2018

Digital Coaching and Athlete's Self-efficacy – A Quantitative Study on Sport and Wellness Technology

Eeva Kettunen
University of Jyväskylä, Jyväskylä, Finland., eeva.k.kettunen@jyu.fi

Tuomas Kari
University of Jyväskylä, Finland, tuomas.t.kari@jyu.fi

Markus Makkonen
University of Jyväskylä, markus.v.makkonen@jyu.fi

Will Critchley
University of Jyvaskyla, wcritchley@gmail.com

DIGITAL COACHING AND ATHLETE'S SELF-EFFICACY – A QUANTITATIVE STUDY ON SPORT AND WELLNESS TECHNOLOGY

Research full-length paper

Track: Improving Lives with Information Technology

Kettunen, Eeva, University of Jyvaskyla, Jyvaskyla, Finland, eeva.k.kettunen@jyu.fi

Kari, Tuomas, University of Jyvaskyla, Jyvaskyla, Finland, tuomas.t.kari@jyu.fi

Makkonen, Markus, University of Jyvaskyla, Jyvaskyla, Finland, markus.v.makkonen@jyu.fi

Critchley, Will, University of Jyvaskyla, Jyvaskyla, Finland, wcritchley@gmail.com

Abstract

The use and demand for sport and wellness technology devices among athletes are increasing. The technology is used to improve the quality of training but also to improve quality of life by, for example, reducing risk of injury. Together with the increased interest towards sport and wellness technology, the demand for clear and easy to understand personalized information is growing. Digital coaching offers solutions for this demand by not only providing valuable training data but also offering instructions and guidance on how to improve the training. By doing this, the sport and wellness technology can act as a personal coach and therefore can also affect athletes' confidence and perception of their own abilities through, for example, evaluative feedback, expectations and verbal persuasion. This exploratory study investigates subjectively perceived effects of digital coach among cross-country skiers. The focus was on the changes in the level of athletes' self-efficacy during a one-month period when preparing for a ski marathon race. The results indicate that a digital coach can increase the athletes' knowledge regarding their technique as well as provide improvement on perceived level of skiing technique. These results give more insight to sport technology companies as well as athletes and coaches about the effects and possibilities of digital coaching among athletes.

Keywords: Digital Coach, Digital Coaching, Sport Technology, Digital Wellness, Self-efficacy, Athlete.

1 Introduction

Recent development in technology has made a significant impact in the field of sports. The information received from technology, especially from various sport and wellness technology devices, has enabled a new level of training feedback during and after a session that athletes and coaches pe nowadays consider invaluable. Receiving reliable and appropriate feedback is an important factor in improvement of sport skills. The probability of learning increases when an athlete is able to compare the internally expected optimum performance with statistics on actual movement outcome (Liebermann et al., 2002). Therefore, the effect of information technology on sport performance seems to be positive as athletes develop more effectively towards their optimum performance.

According to Winstein and Schmidt (1990), feedback sources are more relevant and considered more effective during the beginning of a skill acquisition process and their importance decreases when the skill level increases. Therefore, in general, sport and wellness technology devices providing immediate feedback have been considered to be relevant for recreational, amateur or professional athletes at the initial state of skill acquisition (Liebermann et al., 2002). However, it is important to acknowledge that different athletes have different specific needs regarding feedback sources. According to Halson et al. (2016) sport technology companies should consider the implications for the athletes more since, for example, giving too much information, unnecessary information or inadequate information might cause the user stress and anxiety.

While sport and wellness technology is developing and the devices become less expensive, more athletes have integrated technology into their training. It has been shown to not only improve the quality of their training, but also reduce their risk of injury. Sport and wellness technology can provide the athlete daily feedback, but without professional help interpreting the feedback, it may lead to inappropriate adjustments in training (Duking et al., 2016). Therefore, sport technology companies should not only pay attention to the quality and versatility of the information provided but also the level at which the feedback is easily understood and implemented correctly into practice.

Despite the recent trend on sports regarding digitalization, the topic still remains an understudied topic in the IS discipline (Xiao et al., 2017). When looking at sport and wellness technology more generally, there are a few studies that have focused on the use and effects of technology on physical activity. According to previous studies, sport and wellness technology can increase the level of awareness of personal physical activity and by doing so, increase motivation. (e.g., Chan et al., 2004; Faghri et al., 2008; Kang et al., 2009; Kari et al., 2017a; Wang et al., 2016). Despite the fact that tracking physical activity data may lead to increased awareness, this effect might not be sufficient to maintain the use of sport and wellness technology (Miyamoto et al., 2016). Furthermore, this can have an effect on maintaining physical activity routines (Warraich, 2016). Therefore, it is likely that providing achievable goals and sufficient usage guidance would increase the adherence of using sport and wellness technology devices. These goals and guidance can help users to create and maintain overall wellness routines for example related to physical activity, nutrition and sleep and recovery.

