that encourage healthy behaviors (Centola, 2010, 2011). An alternative approach stresses peer competition within online networks, emphasizing the value of social comparison as a mechanism for increasing individuals' receptiveness to positive behavioral influences (Foster et al., 2010). We evaluate the effects of each of these approaches independently, and in combination, to determine how social motivations for behavior change directly impact people's exercise activity.

Social support is one of the most widely used and studied strategies for encouraging behavior change in social networks (Berkman et al., 2000). When people with similar interests interact to achieve a shared goal, social support can reduce the perceived costs of adopting a new exercise routine by providing companionship in the activity (Cavallo et al., 2014; Uchino, 2004). Further, social support reduces the uncertainty of exploring new exercises by providing access to relevant sources of peer information (Wing and Jeffery, 1999). Thus, cooperative online relationships, where people work towards the same health goals, can foster collective efficacy for improving everyone's levels of physical activity (Cohen et al., 2006).

While social support via cooperative relationships may promote physical activity, an alternative approach utilizes social comparison via

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competitive social relations (Foster et al., 2010; Zhang et al., 2015). Social comparison strategies are implicit in fitness and exercise programs that use rankings, leader boards, and social status markers to increase physical activity (Festinger, 1954). In these competitive environments, people work towards their goals individually, and differences in goal attainment motivate individuals to adjust their aspirations upward. The dynamic process of comparing oneself to others increases everyone's expectation for goal attainment and eventually improves overall levels of physical activity (Leahey et al., 2012; Shakya et al., 2015).

The number of online social network health interventions has increased dramatically in recent years (Laranjo et al., 2015; Maher et al., 2014; Williams et al., 2014). However, the independent causal effects as well as the interaction effects of these two contrasting approaches have not been identified (Cavallo et al., 2012; Napolitano et al., 2013; Neiger et al., 2012). As a result, there is very little guidance as to how these approaches might be used in applied settings to maximize social resources for increased fitness. This is particularly striking in light of recent meta-analyses of online social network health interventions, which have been inconclusive both on identifying which approaches are most effective, and regarding whether there are any systematic network strategies that can reliably be used to promote physical activity (Maher et al., 2014).

These problems of identification are compounded by the fact that the vast majority of research on online social networks and behavior change supplements social motivations with non-social incentives, such as health education and behavior tracking (Korda and Itani, 2013; Williams et al., 2014). This introduces interaction effects that prevent the identification of how, or whether, social factors can directly motivate behavior change. These shortcomings raise serious theoretical difficulties for developing consistent and replicable theories of how online social networks impact physical activity. They also limit the ability to apply online social network interventions to specific behavioral settings, where clear guidelines are required in order to implement effective interventions. We addressed these problems by conducting a double-blind four-arm randomized controlled study that compared the effects of social support and social comparison on increasing physical activity.

2. Methods

2.1. Study design

An 11-week online social network-based exercise program called SHAPE-UP was conducted at a Northeastern university. The program offered 90 exercise classes. On average, eight classes were offered per week on the University's campus, and each class lasted for an hour. Class content covered both aerobic and muscle-strengthening physical activities, including running, spinning, yoga, Pilates, weight lifting, high intensity interval training, and group exercising. All classes were led by instructors from the Department of Recreation and Health Services (DRHS) at the University. Participation in all classes was restricted to the program participants. At the conclusion of the program, participants were rewarded with gift cards for their participation based on the cumulative number of exercise classes they attended.

All participants in the program received access to the SHAPE-UP website, which was the only way for participants to enroll in classes and to interact with the program. Each participant created an online profile including username, gender, age, and their University affiliation. All participants had continuous and equal access to the website. To register for an exercise class, participants selected available classes from an interactive calendar that provided a brief class description and a registration tool. Upon registering, participants immediately received a confirmation email, and a reminder email was sent 12 h before each class started. An online tracking tool provided all participants with a daily journal of their exercise classes.

Upon logging into the website for the first time, participants were randomly assigned to one of four experimental conditions. Fig. 1 illustrates the four experimental conditions and Table 1 summarizes the different intervention components of the four conditions. Participants in the control condition were given the basic website for registering for classes. The control participants were provided with no social motivations, and were rewarded at the end of the program based on their individual record of attendance at exercise classes. The top 10% of participants in the condition were rewarded $20 gift cards at the end of the program. Three different experimental manipulations supplemented the control condition by providing online peer networks with different social incentives that might increase participation.

