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DIGITAL COACHING MOTIVATING TOWARDS PHYSICAL ACTIVITY IN JAPAN DURING THE COVID-19 PANDEMIC

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COVID-19 influenced peoples lives enormously and its impact was also seen in physical activity and exercising. This mixed methods intervention study highlights some of the impact the pandemic had on the physical activity and exercising behaviors of 10 Japanese information systems employees and students. This study also focuses on the influence that using sport and wellness technology digital coaching had on peoples' physical activity, exercise motivation and exercise self-efficacy during the pandemic. Based on the findings digital coaching can have motivational elements to support people towards a more physically active lifestyle for example by making users more aware of their own physical activity. However, digital coaching is not enough if users do not have initial motivation which may be understandable in the challenging times of the COVID-19 pandemic. The findings highlight that digital coaching could be further developed to better support its users. This study and the results bring insight for digital coaching developers and users as well as people working in health care field.

Keywords:
digital
coaching,
exercise
self-efficacy,
COVID-19,
Japan,
Bled
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1 Introduction

Japan was the second country outside of China to have an identified case of COVID-19, in early 2020. Japan's response was considered to be fairly rapid and organized. There was no formal lockdown, as the Japanese government has no power to force businesses to close and people to stay inside. However, local States of Emergency were declared to encourage businesses to close and people to stay home (BBC, 2020). The government encouraged citizens to avoid "the 3Cs": closed spaces, crowded places, and close-contact settings. Despite there being no actual punishment for not following these guidelines, it was recognized that the Japanese populace were generally following them, and thus, crowds of many forms were significantly reduced for much of 2020 (Sayeed & Hossain, 2020). Understandably, these kinds of recommendations could have had a significant impact on sport and exercise participation. In Japan many people use smartwatches and activity trackers to track and measure their daily lives and various activities (Yoshida et al., 2018). Based on the article of IT Media Mobile (2022) 38% of the Japanese population aged between 20-69 have a smart watch. Interestingly, 41.3% of those smart watch owners bought them in 2020. Health management was the top reason for buying a smart watch (IT Media Mobile, 2022). This can be interpreted as showing that the effect of COVID-19 changed people's mind about health management since 29.6% of those who have a smart watch bought it for health management reasons (IT Media Mobile, 2022).

This article focuses on exploring the usage and effects of sport and wellness technology digital coaching in Tokyo, Japan during spring 2020. The aim is to see how the start of the COVID-19 pandemic influenced the exercise behavior of 10 Japanese information systems (IS) field employees and students, how these participants were able to adapt and use sport and wellness technology digital coach into their lives and how the usage of a digital coach influenced their exercise self-efficacy and motivated them toward physical activity and exercise during the beginning of the pandemic. This study brings insight for digital coaching developers, digital coaching users and for people working in health care field. However, because of the limited number of participants due to the restrictions of the pandemic, the purpose of this article is more to highlight interesting aspects of digital coaching usage during the time of the pandemic and suggest potential areas for future studies. This study is unique because it was done in a culturally different environment

compared to other studies of the same topic, as well as being conducted during a pandemic.

2 Theoretical background

2.1 Sport and wellness technology digital coaching

The maturing of the consumer market for sport and wellness technology has meant that there are more lower-cost devices of high-quality available, which has also created an opportunity to do human-centered research in this area (James, 2017). Sport and wellness technology has been shown to increase levels of physical activity in part by the information it can provide a user on their own physical activity and exercising habits (e.g. Larset et al., 2019; Romo et al., 2019). This enhanced awareness of one's own physical activity and exercising habits has the added benefit of being a motivating factor for some users (e.g. Chan et al., 2004; Faghri et al., 2008). Sport and wellness technology can also contribute to the goal setting process (e.g. Gordon et al., 2008), both by setting goals and providing feedback on the progress towards those goals, both of which make users more goal-oriented (e.g. Kari et al., 2016). There is, however, not necessarily always a connect between increased awareness of a user's own physical activity and sustained use of a sport and wellness technology device (Miyamoto et al., 2016). Typical sport and wellness technology that has already been available tend to focus only on providing information and data about previous performances, rather than giving meaningful feedback or guidance on what to do next. Without meaningful or personalized data, a person would need specialized knowledge or professional help to make appropriate decisions in relation to their future exercise plans (Duking et al., 2016).