Based on previous research, users prefer their sport and wellness technology devices to deliver clear, relevant and easy-to-understand information. They also feel they need to receive feedback and instructions on how to maintain or enhance their physical activity and overall wellness. When users receive this type of data, it would likely lead to the use being more goal-oriented (e.g., Kari et al. 2016; Kari et al. 2017b), which can contribute to increased motivation (Locke and Latham, 2002; Shilts, Horowitz, and Townsend, 2004). However, a common problem with sports and wellness technology devices is that instead of providing actual guidance and instructions they mostly provide feedback through numbers and graphs. By providing more instructional and personalised feedback via, for example, personal training plans, these devices not only could make their users more motivated and goal-oriented towards improving their physical activity and overall wellness, but also motivate them to continue using the devices.

One prospective solution to serve this demand is digital coaching. The demand for digital coaching to address personalized and goal-driven support in achievements of physical activity goals was also recognized by Schmidt et al. (2015). Digital coaching refers to a service on a technological device that mirrors that of a real coach, by giving feedback as well as advice and suggestions for a user to follow in the pursuit of their wellness and fitness goals. According to Schmidt et al. (2015) a digital coach can identify the strengths and weaknesses of a user and generate a training plan based on the information received from the user. Whereas traditional sport and wellness technology products improve the user's awareness based on their own fitness data, a digital coach is a one step ahead. It can also create a personalized training plan for the user to follow. The use of a digital coach in a physical activity setting as well as its potential in increasing motivation was also highlighted by Kranz et al. (2013) and Kettunen & Kari (2018).

The interest towards digital coaching solutions has been increasing among different stakeholders. However, since commercial digital coaching solutions are still relatively new, there are only a limited number of studies that focus on the influence of digital coaching on usage experiences. To address this research gap, the purpose of this study is to explore usage experience from a psychological point of view by examining the effect a digital coach can have on athlete's self-efficacy. More precisely, the purpose of this study is to investigate the relationship of digital coaching from a sport psychological point of view by focusing on the following question: Can the use of a digital coach affect cross-country skiers' awareness and self-efficacy when preparing for a ski marathon race. The concept of self-efficacy was chosen for the study as a significant relationship between sport performance affecting the choice of activity, effort expenditure, persistence level and vulnerability to stress and depression has been shown (Bandura, 1997). The study included 38 cross-country skiers taking part in the same ski marathon race, skiing either 30km or 50km. The study participants were divided into intervention and control groups. During the one-month study period the intervention group participants were using a digital coach as their personal trainer. Online self-assessment surveys were sent to all participants at both before the beginning and the end of the study period. The survey measured the participants' self-efficacy and awareness of their technique and fitness. The findings of the study provide interesting first insights on the use of digital coaching solutions. Moreover, this research aims to serve as a catalyst to future research regarding digital coaching in the setting of sports and physical activity as well as sports psychology.

2 Theoretical background

The theoretical background of the study comes from the theory of self-efficacy described by Alfred Bandura (1977). Self-efficacy refers to a person's beliefs in their capabilities of performing a specific task. It is not concerned about the skills an individual possesses but rather about the judgements of an individual regarding what they can do with their skills. People with high levels of self-efficacy are more likely to perceive difficult tasks as challenges to overcome and perform better, whereas people with lower levels of self-efficacy might avoid doing tasks they perceive difficult. The level of self-efficacy can also affect motivation since it affects how much effort a person is willing to expend and how long they will persist in the face of aversive experiences and obstacles. Moderately challenging tasks may produce satisfaction through the experience of achievement. On the other hand, motivation can decrease if the tasks are deemed to be too easy or too difficult compared to the perceived own skills and abilities (Bandura, 1998).

According to Bandura, there are four different sources of information that affect the person's self-efficacy: performance accomplishments, vicarious experience, verbal persuasion and physiological states. Performance accomplishments are based on mastery experiences and are the most influential source of self-efficacy. Vicarious experiences refer to experiences received through observing other people. Verbal persuasion means comments and feedback heard from other people, and lastly, the physiological state means the perceived emotional arousal, such as stress, experienced in a particular situation. The construct of self-efficacy is part of Bandura's social cognitive theory (1986) which em-

phasizes that the actions, reactions and social behaviour of an individual are influenced by actions of others they have observed. The social cognitive theory highlights the role of social experience and observational learning in personality development and has often been used as a framework theory for studies focusing on physical activity and motivation. The theory of self-efficacy has been the most widely used theory when studying self-confidence in sports performance (Feltz, 1988).

