Towards Health Exercise Behavior Change for Teams Using Life-logging

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***Abstract*—Recent technological trends on mobile/wearable devices and sensors have been enabling increasing number of people to collect and store their "life-logs" easily in their daily lives. Beyond exercise behavior change of individual user, our research focus is on the behavior change of teams, based on life-logging technologies and information sharing. In this paper, we propose and evaluate six different types of information sharing model among team members for their exercise promotion, leveraging concepts of "competition" and "collaboration". According to our experimental mobile web application for exercise promotion and extensive user study among 64 total users for three weeks, the model with "external competition" technique resulted the most effective performance for competitive teams such as sport teams.**

I. Introduction

Wide variety and large scale life-log data have been utilized for self behavior change [1], [2], [3], medical care [4], and social analytics [5], [6]. While existing researches on human behavior change using life-log data focus on individual human behavior change, life-logging for teams' behavior change has not been investigated. For example, to the best of the authors knowledge, effective usage of life-logging for keeping workers' healthy in businesses or managing the amount of practice in a sport team is not known.

In teams, there exists various kinds of human relationships, such as employer–employee, teacher–student, or manager–player. Therefore, it is not clear if existing techniques for individual human behavior change can be applied to team-level behavior change.

In this paper, we propose six different types of information sharing models for promoting team behavior change with variation of concepts, such as "competition" and "collaboration". We created "Aaron2", a mobile web application for promoting team behavior change based on proposed information sharing models. With Aaron2, we evaluated and analyzed these models through an extensive user study with 64 participants for three weeks. Our analysis showed that life-log data closely related to the team's original performance indicator was effective for enhancing team behavior change, and that use of "competition" concept model is the most effective for teams in a competitive situation, such as sport teams, among the proposed models.

The contributions of this paper are the following three: (1) proposal of six different types of information sharing models for promoting team behavior change, (2) extensive evaluation of the models with the real-world system, and (3) significant analysis results from the evaluation.

In the remainder of this paper, we present the definitions and clarifications of behavior change along with the problems of team behavior change in Section 2. Section 3 describes six different types of information sharing models for promoting team behavior change. Section 4 presents the evaluation of our information sharing models and introduces Aaron2, our experimental application for promoting team behavior change with implementation of the six models. Section 5 presents results and analysis of the evaluation. We describe related work in Section 6. Finally, we conclude the paper in Section 7.

II. Behavior Change

This section describes our research background, behavior change, and problems in applying it to teams.

A. Techniques of Behavior Change

Behavior change is defined as changing the behavior pattern which was originally made accustomed to a new one [7]. One simple example is changing one's moving behavior during their commute from "using escalators" to "using stairs" for his/her better health. Transtheoretical Model (TTM) [8] is one of the human behavior change models proposed by Prochaska. TTM classifies the process of behavior change in five stages as shown in Figure 1. This model has been broadly used for supporting various types of health activities [9] including stopping smoking and preventing drop-out from dental treatment in the middle [7]. Bandura [10] explained the importance of self efficacy of the stage of behavior change. Especially, experience of achievement is the most effective for improvement of the self-efficacy.

In context of persuasive computing [11], human behavior change with use of information technology has been actively researched and the research outputs have been used in wide variety of real-world products and services. One framework developed in persuasive computing research, known to be effective for promoting human behavior change [12], [13], [14], is "Gamification" [15], [16]. This framework consists of several techniques such as "competition", "collaboration",

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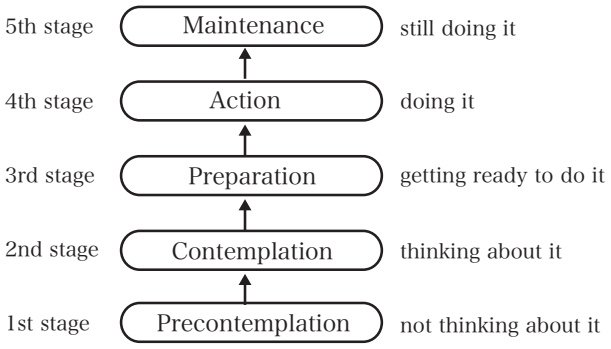


Fig. 1. Transtheoretical Model: TTM

"score", "ranking", "sharing value", "badge" or "level up". In case of health promotion applications and web services with wearable devices, for example, Fitbit products [17], Nike+ Fuelband [18], and Jawbone UP [19] have already introduced those techniques such as "score", "badge" or "ranking" into their functionalities.