The *social comparison* condition supplemented the basic class registration website by giving participants access to 6-person peer networks. Each participant in this condition was randomly assigned 5 peers, which comprised 5 members of the study who were connected to the participant in a program-generated social network. Participants in this condition were able to compare their performance in the program with their peers via a competitive ranking based on their peers' activity levels. As in the control condition, at the conclusion of the program, the rewards for participants were based on each participant's individual record of class attendance. The top 10% of participants in the condition were rewarded $20 gift cards at the end of the program. All peers' information was anonymous, and there was almost no possibility for direct communication between participants in this condition online or offline.

By contrast, the *social support* condition was designed to provide participants with direct peer support from other members of the program who could encourage each other to improve their levels of regular exercise. Participants in this condition were randomly assigned to 6-person teams. At the completion of the program, rewards were based on the team's collective activity levels, incentivizing team members to actively support each other's attendance at exercise classes. All members in the top 10% of teams in the condition were rewarded $20 gift cards at the end of the program. To facilitate supportive social interaction, participants in the social support condition were provided with a chatting tool that they could use to directly communicate with each other in real-time. Team members could see both each other's individual records of class attendance as well as the collective record of the team. Participants in this condition were able to register for classes individually, but they could also coordinate to register for classes collectively.

Finally, to understand if there was an interaction effect of combining the motivations of social support and social comparison, the *combined* condition randomly placed individuals on 6-person teams and provided the same team incentives and technologies as the social support condition; however this condition was supplemented with a competitive feature, in the form of an interface that allowed participants to compare their team's performance against the performances of 5 other teams. All members in the top 5% of teams in the condition were rewarded $20 gift cards at the end of the program.

In these three conditions with online networks, participants in the same network also received real-time web and email notifications about their peers' registration and attendance of classes. For instance, when a network member attended a class, all of her peers would receive a notification about her class attendance. This signaling system was identical for all online networks across conditions.

2.2. Study participants

The SHAPE-UP program was open to all graduate and professional students at the University who were 18 years or older. Participants were recruited through advertisements on the University's website, through the student email list, via advertisements from the graduate student association, and with paper flyers placed on billboards around campus. The recruitment materials specified that the purpose of the project was to improve participants' quality of life through better fitness. Eligibility for enrollment in the study was determined by a physical assessment

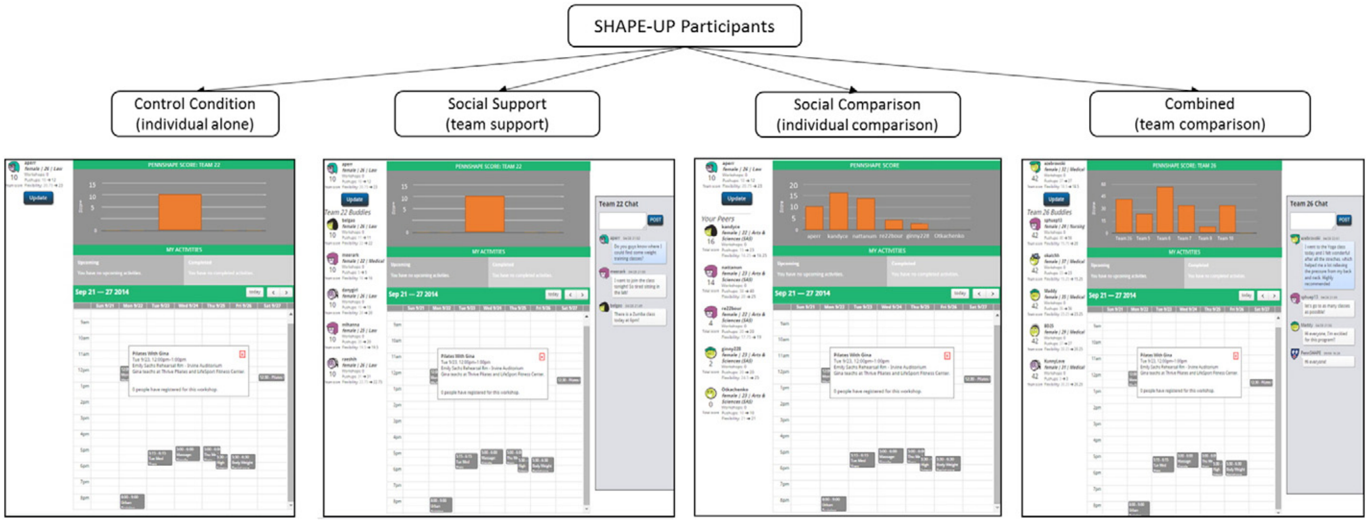

Fig. 1. Example webpage illustrations for the four experimental conditions in the trial, Philadelphia, PA, 2014.