In this study the focus of the theoretical background is to apply to a physical activity and sports setting. Therefore, the theory of self-efficacy is being studied from the point of view of an athlete's self-efficacy regarding their overall skills as well as their self-efficacy related to the upcoming competition and performance situation. The concept of self-efficacy was chosen for the study since it has an important impact on sport performance and is a reliable predictor of sport performance (Moritz et al., 2000). High self-efficacy has also been shown to accompany low pre-competition anxiety, strong goal importance, high personal goals and high trait sport confidence (Feltz and Lirgg, 2001). Athletes with a high level of self-efficacy will also participate more frequently, put more effort and also persist longer, enhancing their performance in sports (Bandura, 1986). Therefore, self-efficacy plays an important role in athletes' everyday life.

Another term this study derives from Bandura's social cognitive theory is the term of proxy agency. It is based on the idea that people play an active and essential role in their self-development, self-renewal and adaption by using mechanisms called agents. Bandura explains the term agency as acts that are done on purpose and describes three different types of agencies: personal, collective and proxy. In the case of personal agency, the persons themselves act as an agent, whereas in the case of collective agency, the agent refers to a group or a community. In the case of proxy agency, a third-party acts as an agent on a person's behalf (Bandura, 1982; Beauchamp and Eys, 2007).

When looking at the theory of proxy agency from a sport and physical activity point of view, a person can act as their own personal agent when coaching themselves. In the case of a collective agency, a sports club or a team can act as an agent, and in the case of a proxy agency, the agent can, for example, be a coach or a personal trainer who is responsible for planning and executing the training plan and evaluating the progress of performance. According to Bandura, there are three reasons for people to use a proxy agent. The first reason explains that people might feel they do not have the skills or knowledge to reach their desired outcome. Secondly, even though people might feel they do have skills and knowledge, they might perceive that a proxy agent is able to better facilitate their journey to the desired outcome. The third reason refers to a situation where people have all the needed resources but they prefer to have a proxy agent because they want to give up the control and responsibility to someone else (Bandura, 1997).

In a sport setting the use of a proxy agent can be helpful in managing tasks and environmental demands as well as controlling and regulating exercise behaviour. It can also help in lifestyle management and giving instructions and support when developing new skills (Beauchamp and Eys, 2007). A proxy agent can also provide social support, which may increase the likelihood of focus, full involvement and enjoyment, and increase the positive outcomes (Jowett and Lavallee, 2007). In sport settings the role of a proxy agent is often performed by a coach or a trainer who is often able to affect the athlete's self-efficacy in different ways such as by providing vicarious experiences and using persuasive techniques. Persuasive techniques are widely used by coaches, trainers, parents, team managers, etc. to influence athlete self-efficacy. These techniques include, for example, verbal persuasion, expectations, evaluative feedback and imagery. The extent of the influence of using persuasive techniques seems to be dependent on the credibility, expertise, prestige and trustworthiness of the persuader. However, the effect of verbal persuasion to the level of athlete self-efficacy is likely to be weaker than the effect of an athlete's own performance accomplishments (Feltz and Lirgg, 2001).

In this study, the role of proxy agency theory is examined from a digital coach point of view. Therefore, the proxy agent in this study refers to a sport and wellness technology device or application combined with digital coaching features. It has been suggested that a long-term use of a proxy agent might lower the user's self-regulatory skills that are necessary for the independent management of physical

activity and sport participation (Shields and Brawley, 2006). Compared to using a personal trainer or a coach as a proxy agent, using a digital coach as a proxy agent requires the user to have a certain amount of independence and self-regulatory skills. Therefore, using a digital coach encourages the user to practice independence while still in the proxy context.

3 Methodology

3.1 The digital coach used in this study

The digital coach used in this study is called Racefox Ski (Racefox, 2018). The reason for selecting this particular product is that it was, according to our knowledge, the only digital coach product developed specifically for cross-country skiing. Racefox is a sport technology device that comprises a chest strap sensor (similar to a typical ECG heart rate strap) mounted with a pod containing an accelerometer, and a companion app. The chest strap is worn while cross-country skiing and measures various key performance indices (KPI) based on the movement of the user, represented by the movement of the user's torso. The maximum values of the KPI's are based on the technique analysis international level cross-country skiers. The data is collected with the chest strap, which may also include heart rate information, and is transmitted via Bluetooth to a user's smart phone. The smart phone's GPS data is also collected to contribute to the analysis (Racefox, 2018).

The app provides three key services for the user. The first is the creation of user-specific training programs. The user can perform a technique test, which provides baseline performance data. The app uses this data to create a two-week training program. After two weeks, the user is instructed to perform the test again, and the next two weeks are generated based on the new results. The user may also specify a specific goal race and result, which the app will factor in when creating the program. The training program provides specific interval training sessions, which include the number and duration of the intervals and values of the KPIs the user should aim to achieve.

Second is the analysis and feedback from exercise sessions. The app measures multiple KPIs specific to the "traditional" style of cross-country skiing. After each session, the user is provided with a graphical and numerical representation of their performance in each of the KPIs. A "coach" function provides text feedback on the user's technique and specific feedback on how to improve. The feedback also includes links to blog posts and videos on skiing technique. An example feedback phrase may be "You are sitting too much. Try to ski with higher hip and more pressure on your forefoot".