One solution for this demand is digital coaching. Sport and wellness technology digital coaching refers to a "service on a technological device that not only gives feedback but also offers advice, suggestions and future steps for a user to follow in the pursuit of their wellness and fitness goals" (Kettunen & Kari, 2018 p.3). Typically sport and wellness technology devices and applications give only performance data and feedback. In addition to this, a digital coach creates a personalised training plan which is continually updated based on the user's actions (Schmidt et al., 2015). It is important to acknowledge that digital coaching does not refer to the use of digital tools by human coaches, rather, it refers to a device or a solution which in itself is

the coach and functions independently without human interaction. The potential of sport and wellness technology digital coach has been recognized in previous IS research (e.g. Kranz et al., 2013; Kettunen et al. 2021) and interest toward more instructional and personalized interaction has become more popular (Boulos & Yang, 2020; Mezei et al., 2020). However, commercial sport and wellness technology digital coaching devices and applications are still relatively new and therefore only a few studies have focused on studying the usage experience and the motivational influence of the use of digital coach. Previous studies have suggested that the most suitable processes for digital coaching are related to behavior change techniques, goal setting persuasion, evaluation, interaction and co-creation Chatterjee et al. (2021) whereas the key element influencing adherence and usability was personalization (Lentferink et al., 2017; Chatterjee et al. 2021). Users seem to be more engaged with digital coaches that take into account the psychological needs related to motivation (Sundar, 2012; Chang et al. 2016).

2.2 Exercise Self-efficacy

The quantitative part of this study is based on the theory of self-efficacy by Albert Bandura (1977). The concept of self-efficacy refers to a person's own beliefs about their own capacity related to performing a specific task. It is important to recognize that a person's self-efficacy does not necessarily correlate to his/her actual capacity to perform a specific task. A person with high levels of self-efficacy is more likely to view a difficult task as an opportunity and a challenge whereas a person with low self-efficacy easily tends to avoid difficult tasks (Bandura 1997). Therefore, it is understandable that self-efficacy can also affect a person's motivation by impacting the amount of effort they are willing to give to overcome a specific task. According to Bandura (1998) there are four main sources of information that affect person's self-efficacy: vicarious experiences, performance accomplishment, verbal persuasion, and physiological states.

Since in this study the topic is physical activity and exercise, the theory of self-efficacy is applied to exercise and physical activity and therefore is called exercise self-efficacy. Self-efficacy plays an important role in exercise since it has been shown to have a high influence in the adoption of physical activity habits (McAuley & Blissmer, 2000). The importance of self-efficacy tends to be even more important in the phase when physical activity has not yet become a habit (Bandura, 1986). Self-

efficacy has also been associated with maintaining long-term physical activity (McAuley et al., 2011). People with high levels of self-efficacy may work harder and participate in physical activity more frequently (Bandura, 1986). Self-efficacy is one of the most researched concepts in the field of physical activity and exercise (Kroll et al., 2007), and is a well-known theory when studying motivation and self-confidence in the field of sport performance (Feltz, 1988). In this paper, exercise self-efficacy is studied from the perspective of sport and wellness technology digital coaching and the aim is to see whether the use of a digital coach can influence the users' exercise self-efficacy during the COVID-19 pandemic and despite the issues and restrictions the pandemic caused related to physical activity and exercising.