B. Problems of Team Behavior Change

As presented above, existing researches and products on behavior change based on life-log data have been focusing on *individual* behavior change. It is not clear if such techniques for individual human behavior work effectively when they are applied to the field of behavior change of *teams*. In teams, content to be shared among the team members, use of behavior change promotion techniques including "collaboration" and "competition", as well as several fundamental properties of the team, such as "goal of the team", are considered to have influence on the team's behavior changes. Efstratuiy [20] constructed a web application that detects daily activities in their laboratory, by using small sensors and microphones, and that shares the activity information among the laboratory members with the "competition" technique. As a result, they received exciting feedback saying "*What was thought not to work by other member was unpleasant.*". Namely, it is more doubtful whether using the competition technique, such as simple ranking for encouraging behavior change, is effective for the whole team in terms of their behavior changes. Additionally, in their study, they investigated only psychological influence of information sharing in the team. Investigation on influence of information sharing techniques is a big research challenge yet to be addressed.

In this research, we propose six different types of information sharing models for promoting team behavior change composed of existing human behavior change techniques. We created an application for team behavior change based on the proposed models and conducted the extensive real-world user study. We analyze the results of the user study and show the effectiveness of the models in terms of team behavior change.

III. Information Sharing Models for Promoting Team Behavior Change

In this paper, we use the word **team** to refer to a group of people who share a common goal. In this sense, laboratory in university and sport team such as baseball club are teams. Teams can be classified into (1)*strong aim sharing team* where they strongly share a common aim with team members, and (2)*weak aim sharing team* where they weakly share the their common aim with team members. Example of strong aim sharing team includes sport teams, project teams in company and those of weak aim sharing team includes a laboratory in university, a class in school.

We define **team behavior change** to promote more team members' behavior change, in this survey, we regard increasing the amount of target action in the whole team as promoting team behavior change.

We propose six types of information sharing models for promoting team behavior change based on different combinations of **collaboration** and **competition**. The competition and collaboration techniques are used by existing system and services as one of the common techniques for human behavior change. Similarly, it is assumed that techniques influence promoting team behavior change. Figure 2 shows the models. A black circle represents a team member while a oval of the dotted line represents a team. Two arrows facing each other represent competition between team members or teams, while back-to-back arrows represent significant collaboration between teams.

Detail of each models are follows;

- Individual Model (*IND*)
  Figure 2(a) shows *IND*. The aim of this model is to achieve their own goal. With this model, each user can access information only on his/her own amount of activity. No information exchange occurs between members. Therefore, in *IND*, the pressure from their team members is lower than that of other models which include colleague information sharing techniques such as collaboration and competition. Since *IND* does not have promoting elements, it is assumed that the amount of activity is lower than other information sharing models.