The third service is real-time analysis and feedback. Using headphones or the user's smart phone speakers, the app can provide audio feedback on the user's technique. During a guided interval session, there are specific values of one of the KPIs the user is instructed to achieve for a certain period of time. They will also be instructed as to when to start the interval (for example, "Interval 1 begin, 3 minutes"), and when to stop ("Rest for 3 minutes").

During each interval, the app provides real-time feedback on the user's performance related to the KPI values they are attempting to achieve. For example, a user may be instructed to perform 6 repetitions of 3 minutes of double-poling, maintaining an "Attack" score of 11.4. After each double-pole stroke, the user will hear either a high pitched, "positive" tone denoting that they achieved the goal value, or a lower "negative" tone if they did not. This continues during the entire the interval workout. A different type of interval workout may provide metronome-style tones that guide the user to a specific frequency of double-poling to achieve during the interval. After the session, the user is notified as to they achieved the goal performance of the workout and provided recommendations for future workouts. A user may also create their own custom interval session and customize the type of feedback they want. Or, they may perform a basic distance workout and receive intermittent feedback based on the time or distance skied. In addition to cross-country skiing, the Racefox system may also be used while roller-skiing or doing stationary double-poling sessions, and the company also uses the same equipment with a companion Racefox Run app, which performs similar functions for runners.

3.2 Data collection and analysis

The study was conducted as an intervention study with an intervention group and a control group. The target population of the study were cross-country skiers (henceforth referred to as skiers) who took part in a long-distance ski race in Finland on March 2018. The two optional race distances were 50 km or 30 km, which could be skied in either classic or skate style. The participants of the study were recruited in co-operation with a local ski club that organised the race. An invitation to participate in the study was sent by the club to approximately 900 people via e-mail. This included both people who had already registered for the race and all the club members. The invitation yielded interest from 40 volunteers who were all recruited for the study. Of them, all who were doing the race in classic style and were interested in using a digital coach when training for the race were allocated to the intervention group. In contrast, those who were doing the race in skate style or who were not interested in using a digital coach when training for the race were allocated to the control group. The skiing style was used as an allocation criterion due to the fact that the Racefox Ski digital coach was not yet able to analyse the skiing done in skate style, only in classic style.

The duration of the study was approximately five weeks. At the beginning of the study, the participants in both the groups were measured for the first time by using an online survey. After this, the participants in the intervention group were each given their personal Racefox Ski digital coach, which they were asked to use in the most suitable way for them when training for the race. In contrast, the participants in the control group continued training for the race in their normal way. A few days before the race, the participants in both the groups were measured for the second time by using another online survey. Here, it is important to note that since this measurement was done before the race, its results were not affected by the race itself.

In the two online surveys, the measurements were conducted identically for both the groups. The survey questionnaire contained 30 items measuring the self-efficacy regarding overall skiing ability and upcoming race performance by using a seven-point Likert scale ranging from 1 = "strongly disagree" to 7 = "strongly agree". The wordings of the items were adapted from the self-efficacy scale developed for the swimming context by Sâmija et al. (2016) by choosing the applicable items and changing their context to skiing. Also, some relevant items focusing more specifically, for example, on skiing technique, were added. Although some of the items shared common themes, the items were not, as such, intended as measures of specific broader constructs related to self-efficacy. Therefore, the responses were examined on the item level rather than aggregating the responses and looking at them on the construct level. In addition, the survey questionnaire contained five items measuring the attitude towards digital coaching by using a seven-point semantic differential scale. The order of the items was randomised for each participant, and responding to the items was non-mandatory, meaning that also missing values were possible.

At the beginning of the study, there were 25 participants in the intervention group and the 15 participants in the control group. However, during the study, two participants from the intervention group had difficulties using the digital coach with their mobile phone due to technical reasons. Therefore, these participants had to be excluded from the study, which resulted in a final sample size of 38 participants, of whom 23 were in the intervention group and 15 were in the control group. Table 1 reports the descriptive statistics of this sample. In terms of gender, the whole sample and the two sub-samples were practically perfectly balanced. The age of the participants at the beginning of the study ranged from 21 to 63 years, with the mean age being 43.0 years (SD = 10.9 years) in the whole sample, 44.3 years (SD = 9.5 years) in the intervention group, and 41.1 years (SD = 12.7 years) in the control group. Most participants in the intervention group were doing the 50 km distance, whereas the 30 km distance was slightly more popular in the control group. The experience level of the participants in skiing ranged from previous or current competitive skiers to those who were doing a long-distance ski race for the first time. Regardless of their skiing experience, all the participants were physically very active. We collected information on the participants' physical activity by using a scale based on the Finnish National Sport Survey (FNSS) (Finnish Sports Federation, 2011), which consisted of seven categories.