3 Methodology

3.1 The Digital Coach Used in the Study

The digital coach used for this study was the Suunto 3 Fitness sports watch, created by Finnish company Suunto OY (Suunto, 2019). The device is designed as a training watch for exercisers and is particularly tuned for aerobic exercising such as walking, running or cycling. The watch has features related to exercise timing, wrist-based heart rate monitoring, sleep monitoring, GPS, and 24/7 activity, stress and recovery tracking. The features that make the watch a digital coach is its “adaptive training guidance” and “real time feedback”. The watch creates a personalised weekly training plan based on the goal user has set. An estimation of the user's fitness level is made using the existing training data. On a training day, the watch provides the workout goals such as the time and the intensity. The digital coach provides real-time guidance during the recommended workout. The guidance is primarily related to staying in a particular heart rate zone. The watch also provides instructions through audio and visual indicators to help the user to keep up with the set goal. After the workout the device provides information about the workout. The training guidance will adapt if a person misses or modifies a workout.

3.2 Research approach, data collection and analysis

The study was a mixed methods intervention study that took place in Tokyo, Japan, at the start of the COVID-19 pandemic from February to April 2020. The intervention lasted three months and included eight male and two female

participants, ages 22-67, who were students or employees working in IS field. The volunteers were recruited from the National Institute of Advanced Industrial Science and Technology and from Tokyo University of Agriculture and Technology. The participants had different types of physical activity backgrounds. The physical activity background was not a selection criterion. Participants did not have previous experience related to digital coaching although some of them had previous experience on of sport and wellness technology.

In the beginning of the intervention all participants were given quantitative paper questionnaires related to exercise self-efficacy and attitude towards sport and wellness technology digital coaching. After answering the questionnaire all participants were given a sport and wellness technology digital coach to use for the duration of the study. The participants were asked to use the digital coach as they felt most suitable for them. In the end of the intervention period the participants were asked to answer again the same questionnaires they answered in the beginning of the intervention. In this second round the questionnaire was an online questionnaire due to the COVID-19 restrictions. The purpose of this quantitative data was to see if there were any changes in their answers due to the intervention. After the intervention the participants were also interviewed about their experiences related to physical activity during COVID-19 and their usage of the digital coach to support their physical activity and exercising. Due to COVID-19 restrictions the qualitative data was collected via online and email interviews in the end of the intervention in early May 2020. The interviews were semi-structured interviews which are the most used interview type in IS qualitative research (Myers & Newman, 2007), consisting of themes related to exercise background, COVID-19 pandemic, adaptation of digital coach, digital coach's influence on physical activity and exercise and ideal digital coach. Interviews done over email followed a more structured format.

The quantitative data was analyzed using Excel. Due to the low number of participants the purpose of the quantitative data analysis was not to provide statistically significant information but instead, by analyzing averages on an item by item basis, to highlight possible trends and areas worth researching more deeply. The qualitative data was analyzed using thematic analysis method which is meant for "analyzing, identifying and reporting patterns within data" (Braun and Clarke, 2006, p. 79) and is widely used in qualitative research (Guest et al., 2012). The analysis

process of the studies began with transcribing the relevant parts of the interviews and becoming familiar with the data. The interview themes were already divided into smaller sections in the interview phase. During the analysis the answers of the individual participants were compiled into an Excel spreadsheet. This made it easier to see the occurring themes and compare the data. The most highlighted issues and topics were presented in the result section.

4 Findings

4.1 Quantitative findings related to exercise self-efficacy and attitude

Exercise self-efficacy was measured using a scale by Kroll et al. (2007). The scale, presented in table 2 below, included statements regarding personal abilities related to physical activity. The self-efficacy was measured on the scale from 1-4 where 1=not true at all, 2= seldom true, 3=somewhat true and 4= completely true. As seen from the table 2 there was no significant changes when comparing the means of the questionnaires before and after the intervention. One statement that seemed to have the biggest change between the two data points was related to exercising when feeling depressed. It seemed that after the intervention the participants were less certain that they are capable of being physically active and exercise when feeling depressed.

