Effects of social network incentives and financial incentives on physical activity and social capital among older women: a randomized controlled trial

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Abstract
Background Financial incentives have been used to increase physical activity. However, the benefit of financial incentives is lost when an intervention ends. Thus, for this study, we combined social network incentives that leverage the power of peer pressure with financial incentives. Few reports have examined the impact of physical activity on social capital. Therefore, the main goal of this study was to ascertain whether a combination of two incentives could lead to more significant changes in physical activity and social capital during and after an intervention. Methods The participants were 39 older women over 65 years of age in Kumamoto, Japan. The participants were randomly divided into a financial incentive group (FI group) and a social network incentive plus financial incentive group (SNI+FI group). Both groups underwent a three-month intervention. Measurements of physical activity and social capital were performed before and after the intervention. Additionally, the effects of the incentives on physical activity and social capital maintenance were measured six months postintervention. The financial incentive group received a payment ranging from US$4.40 to US$6.20 per month, depending on the number of steps taken during the intervention. For the other group, we provided a social network incentive in addition to the financial incentive. The SNI+FI group walked in groups of three people to use the power of peer pressure. Results A two-way ANOVA revealed that in terms of physical activity, there was a statistically significant interaction between group and time (p=0.017). The FI group showed no statistically significant improvement in physical activity during the observation period. In terms of social capital, the change in trust approached significance (p=0.08). Conclusion Our results suggest that social network incentives, in combination with financial incentives, are more effective for promoting physical activity and social trust than financial incentives alone among older women and that these effects can continue after an intervention.

Background
It is common knowledge that an increase in physical activity improves health. It reduces the risk of mortality and cardiovascular diseases [1-4], improves physical function [5], and improves quality of life [6,7]. Additionally, the preventive effects of cognitive impairment [8,9], depression [10,11], and cancer [12,13] have been reported recently. Despite these beneficial effects, the level of physical
activity is still low among the population [14,15].

Previous studies have shown that financial incentives have been used to achieve behavioral change in physical activity in an effort to solve this problem [16,17]. However, the benefit of the incentive is lost when the intervention ends [18,19], meaning that the effect of financial incentives is short-term. Therefore, in this study, we focused on social network incentives that leverage the power of peer pressure to regulate behavior [20]. An advanced study by Aharony et al. (2011) revealed the power of social networking to produce significant behavior change by adding a social dimension to incentive mechanisms [21]. In Aharony et al.’s study, creating peer pressure by adding two “buddies” to one person was necessary to achieve this benefit. Aharony et al. called this strategy “social network incentives.” Furthermore, the study found that increased physical activity continues after the intervention has ended when financial incentives are combined with social network incentives. Therefore, combining social network incentives with financial incentives for physical activity may have a long-term effect. However, the participants in Aharony et al.’s study only included young people. Thus, our study aimed to investigate whether the combination of social network incentives and financial incentives had a long-term effect on physical activity for older persons.

Furthermore, Brach et al.’s (2003) study demonstrated that physical activity plays a significant role in maintaining functional fitness in older women [22]. Additionally, a decrease in muscle strength and mass is likely to be a consequence of more physical inactivity. Therefore, it is important that older women increase their physical activity [23].

On the other hand, recent studies have revealed a relationship between social capital and healthy behaviors. Putnam (2000) defines social capital as the “features of social organizations such as trust, norms, and networks” [24]. Several studies have shown an association between social capital and daily smoking, obesity, and drinking [25-28]. Additionally, relationships with social capital have also indicated increased physical activity [27,29-21]. For example, a study by Ho et al. (2018) showed that larger networks predicted higher physical activity levels [32]. By investigating individual-level social capital, Ueshima et al.’s (2010) study showed that participants with high trust had higher physical activity than those with low trust [33]. Hence, until now, many studies have revealed the effects of
social capital on physical activity; however, few reports have examined the impact of physical activity on social capital.

The main goal of this study was to ascertain whether combining financial incentives with social network incentives could lead to more significant changes in physical activity and social capital among older women compared to financial incentives alone, during and after an intervention.

Methods

Study design and participants

This study was a randomized study in which participants were recruited by handing out leaflets in several different regions in Kumamoto, Japan. Forty-four older women over 65 years of age were recruited between August 2017 and September 2017.

After completing measurements before the intervention, participants drew a sealed envelope to determine whether they were allocated to the financial incentive group (FI group) or the FI plus social network incentive group (SNI+FI group).

During the intervention, two participants in the FI group and three in the SNI+FI group dropped out. Eventually, the study groups comprised 21 participants in the FI group and 18 participants in the SNI+FI group. The study flowchart is presented in Fig. 1.