conducted by the DRHS. Each participant completed a screening questionnaire (Canadian Society for Exercise Physiology (CSEP), 2002) designed to identify adults for whom physical activity might be inappropriate. The assessment lasted for 10 min and also measured participants' physical endurance, strength, and Body Mass Index (BMI).

Participant enrollment and assessments were conducted from August through September 2014. Eligible participants completed a baseline online survey assessing demographic and organizational information including gender, age, race, University department, and gym membership. In addition, we assessed participants' baseline physical activity with 3 items the Centers for Disease Control and Prevention (2001) developed concerning the number of days in which people participate in vigorous physical activity for at least 20 min, moderate activity for at least 30 min, and strength-building activities in the past 7 days. Participants were defined as meeting the 2008 federal physical activity guideline (Department of Health and Human Services, 2008) if they engaged in strength-building activity on at least 2 days and engaged in either 20 min of vigorous activity on at least 4 days or 30 min of moderate activity on at least 5 days.

In the RCT design, computer-generated random number sequences were used to randomly assign participants to the 4 experimental conditions after the baseline assessments. The random assignments were generated using the statistical software R, version 3.1.2.

Classes were held from September 2014 through December 2014. Participants and class instructors were blind to experimental assignments. Data collection was completed by December 2014. The study was approved by the institutional review board of the University, and all participants provided informed consent.

2.3. Outcome

The outcome of interest was the total number of exercise classes that participants attended throughout the 11-week program. Complete attendance data for all classes were provided by class instructors. Instructors collected individual attendance data with student emails and entered them into an online database. The attendance records then automatically showed up on participants' websites in real time. Attendance data were collected on site of each exercise class.

2.4. Statistical analysis

A sample size of 688 was planned because 172 participants per condition could achieve at least 90% power to detect a small to medium effect size of 0.35 (Cavallo et al., 2012; Foster et al., 2010; Zhang et al., 2015) in class attendance difference at the 5% significance level. The preliminary analysis consisted of an analysis of variance to examine the effects of social support and social comparison on the outcome, class attendance. However, it did not account for data clustering in the online networks. In each of the conditions with online networks, individuals received the treatment as members of a fully-connected network of 6 individuals, thus the primary analyses employed a multilevel regression model to account for the clustering of the treatment within these groups. The multilevel model included the social support and the social comparison factors, the support × comparison interaction, and covariates of baseline demographics. All analyses used the intention-to-treat principle and considered all participants who were randomly assigned to a condition, regardless of whether or not they received the treatment. All analyses were conducted in R, version 3.1.2.

3. Results

Of the 1007 participants who registered for the program, 790 attended the fitness evaluation and were randomly assigned to a condition. Fig. 2 shows the flow of participants. A total of 750 participants received at least one treatment exposure, as indicated by logging-in to the website. The attrition rates for participants receiving the treatment

Table 1
Intervention components in the four experimental conditions in the trial, Philadelphia, PA, 2014.

Intervention components	Control	Support	Comparison	Combined
SHAPE-UP website with an interactive calendar for class registration	x	x	x	x
Online networks with real-time web and email notifications of peer activities		x	x	x
Online chatting tool		x		x
Access to performance rankings of other peers or other teams			x	x
Rewards based on *individual* performance	x		x	
Rewards based on *team* performance		x		x