The second part of the questionnaire, presented in table 3 below, focused on self-efficacy related to the participants' overall opinions about their exercising and improving their own fitness. This part included 13 statements, of which six were related to the role of sport and wellness technology. The statements were measured on a scale of 1-7 where 1 represented "strongly disagree" and 7 represented "strongly agree". Based on the results participants seemed less confident at the end of the intervention that they are able to train independently without any guidance or coaching. However, they also found it less hard after the intervention to find out how to improve or analyze their own aerobic fitness. Also the belief of the truthfulness of the information provided by sport and wellness technology was increased during the intervention.

Table 1: Changes in exercise self-efficacy

Statement	Start (Mean)	End (Mean)
I can overcome barriers and challenges with regard to PA and exercise if I try hard enough	3,1	3,3
I can find means and ways to be physically active and exercise	3,4	3,5
I can accomplish my PA and exercise goals that I set	3,1	3,4
When I am confronted with a barrier to PA or exercise, I can find several solutions to overcome this barrier	2,8	3,0
I can be physically active or exercise even when I am tired	2,4	2,2
I can be physically active or exercise even when I am feeling depressed	2,7	1,9
I can be physically active or exercise even without the support of my family or friends	3,1	3,0
I can be physically active or exercise without the help of a therapist or trainer	3,3	3,4
I can motivate myself to start being physically active or exercising again after I've stopped for a while	3,1	3,0
I can be physically active or exercise even if I had no access to a gym, exercise, or rehabilitation facility	2,7	3,2

Attitudes towards using a digital coach was measured by five statements shown in table 4 below. The statements focused on the overall attitude (bad vs. good), the experimental aspect (unpleasant vs. pleasant and uncomfortable vs. comfortable), and the instrumental aspect (useless vs. useful and foolish vs. sensible). As can be seen from the means, participants' attitudes towards digital coaching remained relatively similar. However, after the intervention the participants considered using digital coaching more uncomfortable than before.

Table 2: Changes related to improving fitness, and sport and wellness technology

Statement	Start (Mean)	End (Mean)
I know how to create myself an exercising program	4,0	4,3
I need help in creating myself a suitable exercising program	4,1	4,3
I am able to train independently without any guidance or coaching	5,1	4,0
Sport and wellness technology has an important role in my exercising	4,7	4,6
Sport and wellness technology provides me with important information that I can use in my exercising	5,3	5,6
I am able to improve my fitness with the help of sport and wellness technology	5,3	5,5
I believe that sport and wellness technology provides me with reliable information regarding my own exercising	5,5	5,9
I believe that sport and wellness technology provides me with accurate information regarding my own exercising	5,3	5,6
I believe that sport and wellness technology provides me with truthful information regarding my own exercising	5,1	5,9
It is hard for me to find out how to improve my aerobic fitness	4,9	4,1
I do not know how to increase the level of my aerobic fitness	4,3	4,2
It is hard for me to analyze my aerobic fitness	5,0	4,0
I know how to improve my aerobic fitness	4,1	4,6

Table 3: Changes in attitude towards using a digital coach

Statement	Start (Mean)	End (Mean)
I know how to create myself an exercising program The thought of using a digital coach as a support for my training sounds: bad (1) vs. good (7)	5,5	5,7
The thought of using a digital coach as a support for my training sounds: useless (1) vs. useful (7)	5,7	5,7
The thought of using a digital coach as a support for my training sounds: foolish (1) vs. sensible (7)	6,0	5,7
The thought of using a digital coach as a support for my training sounds: unpleasant (1) vs. pleasant (7)	5,7	5,4
The thought of using a digital coach as a support for my training sounds: uncomfortable (1) vs. comfortable (7)	5,6	4,9