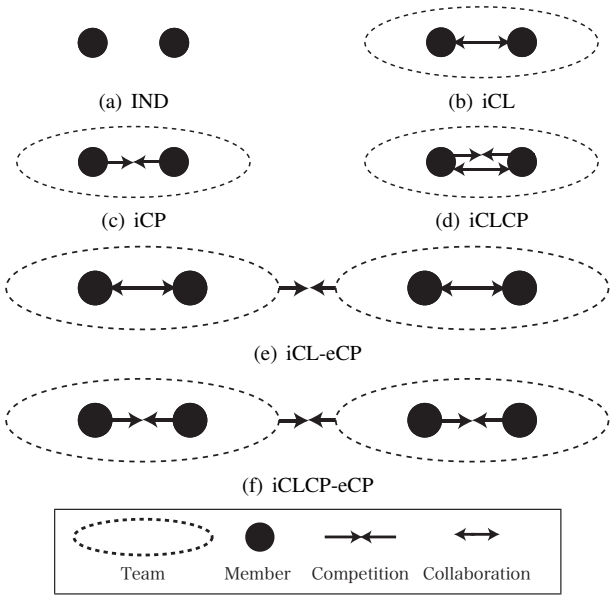


Fig. 2. Information Sharing Model for Promoting Team Behavior Change

- Internal Collaboration Model (*iCL*)
  Figure 2(b) shows *iCL*. The aim of this model is to encourage collaboration between team members, given by a common goal (total amount of activity by the team). With this model, each team member can access information on his/her own amount of activity, as well as total (summated) amount of activity achieved by all team members. The total amount makes team members to become aware of the team goal and achievement towards it. Then, this model does not provide their team member's individual activity information such as daily amount of activity. Therefore, it is assumed that discomfort of information sharing is lower than that is the model using simple competition technique with team members. Additionally, this model shares team members activity information as team total activity, pressure of information sharing is larger than *IND*.

- Internal Competition Model (*iCP*)
  Figure 2(c) shows the *iCP*. The aim of this model is to encourage competition between team members. With this model, each team member can access information on his/her own amount of activity, as well as amount of the activity by other individual members. Total amount of activity achieved by all team members is not shared. *iCP* model provides all team member's daily activity, and so this model promotes competition among members. Moreover, it is assumed that amount of activity is larger than *iCL* with increase of stimulus from sharing information. On the other hand, all members could know the least active member, which increases discomfort of this model is larger than *iCL*.

- Internal Collaboration and Competition Model (*iCLCP*)
  Figure 2(d) shows the *iCLCP*. The model is a combination of *iCL* and *iCP*. With this model, all members' individual amount of activity as well as the total amount of activity of the team is shared among team members. Using two concepts from *iCL* and *iCP* at the same time, the amount of contribution by individual team members becomes more obvious towards achievement of the team goal. Since amount of pressure from other members are supposed to be bigger than the *iCL* and *iCP* models used solely, individual member's amount of activity is assumed to be boosted. As a result, total amount of activity of the team are considered to be increased.

- Internal Collaboration External Competition Model (*iCL-eCP*)
  Figure 2(e) shows the *iCL-eCP*. The model is a combination of *iCL* and competition between multiple teams, which is called external competition. The aim of this model is to encourage competition among teams by visualizing each team's total activity. Each team member can access information on his/her own amount of activity, total amount of activity achieved by the team he/she belongs to, and total amount of activity done by competing teams. With this model, having a clear goal of *"Winning the opposing team"*, team members are supposed to try to achieve better total team amount collaboratively in order to compete with other teams. Meanwhile, competition among members in the same team will not occur since this model does not share activity of individual team member.

- Internal Collaboration, Competition and External Competition Model (*iCLCP-eCP*)
  Figure 2(f) shows the *iCLCP-eCP*. The model is a combination of *iCLCP* and competition between multiple teams. The aim of this model is to encourage competition among team members, as well as competition among multiple teams where collaboration between team members occurs simultaneously. With this model, each team member can access all types of information, such as information on his/her own amount of activity, amount of activity by other individual team member, total amount of activity achieved by the team he/she belongs to, and total amount of activity done by competing teams. Similar to the *iCL-eCP* model, team members are supposed to try to increase total team amount collaboratively in a competitive situation with other teams. However, this model may also lead competition inside the team simultaneously since activity of individual team member is shared. Since there are two types of competition in this model, amount of pressure for each member is considered to be bigger than the *iCL-eCP* case.

IV. Evaluation Setup

This section details our evaluation of models, with extensive user study with 64 participants for three weeks. The goal given to the participants is to increase the sit-up count. We designed the experiment to establish difference of effect of six kinds of proposed information sharing models. Increasing the amount of sit-up activity is important for preservation of whole team members' health. For example, sit-ups are effective for preventing backache, especially, strengthening of abdominal muscle leads to improvement of their sports performance.

A. Team and Model Configuration

We focus Keio University official baseball club (hereinafter referred to as the **baseball club**) and the computer science laboratory in Keio University (hereinafter referred to as the **laboratory**) as team target for our experiment. The baseball club and laboratory consists of 32 members respectively. The average ages of laboratory members is 24.45 years old in laboratory, while that of baseball club members is 19.63 years old. Additionally, the laboratory is composed of 20 bachelor students, 6 master students, 3 Ph.D students, and 3 faculty members. On the other hand, the baseball club is composed of 32 bachelor students. Moreover, the laboratory members' average of sport experience at sport club is 5.62 years. The baseball club members' that value is 11.18 years.