The categories in the order from the most active to the least active were competition athletes, fitness athletes, fitness participants, health enhancing participants, utilitarian participants, casual participants, and inactive or sedentary people. In both groups, most categorised themselves as fitness participants.

	Whole sample (N = 38)		Intervention group (N = 23)		Control group (N = 15)	
Gender						
Male	19	50.0	11	47.8	8	53.3
Female	19	50.0	12	52.2	7	46.7
Age						
21–30 years	6	15.8	2	8.7	4	26.7
31–40 years	10	26.3	6	26.1	4	26.7
41–50 years	13	34.2	9	39.1	4	26.7
51–60 years	6	15.8	5	21.7	1	6.7
61–70 years	3	7.9	1	4.3	2	13.3
Skiing distance						
30 km	11	28.9	2	8.7	9	60.0
50 km	27	71.1	21	91.3	6	40.0
Skiing style						
Classic	31	81.6	0	0.0	8	53.3
Skate	7	18.4	23	100.0	7	46.7
Physical activity						
Competition athletes	8	21.1	4	17.4	4	26.7
Fitness athletes	21	55.3	13	56.5	8	53.3
Fitness participants	9	23.7	6	26.1	3	20.0

Table 1. Descriptive statistics of the whole sample and the two sub-samples.

The collected data was analysed by using the IBM SPSS Statistics 24 software. Because of the small sample size and the non-normal distributions in some of the items, the statistical significance of the changes between the measurements were tested by using the non-parametric Wilcoxon (1945) signed-rank test instead of the parametric Student's paired-samples t-test. As a threshold of statistical significance, we used $p < 0.05$. The potential missing values were handled by excluding the response of a particular participant to a particular item if he or she had not responded it in both the surveys. In other words, no imputation was used.

4 Results

The results are presented in three sub-sections, of which the first concentrates on the self-efficacy regarding overall skiing ability, the second concentrates on the self-efficacy regarding the upcoming race performance, and the third concentrates on the attitude towards digital coaching. For each item, we report separately for the intervention group (in white) and the control group (in grey) the mean and the standard deviation of the measurements, the mean change between the measurements and its standard deviation, as well as the results of the Wilcoxon signed-rank test in terms of the standardised z statistic and the p value, with the statistically significant changes as bolded.

4.1 Self-efficacy regarding overall skiing ability

The self-efficacy regarding overall skiing ability was measured by 17 items. Of them, six items concentrated on the self-efficacy regarding the ability to analyse and improve one's skiing and to create a suitable training program for oneself. The results of these measurements are reported in Table 2. As can be seen, statistically significant changes between the measurements were found in two items. First, the knowledge on how one should improve one's skiing technique had increased in the intervention group, whereas practically no change was found in the control group. Second, the perception that it is difficult for oneself to find out how to improve one's skiing technique had decreased in the intervention group. In contrast, this perception seemed to have increased in the control group, but the change remained as statistically not significant.

Statement	N	Survey 1		Survey 2		Change		Wilcoxon test	
		Mean	SD	Mean	SD	Mean	SD	z	p
I do not know how to become a better skier	22	3.1	1.5	2.6	1.1	-0.5	1.6	-1.824	0.068
	15	2.5	1.6	2.9	1.2	0.4	1.2	-1.540	0.124
I know how I should improve my skiing technique	23	3.9	1.1	5.2	1.1	1.3	1.2	**-3.464**	**0.001**
	15	4.6	1.7	4.7	1.4	0.1	0.9	-0.302	0.763
It is difficult for me to find out how to improve my skiing technique	22	4.6	1.5	3.8	1.7	-0.8	1.7	**-2.160**	**0.031**
	15	2.7	1.6	3.5	1.7	0.8	2.3	-1.389	0.165
It is difficult for me to analyze my skiing technique	23	4.4	1.3	4.5	1.6	0.1	1.0	-0.263	0.793
	15	3.3	1.7	3.7	1.5	0.5	2.0	-0.945	0.344
I am able to create a training program that is suitable for me	23	4.3	1.5	4.3	1.6	0.1	1.2	-0.209	0.834
	14	4.7	1.5	4.6	1.2	-0.1	1.2	-0.439	0.660
I need help in creating a training program suitable for me	23	4.7	1.5	4.7	1.5	0.0	1.0	-0.165	0.869
	15	4.2	2.0	4.5	1.7	0.3	1.4	-1.016	0.310

Table 2. Changes in the self-efficacy regarding the ability to analyse and improve skiing and create a suitable training plan.

In turn, the remaining 11 items concentrated on the self-efficacy regarding one's overall skiing technique. The results of these measurements are reported in Table 3. As can be seen, statistically significant changes between the measurements were found in three items. First, the perception that one's skiing technique in diagonal stride (diagonal stride and double polling are both techniques of classic style skiing) is good had decreased in the control group. In contrast, this perception seemed to have increased in the intervention group, but the change remained as statistically not significant. Second, the perception that one's skiing technique is good enough so that one can modify it to fit the circumstances had increased in the intervention group, whereas practically no change was found in the control group. Third, the perception that skiing would feel more pleasant if one had better technique had increased in the intervention group. A similar increase was found also in the control group, but this change remained as statistically not significant.