4.2 Qualitative findings

4.2.1 COVID-19 influencing exercise behavior

The exercise background of the participants varied. Four participants had walking and commuting to work/school as their only exercise and other participants reported also having exercise related hobbies such as strength training, dancing, running or team sports. During the COVID-19 pandemic their exercise behavior changed significantly due to the restrictions. Exercise related hobbies that were held in public places such as gyms and exercise arenas were cancelled causing a decrease in physical activity level for many participants. Since people worked from home, so the amount of walking decreased from the elimination of commuting. Some participants continued or started running during the pandemic but even running was considered more difficult due to big crowds outside. As one participant stated “I avoided people jams. For instance I started running around the park near home at midnight”. In general participants reported that COVID-19 had a negative influence on their physical activity as well as on their exercise motivation: “I have no motivation to go out anymore”(Male, 25 years), “The frequency of training has decreased”(Male, 24 years). Despite the restrictions and limitations, some participants found a way to remain physically active: “I decided to do longer walk exercises as my commuting activity disappeared” (Female, 46 years), “I became more

motivated to exercise since I felt stressed at home. Exercise became my new routine.” (Male 22).

4.2.2 Adaptation and usage of the digital coach

None of the participants had used a sport and wellness technology digital coach before but a couple of them had used a pedometer or a running application. Most participants had either no expectations or high expectations towards digital coaching hoping that it would guide and encourage them to exercise. Participants felt that starting to use the digital coach was relatively easy. Most wore the digital coach every day during the intervention although some participants felt uncomfortable wearing it overnight. Few participants wore the digital coach only during exercising. The lock down and working remotely affected some participants’ usage of the digital coach: “I used the digital coach all day before I started working from home. After that I wore it occasionally when I went to sleep or for a walk” (Female, 46 years). The feature participants used the most were heart rate, step counting, sleep tracking and exercise tracking. Only a few participants followed the training program offered by the adaptive training guidance since participants thought it was hard to understand or that they would have liked to schedule their training themselves. As some participants noted: “I did not use the adaptive training guidance. It looked rational but I would have liked to schedule the training myself” (Male, 24 years), “I did use it at first but it was a little too hard to understand” (Male, 24 years) The real time feedback feature was perceived somewhat more useful since half of the participants used it. The usage of the digital coach changed as the pandemic continued. Some participants decreased the usage since their exercise levels decreased.

4.2.3 Motivational influence of the digital coach

After the intervention most participants reported becoming more aware about their physical activity or lack of physical activity. Most participants had also learned something new about their own physical activity, such as their heart rate levels. As one participant stated: “I realized my heart rate is quite high. I also realized how much I walk every day, I walk more than I thought” (Male, 28 years). Because people were working more from home, some participants found more time to exercise. A few participants started running and felt that having a digital coach along their exercising increased motivation and made running more regular and consistent.

Participants also perceived seeing their exercise progress as well as seeing their daily activities motivational. According to one participant: “Using the digital coach has improved my health since it gives me numbers and I can set goals. This increases my motivation which will improve my health” (Male, 22 years). COVID-19 decreased the exercise motivation for some participants, and the use of a digital coach was not a good enough motivator to start increasing their exercise levels. According to one participant: “Being unable to exercise outside reduced my motivation” (Male, 22 years).

Using the digital coach encouraged some of the participants to make some changes to their exercise and wellbeing. Some participants reported having made changes to their training and health management due to the usage of the digital coach: “ I learned that I exercised too hard, so I reviewed my training plan” (Male, 24 years), “ Because of using the digital coach, I am now trying to keep an ultra slow pace in early stage of running” (Male 67 years), “Before I thought I slept more but after using the watch I tried to go to bed earlier and have better sleep quality by calming down before going to bed” (Male, 22 years). In general participants found it motivational to receive exercise and health related data as well as being able to compare the progress. As one participant noted: “Digital coach assists on exercising but the responsibility is on the person. That makes it easy to start with the digital coach” (Male, 28 years). For some participants tracking exercise became fun and easy: “By making it appear numerically, the exercise became fun and easy” (Female, 60). For some participants the purpose of using a digital coach changed during the intervention: “Digital coach usage has changed from exercise management to life management such as sleep management” (Male, 22 years).