For each team, we created 8 groups of 4 people, group (A) to (H). Each team was assigned one of the six kinds of information sharing models as shown in Table I. Since the *iCL-eCP* and *iCLCP-eCP* models respectively need opponent teams, we applied two groups to those models.

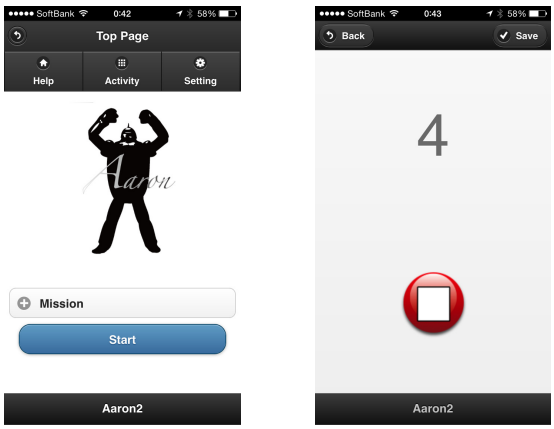
TABLE I. CORRESPONDENCE OF EACH GROUP AND INFORMATION SHARING MODELS

Information Sharing Models	Laboratory	Baseball Club
IND	Lab-A	Baseball-A
iCL	Lab-B	Baseball-B
iCP	Lab-C	Baseball-C
iCLCP	Lab-D	Baseball-D
iCL-eCP	Lab-E,F	Baseball-E,F
iCLCP-eCP	Lab-G,H	Baseball-G,H

B. Aaron2: Application for Team Behavior Change

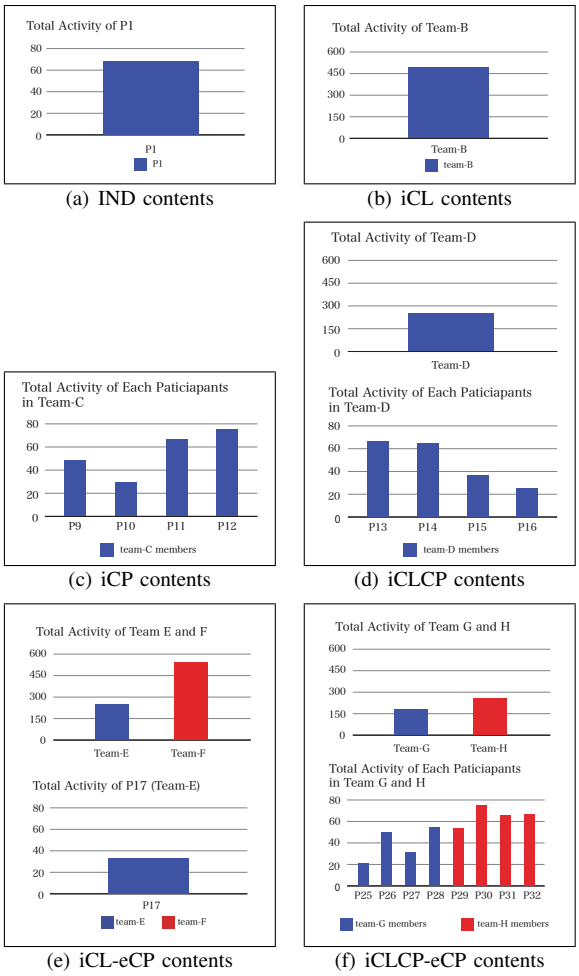
Aaron2 is a web application on iOS and Android platforms counting user's daily exercise activities. For example, with Aaron2 user can count up his/her exercise, such as sit-up, push-up, or squat, and share their activity records to other team members. We used jQuery Mobile 1.1 [21] for user interface framework and the Google Chart Tools [22] for the chart. In order to evaluate our proposed information sharing models, Aaron2 has a capability of using one of the models selectively to each user. From the user's viewpoint, according to the configured model, different types of information, such as own activity record or other members' record, will be displayed on the screen. At an exercise session, Aaron2 generates beeping sounds at regular intervals so that user can perform own exercise by following the sounds.