Each participant in the FI group received a payment ranging from US$4.40 to US$6.20 per month, depending on the number of steps taken per day during the intervention. The SNI+FI group participants walked in groups of three people to utilize the power of peer pressure, in addition to receiving the financial incentive. The three people chose each other among the participants in the SNI+FI group after grouping by randomization. The groups of buddies remained the same over the three-month intervention in this study. The participants were informed that they would walk in groups of three people about once a week. Furthermore, their rewards were designed to reflect the largest number of steps taken among their “buddies.” The payment rewards ranged from US$4.40 to US$6.20 per month and were available for both groups. After the three-month intervention, the participants were not asked to walk with their peers. However, they could decide for themselves whether to walk or not.
Both groups underwent a three-month intervention between September 2017 and December 2017. Before the intervention, each group was assessed for age, body height, body weight, body mass index, and percentage of body fat. Measurements of physical activity and social capital were performed before and after each intervention. Additionally, the effects of the incentives on activity maintenance were measured six months after the intervention.

All participants provided written informed consent to participate in the study, which was approved by the ethics committee of Osaka Sangyo University (2017-JINRIN-016).

**Blinding**

Those assessing the outcomes were blinded to the grouping allocation; however, owing to the nature of the intervention, participants were not blind to their allocation. The FI group participants did not know about the SNI+FI group reward structure.

**Anthropometric measures**

Body height was measured to the nearest 0.1 cm. Body weight was measured to the nearest 0.1 kg using a digital scale. Body mass index (BMI) was calculated using the formula $\text{BMI} = \frac{\text{body mass (kg)}}{\text{(body height [m])}^2}$. The percentage of body fat was calculated using the formula: $\text{adult body fat}% = (1.20 \times \text{BMI}) + (0.23 \times \text{age}) - (10.8 \times \text{sex}) - 5.4$ [34].

**Physical activity**

Before starting the study, a pedometer (EX-500, YAMASA TOKEI KEIKI CO., LTD, Tokyo, Japan) was given to each participant to measure the number of steps per day. Each participant also received a diary to record their daily step count (pedometer). For the evaluation of the number of steps, the average daily step count for one month was calculated.

**Social capital**

Social capital was assessed in both the cognitive and structural domains. Cognitive social capital was
assessed by inquiring about trust and norms. Trust was assessed by a single item: “Generally speaking, would you think that most people can be trusted?” The responses were selected using a Likert scale [33]. From a previous study by the Japan Science and Technology Agency Index of Competence (JST-IC), the norm was assessed using four items of social participation from the JST-IC [35,36]. The four items were as follows: (1) Participate in regional events; (2) Participate in a neighborhood association; (3) Assume a managerial position or role such as the leader in a residents’ association; and (4) Engage in charity. These items were assessed using Yes=1/No=2, and the points were summed. Structural social capital was assessed by inquiring about the network using two questions. The first question was regarding “Relationship with neighbors.” This question included a four-point scale (none; would greet; would talk while standing; would consult with life concerns). The second question concerned the “Number of neighbors with whom one has a relationship.” This was also a four-point scale with the following possible answers: zero, four or fewer people, five to nineteen people, and twenty people or more.

For social capital, individual indexes were calculated by standardizing each item.

**Statistical analysis**

Data were analyzed using SPSS Statistics 20.0 (IBM Corporation, Tokyo, Japan). All descriptive and statistical data are shown as the mean ± SD. An unpaired t-test was used to compare the differences in age, body height, body weight, BMI, and percentage of body fat between the FI group and SNI + FI group before the intervention. Two-way repeated-measures ANOVA was conducted to compare the effects of the intervention and the six-month postintervention physical activity and social capital between groups. Post hoc analyses were conducted using simple main effects. The partial eta squared (η² p) was used to assess the effects size from the ANOVA analyses. The significance level was set at p < 0.05.

**Results**

Before the intervention, there were no significant differences in age, body height, body weight, BMI, or percentage of body fat between the FI group and the SNI+FI group (Table 1). A two-way ANOVA
revealed that in terms of physical activity, there was a statistically significant interaction between group and time (F (1, 37) = 6.24, p = 0.017, Fig. 2). The physical activity of the SNI+FI group increased significantly between the preintervention and the six-month postintervention periods (F (2, 36) = 5.41, p = 0.006, Fig. 2). However, the FI group showed no statistically significant improvement in physical activity during the observation period (Fig. 2). In terms of social capital, a two-way ANOVA revealed that, in networking and the JST-IC, there was no significant interaction (network, p = 0.18; JST-IC, p = 0.84, Table 2), while trust was close to significance (F (1, 37) = 3.24, η = 0.08, p = 0.08, Table 2).