4.2.4 Ideal digital coach

Participants were also asked how to develop digital coaching to make it more motivational and suitable for them. Some participants felt the coach should be more encouraging, more clear, and more straight forward. The data should be more accurate and the device itself could be more comfortable. In general participants wanted their ideal digital coach to include features related to weight training, and calorie consumption. It should also connect more effectively with other technologically. In general, participants felt that digital coaching is suitable for different types of people but especially for people who want to increase their exercise

level and learn more about their own physical activity and health. One participant stated: “Digital coach is for people who want to increase their exercise level and do not know a lot about exercising.” (Male, 22 years). When comparing a human coach to a digital coach, participants felt that a human coach can be more flexible, provide more detailed instructions and give more personal advice. A human coach would also possibly earn more respect and as a result motivate the client to work harder. One participant felt that: “With a human coach you have to show respect and work harder and do exercise” (Male, 25 years). The benefits of a digital coach were flexibility, cheaper price, ease of use and rich personal information. As one participant said: “You have more freedom to do things your way. It creates less stress. No schedules are needed and the response is fast” (Male, 28 years).

5 Discussion

This study focused on exploring the usage, effect on exercise self-efficacy and the motivational influence of sport and wellness technology digital coaching during the COVID-19 pandemic in Japan. Based on the findings it seems that the overall attitude towards physical activity and exercising also affected the usage of digital coach during COVID-19. The motivational influence of digital coaching seemed inconclusive. Whereas for some participants digital coach brought extra motivation, for others the COVID-19 restrictions decreased the exercise motivation such that the usage of digital coaching could not bring back the motivation. This result is consistent with previous research (Kettunen et al. 2021) suggesting that motivational elements of the digital coach are not enough if the user themselves are not initially motivated to exercise. The quantitative findings highlight that digital coach usage can make people more confident about training without outside support and being more in charge of their own fitness development. This finding is also consistent with previous studies (Kettunen et al., 2019; Kettunen et al., 2021). However, it seems that the atmosphere created by COVID-19 has made people less confident that they can train when feeling depressed. The trust in the truthfulness of the data provided by the digital coach increased during the intervention. This finding is opposite to previous similar studies (Kettunen et al. 2019; Kettunen et al., 2020) done in Finland. The attitude towards digital coaching was relatively high already in the beginning of the study and remained about the same throughout the intervention. An exception to this was that people perceived using a digital coach as less comfortable after the intervention.

According to the findings the digital coach was perceived as interesting and useful in helping people learn about their physical activity as well as increased the exercise motivation. Digital coaching also makes the training more visible and exciting to some participants by giving numbers and setting goals. Thus, a digital coach has potential in influencing exercise motivation even during difficult times such as during the COVID-19 pandemic. However, digital coaching could be developed much further to increase its motivational influence. For example, enhancing communication between the user and the device was highlighted. It is notable that most technology related to health improvement reaches only those who are already health-conscious, sporty, and active, so the problem seems to be rather how to reach those who do not care about their health. There does not appear to be a good solution for this. Based on this study digital coaching has potential and therefore might be the key to solve that problem, so it would be useful to conduct more studies with different target groups and using different types of digital coaches. It is also important to recognize that technology such as a digital coach may not be able to overcome the individual traits that guide a person's behavior during extraordinary events like the COVID-19 pandemic was. Thus, the impact of a digital coach on a person's exercise behavior might have been somewhat different in an otherwise more normal time period.

6 Limitations and suggestions for future research

The results of the study are based on a relatively small and homogenous target group and the usage of one particular digital coaching device. Due to the pandemic and the limited number of digital coaches it was not possible to extend the number of participants. It is also important to note that the participants were all working or studying in the information systems field which might have influenced the adoption of new technology. Since the quantitative data is based on a small number of participants the quantitative results serve as highlighting possible trends and areas worth researching more deeply. Doing research on a unique time such as during a pandemic made the topic more interesting but at the same time made analysis harder as it is hard to know for sure whether some results were more related to the usage of the digital coach or to the change in lives due to COVID-19. Future studies could focus on the influence that digital coaching usage has on exercise motivation and self-efficacy especially. The usage of sport and wellness technology digital coaching

in Japan could also be studied more broadly, since to our knowledge this study is among the few studies, if not the only one, conducted in Japan about the topic.