Statement	N	Survey 1		Survey 2		Change		Wilcoxon test	
		Mean	SD	Mean	SD	Mean	SD	z	p
I am satisfied with the level	23	4.1	1.4	4.3	1.4	0.3	1.5	-0.794	0.427

of my skiing technique	15	5.1	1.8	4.7	1.4	-0.4	1.3	-1.150	0.250
My skiing technique in classic style is good	23	5.0	1.0	5.3	1.0	0.3	1.1	-1.084	0.279
	13	5.5	1.3	5.2	1.1	-0.4	0.7	-1.890	0.059
My skiing technique in skate style in good	22	4.0	1.7	4.2	1.7	0.3	1.0	-1.540	0.124
	13	4.8	2.0	4.4	1.9	-0.5	1.6	-0.954	0.340
My skiing technique in diagonal stride is good	23	4.7	1.2	5.1	1.1	0.4	0.9	-1.897	0.058
	13	5.8	1.1	5.0	1.4	-0.8	1.1	**-2.326**	**0.020**
My skiing technique in double poling is good	23	4.8	1.3	4.7	1.2	-0.1	1.2	-0.294	0.768
	12	5.2	1.3	5.3	0.8	0.2	0.8	-0.707	0.480
My skiing technique is better than a year ago	23	4.3	1.8	4.9	1.7	0.5	1.5	-1.562	0.118
	15	4.4	1.9	4.7	1.2	0.3	1.3	-0.997	0.319
My skiing technique is worse than a year ago	23	2.1	1.2	1.9	1.0	-0.3	1.1	-1.153	0.249
	15	1.9	1.2	2.0	1.0	0.1	1.1	-0.144	0.885
My skiing technique is good enough so that I can modify it to fit the circumstances	23	4.7	1.3	5.2	1.0	0.5	1.1	**-2.000**	**0.046**
	15	5.6	1.1	5.5	1.2	-0.1	0.7	-0.707	0.480
Physical fatigue does not affect my skiing technique	23	2.3	0.9	2.6	1.6	0.3	1.4	-0.884	0.376
	15	3.0	1.3	2.5	1.2	-0.5	1.2	-1.427	0.154
Improving my skiing technique would make me a significantly better skier	23	5.8	1.2	5.8	1.3	0.0	1.1	-0.074	0.941
	15	4.9	1.5	4.9	1.6	-0.1	1.9	-0.918	0.359
Skiing would feel more pleasant if I had a better technique	22	4.8	1.8	5.5	1.5	0.8	1.6	**-1.992**	**0.046**
	13	4.4	2.0	5.4	1.4	1.0	1.9	-1.736	0.083

Table 3. Changes in the self-efficacy regarding overall skiing technique.

So, in summary, the usage of a digital coach seemed to promote both the self-efficacy regarding the ability to analyse and improve one's skiing and the self-efficacy regarding one's overall skiing technique. These findings also gained support from three additional items in the second survey, in which the participants were asked whether they perceived that their skiing technique, their knowledge about their skiing technique and training, and their physical skiing fitness had improved during the past month. Here, about 65 % of the intervention group but only about 20 % of the control group reported an improvement in their skiing technique, whereas about 70 % of the intervention group but only about 33 % of the control group reported of an improvement in their knowledge about their skiing technique and training. In terms of physical skiing fitness, the difference was less considerable as both about 74 % of intervention group and about 67 % of the control group reported of an improvement.

4.2 Self-efficacy regarding upcoming race performance

The self-efficacy regarding the performance in the upcoming race was measured by a total of 13 items. Of them, three items concentrated on the self-efficacy regarding one's physical fitness in the upcoming race. The results of these measurements are reported in Table 4. As can be seen, statistically significant changes between the measurements were found in two items. First, the perception that one's physical fitness is good enough for one to be able to have a good race performance had decreased in the control group, whereas practically no change was found in the intervention group. Second, the trust in one's physical fitness considering the upcoming race had increased in the intervention group. In contrast, this trust decreased in the control group, but the change was not statistically significant.

Statement	N	Survey 1		Survey 2		Change		Wilcoxon test	
		Mean	SD	Mean	SD	Mean	SD	z	p
My physical fitness is good enough for me to be able to finish the race	22	6.6	1.1	6.6	1.0	0.0	0.4	0.000	1.000
	15	6.8	0.4	6.9	0.4	0.1	0.5	-0.577	0.564
My physical fitness is good enough for me to be able to get a good race performance	23	5.2	1.2	5.1	1.1	0.0	1.5	-0.213	0.831
	15	5.9	0.8	5.5	1.1	-0.4	0.6	**-2.121**	**0.034**
I trust my physical fitness considering the upcoming race	23	5.3	1.5	5.8	1.0	0.5	1.2	**-1.976**	**0.048**
	15	6.1	1.1	5.7	1.1	-0.4	0.8	-1.732	0.083

Table 4. Changes in self-efficacy regarding physical fitness in the upcoming race.