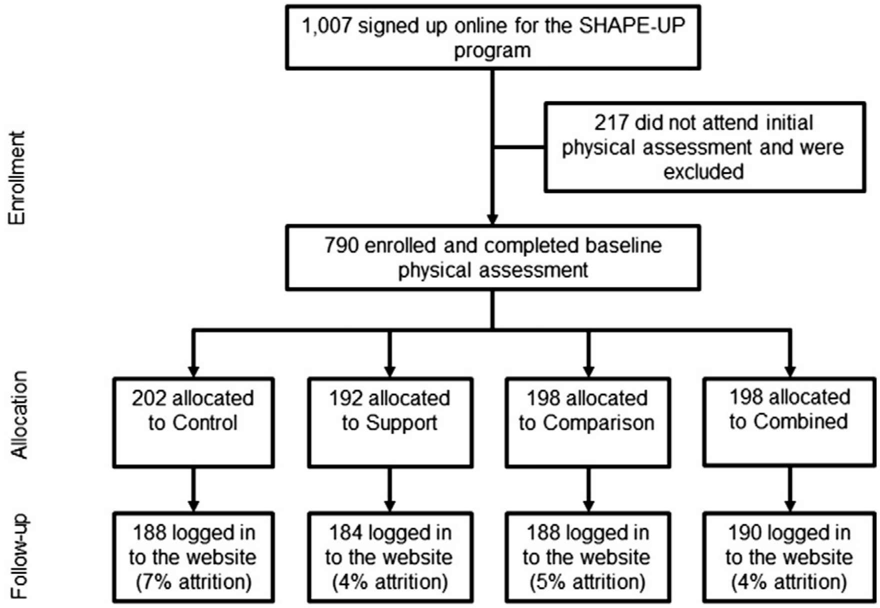

Fig. 2. Flow diagram of participants through the trial.

were statistically indistinguishable across all conditions, with 95% of all participants receiving the treatment.

Table 2 shows participants' characteristics. Participants ranged in age from 20 to 59 years (mean = 25.2, SD = 3.4), and ranged in BMI from 16.1 to 45.0 (mean = 23.0, SD = 3.8). In total, 454 (57.47%) participants did not meet the physical activity guideline. There were no significant differences in participants' characteristics at baseline across conditions.

Participants showed high levels of engagement with the website, averaging 22.8 logins (SD = 47.2) across all conditions during the program. Participants in the social support condition generated 81 online messages and participants in the combined condition generated 80 messages. The majority of the messages provided informational support regarding participants' plans for attending classes, their experiences, and opinions about the classes.

The number of exercise classes that each participant attended ranged from 0 to 39 classes. Attendance rates were 90% higher in the social comparison and the combined conditions (mean = 1.9, SE = 0.2) in contrast to the two conditions without social comparison (mean = 1.0, SE = 0.2). Both the social comparison and the combined conditions had significantly higher mean attendance rates (mean = 1.9, SE = 0.3 and mean = 1.9 SE = 0.2, respectively) than the control (mean = 1.1, SE = 0.3), while social support surprisingly performed worse (mean = 0.9, SE = 0.2). An analysis of variance shows that the presence of social comparison significantly increased activity levels (F = 8.96, $p = 0.003$, Cohen's D = 0.21). In contrast, the presence of social support did not significantly affect participants' exercise levels (F = 0.04, $p = 0.85$, Cohen's D = 0.01). There was no interaction between the two factors (F = 0.18, $p = 0.67$).

Table 3 presents results of the multilevel models that accounted for network-level influences within each condition. On average, social comparison increased attendance by 82% [95% CI: −5%, 168%], or 0.97 classes per participant ($p = 0.07$). After adjusting for baseline covariates, social comparison increased attendances by 62% [95% CI: 5% to 119%], or 1.06 classes per participant ($p = 0.03$). In contrast, social support had no significant effect ($p = 0.68$). Additionally, the non-significant interaction between support and comparison suggests that social support did not contribute to the increased attendance rates in the combined condition. The success of the combined condition can be thus attributed to the effects of team-based social comparison.

The mean class attendances per week were 35.7, 38.5, 20.3, and 16.8 in the social comparison, the combined, the control, and the social

Table 2
Baseline demographic characteristics of participates per experimental condition, Philadelphia, PA, 2014.