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References

- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review* 84 (2), 191-215.
- Bandura A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice Hall.
- Bandura, A. (1998). Health promotion from the perspective of social cognitive theory. *Psychology and Health* 13 (4), 623–649.
- Boulos, M. N. K., & Yang, S. P. (2021). Mobile physical activity planning and tracking: a brief overview of current options and desiderata for future solutions. *Mhealth*, 7.
- Braun, V., and V. Clarke (2006). "Using thematic analysis in psychology," *Qualitative research in Psychology* 3 (2), 77-101.
- BBC. (2020). Coronavirus: State of emergency lifted in most of Japan. BBC News. Retrieved September 29, 2022, URL: <https://www.bbc.com/news/world-asia-52658551>
- Chan, C. B., Ryan, D. A., & Tudor-Locke, C. (2004). Health benefits of a pedometer-based physical activity intervention in sedentary workers. *Preventive Medicine*, 39(6), 1215-1222.
- Chang, R. C. S., Lu, H. P., Yang, P., & Luarn, P. (2016). Reciprocal reinforcement between wearable activity trackers and social network services in influencing physical activity behaviors. *JMIR mHealth and uHealth*, 4(3), e5637.
- Chatterjee A, Gerdes M, Prinz A, Martinez S. 2021. Human Coaching Methodologies for Automatic Electronic Coaching (eCoaching) as Behavioral Interventions With Information and Communication Technology: Systematic Review *J Med Internet Res*, 23(3):e23533
- Faghri, P. D., Omokaro, C., Parker, C., Nichols, E., Gustavesen, S., & Blozie, E. (2008). E-technology and pedometer walking program to increase physical activity at work. *The Journal of Primary Prevention*, 29(1), 73-91.
- Feltz, D. (1988) "Self-confidence and sports performance." *Exercise and Sport Sciences Reviews* 16 (1), 423-458.
- Finnish Sports Federation. (2011). *Kansallinen liikuntatutkimus 2009–2010: Aikuis- ja senioriliikunta. [National Sports Study 2009-2010: Adult and Elderly Physical Activity (Report)]*, Helsinki: Finnish Sports Federation.
- Gordon, M., Althoff, T., & Leskovec, J. (2019). Goal-setting and achievement in activity tracking apps: a case study of MyFitnessPal. *The World Wide Web Conference, USA*, 571-582.
- Guest, G., MacQueen, K. M. and E. E. Namey (2012). *Applied Thematic Analysis*. Los Angeles: SAGE.
- IT Media Mobile. (2022) Smart watch ownership rate is 38.0%, top reason for purchase is "health management". URL: <https://www.itmedia.co.jp/mobile/articles/2102/09/news086.html>
- James, D. (2017). Wearable Technology in sport, a convergence of trends. *Journal of Advanced Sport Technology*, 1(1), 1-4.