This application is composed of the *Top Page* (Figure 3(a)), *Application Page* (Figure 3(b)), *Setting Page*, and *Activity Page* (Figure 4) pages. *Top Page* manages login information and displays the team goal of activities, such as the number of sit-ups to be achieved as a team. *Application Page* provides functionality of exercise activity counter. When a user pushes a red button at the center of the screen, Aaron2 starts its counting. When the user pushes the red button again, Aaron2 stops counting and uploads the activity record to the server. In *Setting Page*, users can set up the type of beeping sound, sound interval, and the maximum sound count of a single set by themselves. Users can configure their exercise according to their own performance and condition. *Activity Page* shares other team members' activity count based on a proposed information sharing models configured to the user respectively. Figure 4 shows the information display on the *Activity Page* for each of six different kinds of information sharing models.



(a) Top Page (b) Application Page

Fig. 3. Screenshot of *Top Page* and *Application Page* in Aaron2



(a) IND contents (b) iCL contents (c) iCP contents (d) iCLCP contents (e) iCL-eCP contents (f) iCLCP-eCP contents

Fig. 4. Components of *Activity Page*

C. User Study Procedure

At the first day, we held a meeting with all participants. Introduction of the user study, usage of the Aaron2 application, the group configuration were introduced to the participants. We conducted a questionnaire to the participants on his/her own goal of daily sit-up amount. We also collected signed permission agreement letters from the all participants.

For all 64 participants, the user study was started at the same day. During the period of the user study, each participant used his/her own iOS or Android smart phones for use of Aaron2. The participants were required to open the Aaron2 at least once a day, and they were able to use it as much as they want. Off-line information exchange on the exercise performance across the groups and teams were prohibited.

After three weeks, at the final day, we conducted another survey for the all participants on usability of Aaron2. The participants had to answer the following questions using a 5-point Likert scale (5-Strongly Agree, 4-Somewhat Agree, 3-Neutral, 2-Somewhat Disagree, 1-Strongly Disagree). The survey is composed of four questions. The participants have to answer question-1, question-2, and question-3 using a 5-point Liker scale, and question-4 using free description. The question items of question-1 is "*How do you feel activity sharing*

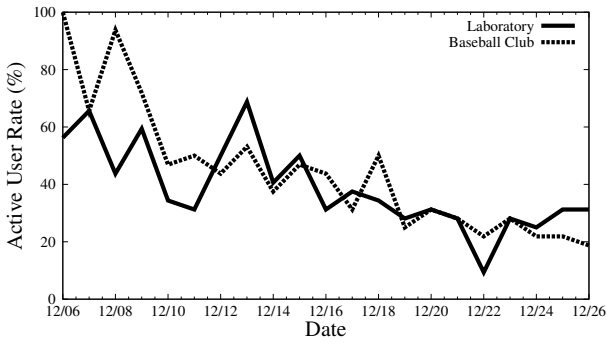


Fig. 5. Active User Rate of Aaron2

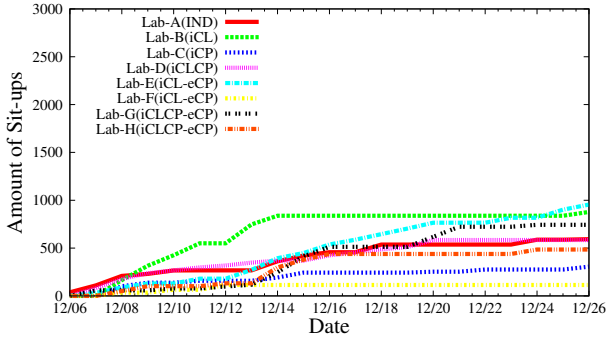


Fig. 6. Sit-up Activity in Laboratory

using application?" and question-2 is "*Do you want to use this application continuously?*". The question-1 and question-2 are question about discomfort of information sharing. The question item of question-3 is "*Do you feel pressure from other members?*", this question is about pressure from their team members. The question items of question-4 is "*Please write impressive event during evaluation.*". The user study was conducted for three weeks, from December 6th to 27th in 2013.