Participants (N)	Total 790	Control 202	Support 192	Comparison 198	Combined 198	*p* values
Age (years; M [SD])	25.2 [3.4]	25.0 [2.7]	25.4 [3.5]	25.3 [3.8]	25.1 [3.5]	0.539[c]
Male sex (N [%])	25.9	27.2	26.5	28.3	21.7	0.455[d]
Body Mass Index (kg/m^2; M [SD])	23.0 [3.8]	22.9 [4.0]	22.8 [3.6]	23.4 [3.8]	22.9 [3.7]	0.259[c]
Overweight (BMI [25.0–29.9]; N [%])	124 [15.7]	26 [12.9]	30 [15.6]	37 [18.7]	31 [15.7]	0.465[d]
Obese (BMI ≥ 30; N [%])	42 [5.3]	14 [6.9]	9 [4.7]	10 [5.1]	9 [4.5]	0.547[d]
Met physical activity guideline (N [%])[a]	336 [42.5]	87 [43.1]	80 [41.7]	83 [41.9]	85 [42.9]	0.998[d]
Race (N [%])[b]						0.448[d]
White	352 [44.6]	88 [43.5]	85 [44.3]	100 [50.5]	79 [39.9]	
Black	58 [7.3]	14 [7.9]	12 [6.2]	13 [6.6]	19 [9.6]	
Hispanic	62 [7.8]	15 [7.4]	12 [6.3]	12 [6.1]	23 [11.6]	
Asian	287 [36.3]	73 [36.1]	76 [39.6]	61 [30.8]	77 [38.9]	

[a] Participants met the guideline if they engaged in strength-building activity on at least 2 days and engaged in either 20 min of vigorous activity on at least 4 days or 30 min of moderate activity on at least 5 days.
[b] The omitted race category is "Other."
[c] The *p* values were based on one-way analyses of variance.
[d] The *p* values were based on chi-squared tests.

Table 3
Multilevel models for the effects of experimental conditions on exercise class attendance, Philadelphia, PA, 2014.

	Class attendance	
	Unadjusted for covariates Estimate (95% CI)	Adjusted for covariates Estimate (95% CI)
Comparison	**0.97**[*]	**1.06**[**]
	(−0.06, 2.00)	(0.08, 2.04)
Support	−0.17	−0.21
	(−1.21, 0.88)	(−1.21, 0.79)
Comparison × support	0.18	0.06
	(−1.38, 1.74)	(−1.43, 1.55)
Constant	**1.19**[***]	1.72
	(0.56, 1.82)	(−1.38, 4.82)
Observations (N)	790	789
Log likelihood	−2,309.55	−2,271.03
Akaike Inf. Crit.	4,631.10	4,594.05
Bayesian Inf. Crit.	4,659.14	4,715.49

Notes: Covariates included age, gender, race, department, and having a gym membership in the previous semester. The difference in sample sizes arises from one missing data point for age.
* Boldface indicates statistical significance at $p < 0.1$.
** Boldface indicates statistical significance at $p < 0.05$.
*** Boldface indicates statistical significance at $p < 0.01$.

support conditions. Fig. 3 plots cumulative class attendance in each condition. Both of the conditions with social comparison (i.e., comparison and combined) showed significantly higher levels of attendance each day, averaging 5.1 and 5.5 people attending exercise classes per day, respectively. Both were significantly higher than the average of 2.9 attendances per day ($p < 0.001$) in the control condition. Class attendance in the support condition grew at a significantly slower rate than in the control condition, averaging only 2.4 attendances per day ($p < 0.001$), suggesting that social support reduced daily exercise rates as compared to the control condition.

4. Discussion

Despite the proliferation of online social network health interventions, social influence processes underlying social network effects have remained poorly understood. In this study, we found that social comparison in online networks provided a significantly greater source of social incentives for increasing physical activity than social support. Exposing individuals to relevant reference points, whether those reference points were other individuals or other teams, increased responsiveness to the physical activity of their peers. As a result, attendance at exercise classes was greatest in conditions where individuals and teams were motivated to exercise through competitive social relationships.

Physical activity in the social comparison and control conditions was incentivized based on individual rewards for exercising, while activity in the support condition was incentivized based on group rewards. The differences between the social comparison and social support conditions suggest that the observed reduction in activity in the support condition may be due to the ineffectiveness of collective rewards for motivating exercise. However, exercise levels were greatest in the combined condition, which also used collective rewards to incentivize participation. Moreover, the comparison condition and the combined condition generated nearly identical levels of exercise activity. This suggests that differences in incentives did not affect participants' exercise levels (Halpern et al., 2015; Jeffery et al., 1983; Leahey et al., 2012). Both individual and team rewards were equally effective for motivating activity.