The increase in social capital of the SNI+FI group approached significance between the preintervention and the three-month (F (2, 36) = 3.28, p = 0.07, Table 2) and six-month postintervention periods (F (2, 36) = 3.28, p = 0.07, Table 2). The social capital analysis results were the same regardless of standardization (not shown).

Discussion

The results of this study suggest that social network incentives combined with financial incentives increased the physical activity of older women during the six months after the intervention but that those receiving financial incentives only lost their effects after the intervention.

Aharony et al. (2011) focused on social network incentives leveraging the power of peer pressure by using peer rewards [21]. In their experiments, the process by which the target participants’ good behavior rewards the “buddy” enhanced the physical activity of both the target and the “buddy.” Therefore, face-to-face communication was considered effective in increasing their physical activity.

The results of our study are consistent with those of Aharony et al. However, a key distinction of our study is that it is the first to investigate whether social network incentives have beneficial effects on physical activity among older persons after an intervention using a randomized study.

In a previous study about the effects of financial incentives alone, it was found that even when tangible rewards were offered, they decreased intrinsic motivation for activity [18]. Additionally, the rewards are likely to be accompanied by surveillance, evaluation, and competition, which have also been found to undermine intrinsic motivation [37]. For these reasons, we concluded that physical activity does not increase through financial incentives alone. Conversely, if the rewards were higher,
physical activity might have increased. High financial incentives, with total possible rewards exceeding $100, have been found to create change in behavior [38, 39]. However, once the incentives are no longer apparent, lasting effects have been observed only in a few cases. Therefore, it is interesting that by using social network incentives, even low financial incentives have beneficial effects on physical activity in older persons, even after an intervention. Additionally, in older persons, maintaining increased physical activity will not only prevent cardiovascular disease and improve QOL [1-4, 6, 7] but also prevent cognitive function and depression [8-11], which may prevent receipt of care.

In the present study, combining social network incentives with financial incentives seemed to have increased trust in the community among older women. Although the resulting mechanism is unclear, our results seem to suggest that interaction with others creates social norms. Putnam and Feldstein’s study (2003) showed that smaller groups with face-to-face communication promote empathy about the factors that create social capital among the participants [40]. In our study, we formed groups of three people to create the power of peer pressure. We believe that groups of three people are the minimum size necessary to maximize social network incentives and that even numbers have the risk of causing division. Additionally, previous studies have shown that trust is an independent health determinant [41, 42]. Therefore, increasing the number of people walking with buddies in the region may contribute to the development of local social capital and health.

There were a few limitations to this study. First, the sample was small, with females only, and we limited the study to Japan’s regions only. Additionally, because our sample was healthy, the results may not be generalizable to less healthy people, men, and other racial or ethnic groups. Future studies should involve a large number of participants and men. Second, although a randomized design was employed, the study enrolled only those persons who voluntarily responded to an advertisement and agreed to participate in the program. Finally, it is unclear whether different incentive designs would yield greater effectiveness at a lower cost. Moreover, because physical activity was measured using a pedometer, we could not quantify other forms of physical activity, such as cycling or swimming.
Conclusion
Our results suggest that social network incentives combined with financial incentives are more effective for promoting physical activity and social trust among older women than financial incentives alone and that these effects can continue postintervention. We therefore recommend a sustainable walking program that can lead to better health for both older persons and the community.

Abbreviations
FI: financial incentive
SNI: social network incentive
ANOVA: analysis of variance

Declarations

Ethics approval and consent to participate
Ethical approval for the study was granted by the ethics committee of Osaka Sangyo University (2017-JINRIN-016). Written informed consent was obtained from each participant before data collection.

Consent for publication
Not applicable.

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on request.

Competing interests
The authors declare that they have no competing interests.

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Author contributions
RY was a major contributor in writing and revising the manuscript, conducted the analysis, and interpreted the results. SS assisted with the study design, assisted with the writing of the manuscript, and assisted with the interpretation of the results. RA assisted with the writing of the manuscript. TD assisted with the study design. ST, TY, and SO contributed to critically revising the manuscript. EH
supervised this study and approved the final paper. All authors read and approved the final manuscript.

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Tables
Due to technical limitations the Tables are available as a download in the Supplementary Files.

Table 1 Comparison of Clinical Characteristics between SNI+FI group and FI group

Table 1, legend: Values are expressed as the mean ± SD.

Table 2 Comparison of intervention effects for social capital variables

Table 2, legend1: Values are expressed as the mean ± SD.
Table 2, legend2: * simple main effect compared to pre intervention, \( p = 0.07 \)

Figures

Flow diagram of the two groups’ progress through the phases the randomized trial

Figure 1

Flow diagram of the two groups’ progress through the phases the randomized trial
Comparison of intervention effect for physical activity

Supplementary Files
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table 2.ppt
table 1.ppt