V. Results and Analysis

Daily active user rate (number of users opened the application out of total number of participants) decreased toward the end of experiment, as shown in Figure 5. Average active user rate throughout the user study period was 44.35% (baseball club) and 38.84% (laboratory).

Figure 6 and Figure 7 shows the amount of sit-up activity of 8 groups in each team respectively. Values show cumulative numbers of sit-up exercise. The total amount of activity of 8 groups in baseball club, 6 groups (except for Baseball-A (*IND*) and Baseball-B (*iCL*)) outperformed all groups in laboratory team.

This result is considered that sharing amount of sit-up activity is closely related to performance such as players' performance preventing injuries in baseball club. On the other hand, in the laboratory, that activity is not closely related to their performance such as research skill and programing skill. Therefore, our analysis shows that life-log data closely related to performance indicator of the team was effective for enhancing team behavior change.

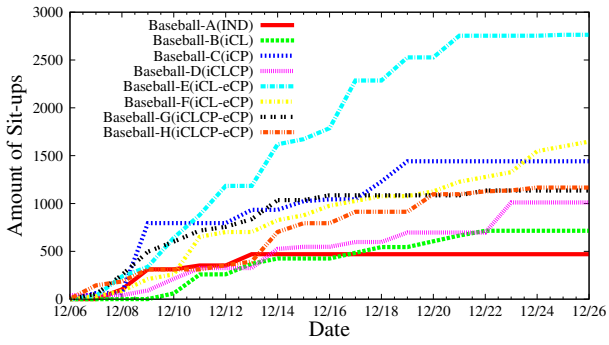


Fig. 7. Sit-up Activity in Baseball Club

Based on the result above, our analysis showed several significant differences between six proposed models.

1) Worst among proposed models: All models with information sharing between users (*iCL*, *iCP*, *iCLCP*, *iCL-eCP* and *iCLCP-eCP*) outperformed *IND*, the model without any information sharing. Especially the *iCL-eCP* model resulted 588% better result than the *IND* model. Additionally, average value of all models other than *IND* resulted 324 % better result than the *IND*. Based on the fact that the *IND* model is actually equivalent of the individual behavior change, this result implies that team-based behavior change is clearly more effective than individual-based behavior change.

2) Competition Elements: The models with "competition" element, such as *iCP*, *iCLCP*, *iCL-eCP* or *iCLCP-eCP*, showed better results than the *iCL* model. This result indicates that use of internal collaboration solely is not effective and some additional "competition" elements, either iCP or eCP, are expected to reveal even better performance.

3) Number of shared information elements: The *iCLCP-eCP* model, the one with the largest number of information elements shared among teams and team members, did not reveal the best result and actually underperformed other models with less number of shared information elements (*iCL*, *iCP*, *iCLCP*, *iCL-eCP*). This implies that the performance of team behavior change is not subject to number of information elements to be shared.

4) Comparing two "external competition" models: Comparing two "external competition (eCP)" models, *iCL-eCP* and *iCLCP-eCP*, the *iCL-eCP* model without "internal competition" element performed better. Furthermore, Figure 8 shows the detailed user-by-user comparison between two models. The standard deviation of *iCL-eCP* (459.71) was much larger than that of *iCLCP-eCP* (190.67). In the *iCLCP-eCP* model, individual team member can access to activity number of other team members. Thus, with the effect of internal competition in a team, all team members are considered to have made exercise effort more evenly than the members with *iCL-eCP* model where internal competition does not occur.

Figure 9 shows result of questionnaire in baseball club. In question-1 and question-2 that was question about discomfort of information sharing, Baseball-A (*IND*) and Baseball-G (*iCLCP-eCP*) replied it with value less than 2.5 point. Additionally, question-3 was question about the pressure that a user felt from other members. Result of Baseball-A (*IND*),