In turn, three items concentrated on the self-efficacy regarding one's skiing technique in the upcoming race. The results of these measurements are reported in Table 5. As can be seen, statistically significant changes between the measurements were found only in one item. This concerned the perception that one's skiing technique is not preventing one from getting a good competition performance, which had decreased in the control group. In the intervention group, practically no change was found.

Statement	N	Survey 1		Survey 2		Change		Wilcoxon test	
		Mean	SD	Mean	SD	Mean	SD	z	p
My skiing technique is good enough for me to get a good race performance	23	5.2	1.2	5.4	0.8	0.2	1.0	-0.975	0.329
	14	6.0	1.2	5.7	1.1	-0.3	0.6	-1.633	0.102
My skiing technique is not preventing me from getting a good race performance	23	5.0	1.4	5.0	1.2	0.1	1.3	-0.182	0.856
	15	6.3	1.0	5.5	1.2	-0.7	0.7	**-2.810**	**0.005**
My race performance would be considerably better if I improved my skiing technique	23	4.9	1.6	4.8	1.7	-0.1	1.7	-0.087	0.931
	15	3.9	1.9	4.1	1.8	0.2	1.2	-0.730	0.465

Table 5. Changes in the self-efficacy regarding skiing technique in the upcoming race.

Finally, the remaining seven items concentrated on the self-efficacy regarding one's overall race performance. The results of these measurements are reported in Table 6. As can be seen, statistically significant changes between the measurements were found in three items. First, the fear of not reaching one's race goal had increased in the control group. A similar increase was found also in the intervention group, but this change remained as statistically not significant. Second, not being confident about one's own race performance had increased in both the groups. Third, the feeling that one's confidence in one's abilities will not falter during the race had decreased in the control group, whereas practically no change was found in the intervention group.

Statement	N	Survey 1		Survey 2		Change		Wilcoxon test	
		Mean	SD	Mean	SD	Mean	SD	z	p
I will get a better result than in my previous races	15	5.0	1.2	4.8	1.0	-0.2	1.2	-0.604	0.546
	9	5.1	1.5	4.4	1.3	-0.7	1.6	-1.186	0.236
I will reach the race goal I have set for myself	23	5.0	1.1	4.9	0.9	-0.2	1.1	-0.919	0.358
	14	5.7	0.7	5.4	0.7	-0.4	0.8	-1.518	0.129
I am afraid of not reaching	23	2.5	1.4	3.0	1.9	0.5	1.8	-1.383	0.167

my race goal	15	1.7	1.1	2.5	1.0	0.8	1.0	**-2.489**	**0.013**
I am not confident about my own competition performance	23	3.1	1.5	4.1	1.8	1.0	1.6	**-2.528**	**0.011**
	15	1.8	0.9	2.9	1.5	1.1	1.2	**-2.716**	**0.007**
I will not get discouraged during the race	23	5.1	1.6	5.4	1.5	0.3	1.6	-0.660	0.509
	15	6.1	1.0	5.7	1.1	-0.3	0.7	-1.667	0.096
My confidence in my abilities will not falter during the race	23	4.9	1.5	5.0	1.4	0.1	1.5	-0.291	0.771
	15	5.9	1.2	5.1	1.4	-0.9	1.2	**-2.289**	**0.022**
I will be satisfied with myself after the race	23	5.5	1.0	5.5	0.8	0.0	0.6	-0.333	0.739
	15	5.9	0.8	5.7	0.7	-0.2	0.7	-1.134	0.257

Table 6. Changes in the self-efficacy regarding overall race performance.

So, in summary, it seems that the usage of a digital coach promoted the self-efficacy regarding the performance in the upcoming race or at least protected the intervention group from a similar pre-race anxiety that was characteristic especially for the control group.

4.3 Attitude towards digital coaching

The attitude towards digital coaching was measured by five items, which concentrated on the overall attitude (bad vs. good) as well as on the instrumental (useless vs. useful and foolish vs. sensible) and experimental (unpleasant vs. pleasant and uncomfortable vs. comfortable) aspects of attitudinal evaluations. The results of these measurements are reported in Table 6. All in all, the attitude of both the groups was found to be relatively positive. In the first survey, it also seemed to be slightly more positive in the intervention group than in the control group. In the second survey, these differences had more or less disappeared as the attitude had changed into less positive in the intervention group and more positive in the control group. However, of these changes, only the change in the foolish vs. sensible scale in the intervention group was found as statistically significant.