- Kari, T., Koivunen, S., Frank, L., Makkonen, M., & Moilanen, P. (2016). Critical Experiences During the Implementation of a Self-tracking Technology. PACIS 2016: Proceedings of the 20th Pacific Asia Conference on Information Systems, Taiwan, 129.
- Kettunen, Eeva (2021) Using Digital Coaching to Promote Physical Activity to University Students with Low Levels of Physical Activity: A Qualitative Intervention Study. In Proceedings of the 54th Hawaii International Conference on System Sciences, University of Hawai'i.
- Kettunen, E., and Kari, T. (2018). "Can Sport and Wellness Technology be My Personal Trainer?: Teenagers and Digital Coaching." in Proceedings of the 31st Bled eConference. Digital Transformation: Meeting the Challenges", Bled, Slovenia, pp. 463-476
- Kettunen, E., Kari, T., Makkonen, M., Critchley, W., & Sell, A. (2019) Digital Coaching among Physically Inactive University Students: A Quantitative Intervention Study on Exercise Self-efficacy. In Proceedings of the 32th Bled eConference. Humanizing Technology for a Sustainable Society.
- Kettunen, E., Kari, T., Makkonen, M., Frank, L. & Critchley, W. (2020). Young Elderly and Digital Coaching: A Quantitative Intervention Study on Exercise Self-Efficacy. In the proceedings of the 33rd Bled eConference : Enabling technology for a sustainable society. Maribor: University of Maribor, 469-484
- Kranz, M., A. Möller, N. Hammerla, S. Diewald, L. Roalter, T. Ploetz and P. Olivier (2013). "The Mobile Fitness Coach: Towards Individualized Skill Assessment Using Personalized Mobile Devices" *Pervasive and Mobile Computing* 9, 2013, pp. 203-215.
- Kroll, T., Kehn, M., Ho, P. S., & Groah, S. (2007). The SCI Exercise Self-Efficacy Scale (ESES): development and psychometric properties. *The international journal of behavioral nutrition and physical activity*, 4, (34).
- Larsen, R. T., Christensen, J., Juhl, C. B., Andersen, H. B., & Langberg, H. (2019). Physical activity monitors to enhance amount of physical activity in older adults—a systematic review and meta-analysis. *European Review of Aging and Physical Activity*, 16(1), 1-13.
- Lentferink, A. J., Oldenhuis, H. K., de Groot, M., Polstra, L., Velthuisen, H., & van Gemert-Pijnen, J. E. (2017). Key components in eHealth interventions combining self-tracking and persuasive eCoaching to promote a healthier lifestyle: a scoping review. *Journal of medical Internet research*, 19(8), e7288.
- McAuley E. & Blissmer B. (2000). Self-efficacy determinants and consequences of physical activity. *Exercise and Sport Sciences Reviews*, 28, 85–88.
- McAuley, E., Szabo, A., Gothe, N., & Olson, E. A. (2011). Self-efficacy: Implications for Physical Activity, Function, and Functional Limitations in Older Adults. *American journal of lifestyle medicine*, 5(4),
- Mezei, J., Sell, A., & Walden, P. (2020). Digital coaching-an exploratory study on potential motivators. Proceedings of the 53rd Hawaii International Conference on System Sciences, USA.
- Miyamoto, S. W., Henderson, S., Young, H. M., Pande, A., & Han, J. J. (2016). Tracking health data is not enough: a qualitative exploration of the role of healthcare partnerships and mHealth technology to promote physical activity and to sustain behavior change. *JMIR mHealth and uHealth*, 4(1), Article e5.
- Romeo, A., Edney, S., Plotnikoff, R., Curtis, R., Ryan, J., Sanders, I., Crozier, A., & Maher, C. (2019). Can smartphone apps increase physical activity? Systematic review and meta-analysis. *Journal of Medical Internet Research*, 21(3), Article e12053. <https://doi.org/10.2196/12053>
- Sayeed, U. B., & Hossain, A. (2020). How Japan managed to curb the pandemic early on: Lessons learned from the first eight months of COVID-19. *Journal of global health*, 10(2), 020390. URL: <https://doi.org/10.7189/jogh.10.020390>
- Sundar, S. S., Bellur, S., & Jia, H. (2012, June). Motivational technologies: a theoretical framework for designing preventive health applications. In *International conference on persuasive technology* (pp. 112-122). Springer, Berlin, Heidelberg.
- Suunto, 2022 URL: https://www.suunto.com/en-gb/Support/Product-support/suunto_3/suunto_3/

- Yoshida, Y., Nishimura, T., Jokinen, K. (2018). Biomechanics for understanding movements in daily activities. LREC Workshop "Language and Body in Real Life & Multimodal Corpora" (REAL-MM), 7-12 May 2018, Miyazaki, Japan. <http://lrec-conf.org/workshops/lrec2018/W20/index.html>