A significant advantage of the four-arm experimental design is the ability to identify the independent and combined effects of social support and social comparison. A two-arm experiment that contrasted, e.g., the social support and social comparison conditions, or the combined condition with the control condition, would have been likely to produce incorrect inferences. For instance, in a two-arm experimental test between the combined condition and the control condition, it would appear as if social support (via team memberships) was effective at motivating increased participation. The four-way comparison between the control condition, social support, social comparison and the combined condition shows the opposite to be true – team memberships were effective for social comparison, but not for social support. It is only when the combined condition is compared independently with the social comparison condition that team memberships are shown not to produce any additional support-based motivations to exercise.

The strengths of this experimental design also entail limitations on the scope of the study. Most notably, while online networks typically evolve through endogenous social selection based on similar interests or characteristics, we artificially constructed the online networks used in this study. While this allowed us to ensure that there were no confounding effects from exogenous social information, it raises the potential concern that endogenous tie selection might create networks that were stronger sources for more effective generation of social support. In other words, our design might underestimate the effects of social support networks. Another limitation is that, although we created different social incentives in the experimental conditions, we did not measure psychological variables after the intervention, including perceived social support and social comparison. Thus, we were not able to conduct mediation analyses to test whether the intervention effects were mediated through hypothesized mechanisms. It was possible that the comparison incentive also increased participants' perceived descriptive social norms regarding physical activity as participants might pay more attention to other peers' efforts under the competitive mindset. Similarly we were not able to quantify the extent of class registration coordination among team members. Future research can extend our design with mediation surveys to identify the hypothesized psychological variables and with process evaluations to quantify participants' engagement with different components of the program. Finally, findings from this study sample are based on young adults from one university and may not be generalizable to other segments of the broader population. Future research can apply this design to study other population samples in other social contexts, as well as to study additional outcomes measures (e.g., body weight and muscle strength) that might be studied over longer periods of time.

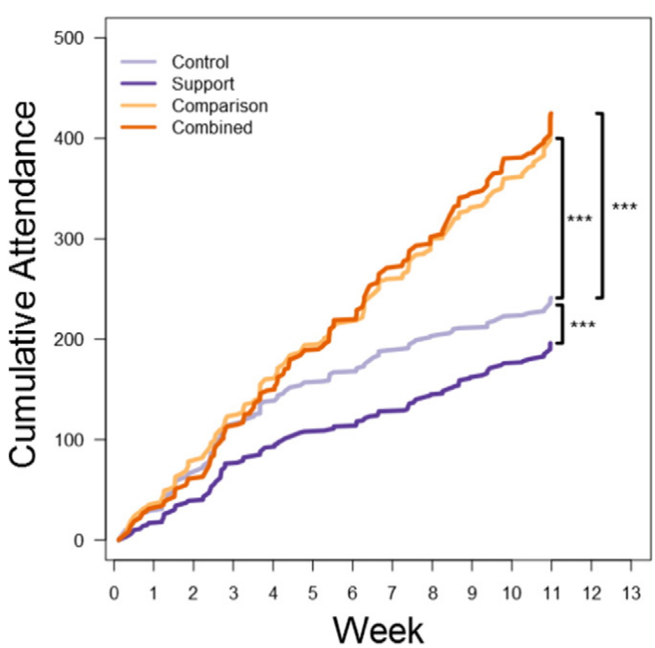

Fig. 3. Cumulative attendance at exercise classes in each of the four conditions. $^{***}p < 0.001$.

Our results suggest that networks that emphasize social comparison among members can be surprisingly effective for motivating desirable behaviors. The results from the combined condition, where adding team performances to a supportive environment significantly increased exercise levels, suggest that the introduction of a minimal competitive reference point into an otherwise support-based environment can change ineffective health networks into highly motivating social resources. Healthcare providers, online fitness programs, and peer-to-peer communities for improving patient health all seek ways to structure social interactions among their members to provide the greatest incentives for adopting and maintaining health behaviors. Social comparison might be harnessed to address a variety of other health issues such as medication compliance, diabetes control, smoking cessation, flu vaccinations, weight loss, and preventative screenings (Centola, 2013). Future research can extend our approach to test whether the strong effect of social comparison through constructed online networks can be realized in health promotion domains other than physical activity.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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