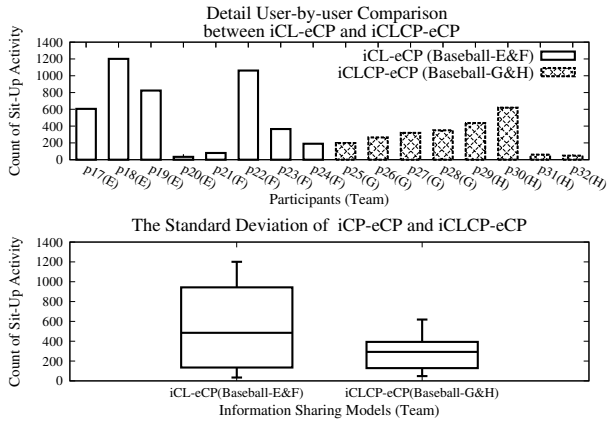


Fig. 8. Comparison between iCLCP-eCP and iCL-eCP

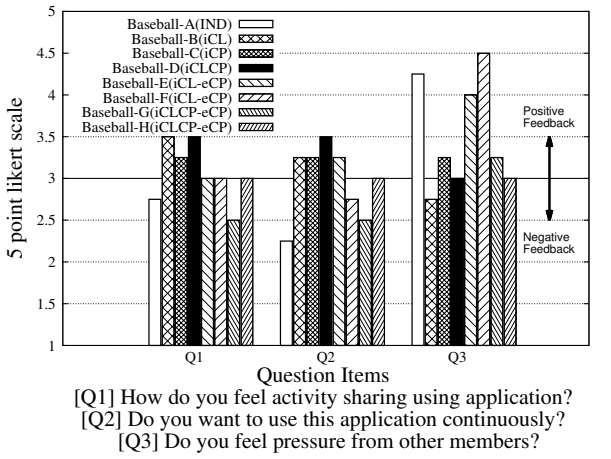


Fig. 9. Results of Questionnaire in Baseball Club

Baseball-E (*iCL-eCP*), and Baseball-F (*iCL-eCP*) showed more than 4 point. This result suggests that participants do not want to use Aaron2 continuously in the case of *IND* and *iCLCP-eCP*. Participants of the *iCLCP-eCP* and *IND* models left that an unpleasantness is larger than other model's unpleasantness. Amount of sit-up activity of the *iCLCP-eCP* model is few than *iCP* and *iCL-eCP*. Thus, it is assumed that unpleasant of information sharing lead to bad influence of increase in amount of activity.

VI. Related Work

Kamal [23] constructed the ABC Framework. This framework provides determinants for leveraging the motivational power of online social networks with the determinants for promoting health behavior change. They evaluated the determinants of appeal, belonging and commitment using both direct and indirect methods with 36 adult subjects. This research used system based on the online social network. However, this research's target group members do not share a common goal for the whole group activity because groups were recruited through university listserves, posters around university campus and through advertisements on Craig's list. Therefore, this research's target group is not same as our target group.

Efstratuiy [20] constructed the activities sharing web application that detects daily activities in their laboratory using small sensors and microphone and share their daily activities with laboratory members. Their aim of that project was to encourage human behavior change using daily activities sharing, but they got exciting feedback that was "What was thought not to work by other member that was unpleasant.".

The Display of Business Microscope [24] system shared information from Business Microscope [6] with company employees using semipublic digital signage with the aim of activation of communication. Business Microscope uses sensor technology to measure and analyze inner company communication and activities. Multiple sensor devices are placed inside a nameplate-shaped sensor that is attached to company employees. The aim of this research is the group behavior change using life-log that is similar to our research. However, this research did not evaluate feedback effect for difference of feedback method.

VII. Conclusion

Recent technological trends on mobile/wearable devices and sensors have been enabling increasing number of people to collect and store their "life-logs" easily in their daily lives. Beyond exercise behavior change of each user, our research focus is on the behavior change of teams based on life-logging technologies and information sharing where relationships between human relations, information sharing strategy and resulted exercise behavior are not yet explored. In this paper, we proposed and evaluated six different types of information sharing model, such as *IND*, *iCL*, *iCP*, *iCLCP*, *iCL-eCP*,*iCLCP-eCP*, by leveraging concepts of competition and collaboration. According to our Aaron2 experimental exercise promotion web application on smart phones and extensive user study among 64 total users for three weeks. The evaluation result suggested that life-log data closely related to performance indicator of the team was effective for enhancing team behavior change. Furthermore, in six kinds of proposed models, the use of an external competition concept model was the most effective for teams of competitive situation such as sport teams.

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