Statement	**N**	**Survey 1**		**Survey 2**		**Change**		**Wilcoxon test**	
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**z**	**p**
The thought of using a digital coach while skiing during the entire ski season sounds: bad vs. good	22	5.6	1.4	5.1	1.7	-0.5	1.3	-1.530	0.126
	13	4.4	1.7	5.1	1.4	0.7	1.7	-1.667	0.096
The thought of using a digital coach while skiing during the entire ski season sounds: useless vs. useful	22	5.7	1.4	5.2	1.8	-0.5	1.4	-1.327	0.185
	14	4.8	1.7	5.1	1.2	0.4	1.9	-0.425	0.671
The thought of using a digital coach while skiing during the entire ski season sounds: foolish vs. sensible	22	5.7	1.4	5.0	1.7	-0.8	1.3	**-2.434**	**0.015**
	14	4.9	1.4	4.9	1.3	0.1	1.2	-0.439	0.660
The thought of using a digital coach while skiing during the entire ski season sounds: unpleasant vs. pleasant	22	5.4	1.6	4.9	1.5	-0.5	1.5	-1.268	0.205
	14	4.7	1.5	4.6	1.7	-0.1	1.2	-0.491	0.623
The thought of using a digital coach while skiing during the entire ski season sounds: uncomfortable vs. comfortable	22	5.3	1.5	4.9	1.6	-0.4	1.7	-1.010	0.312
	13	4.5	1.9	5.1	1.4	0.6	2.1	-0.794	0.427

Table 7. Changes in the attitude towards digital coaching.

5 Discussion

This study examined the changes in self-efficacy regarding cross-country skiers' perceived skiing abilities as well as their confidence related to an upcoming ski marathon race. The group of 38 volunteer participants consisted of skiers from different age groups and skiing backgrounds. The study was conducted as an intervention study containing both an intervention group and a control group. The measures used in the study were based on psychological measurement of self-efficacy that consisted of two online surveys regarding participants' perceptions regarding their own skills and confidence.

Based on the results it can be seen that using a digital coach had some effects on the participants' perceptions of their skiing technique. After the intervention, the intervention group participants were more knowledgeable on how they should change their skiing technique as well as found it easier to analyse their technique. This suggests that even in the case of more experienced cross-country skiers, a digital coach can be able to increase the knowledge regarding their own techniques.

When participants were asked about their overall confidence regarding the upcoming ski marathon race, both groups seemed less confident just before the race. This indicates the known phenomenon of pre-competition anxiety, which relates to anxiety experienced before a sport performance and is affected by perceived readiness and race goals (Lane et al., 1995). However, negative concerns about their race performance and reaching their goals had increased more in the control group participants. Regardless of the decreased level of confidence in general, the intervention group participants seemed to be equally sure they would not lose confidence in their abilities during the race whereas control group participants were more unsure about maintaining their confidence during the race. The difference in the perceptions of these groups regarding confidence during the race may have been a result of the intervention group's increased level of awareness regarding their skiing technique.

It also seemed that compared to control group participants, intervention group participants suffered less from pre-race competition anxiety regarding their technique. In other words, they did not lose their confidence on their skiing technique just before the race but instead were more confident for example on their skiing technique being good enough and to be able to adjust it based on the circumstances, such as weather conditions. According to Martens et al. (1990) a part of competition anxiety is cognitive anxiety, which is defined as cognitive concerns and negative expectations about oneself related to the situation at hand. In this study, the technique related anxiety can be seen as cognitive anxiety. The increase in self-efficacy regarding skiing technique might have resulted from the increased level of awareness regarding their technique.

Besides changes to perceived skiing technique, the intervention group participants also seemed to be more confident of their physical fitness before the upcoming race. One reason for this could be that using the digital coach made the participants more aware of their training history, which might have affected their self-efficacy. Another possible reason for the increased self-efficacy regarding physical fitness is that the digital coach changed the training routines of participants by increasing the amount or intensity of training.

When participants evaluated the changes in their knowledge and abilities during the intervention time it seemed that using the digital coach had resulted in increased knowledge of skiing technique as well as improvements in skiing technique. However, when examining the changes in participants' attitudes towards digital coaching, the attitudes of intervention group had become slightly less positive, whereas control group experienced a slight increase. Nevertheless, both groups in general had a positive attitude toward digital coaching before and after the interventions. This suggests that digital coaching is perceived by cross-country skiers as a positive tool particularly for enhancing skiing technique. However, due to the slight decrease in the attitude of intervention group, it suggests that digital coach devices and applications could be better developed to meet the skiers' needs and desires even more. As highlighted in previous literature (Yardley et al., 2015) it is important, especially in digital interventions, to have a product that uses a person-based approach. This means that digital coach devices should take into account personal differences and preferences while having an emphasis on autonomy

and independent use. The person-based approach is considered essential in maximising the acceptability as well as effectiveness of interventions (Yardley et al., 2015).

As for our practical implications, to tackle this issue, we propose certain design considerations that would most likely be fruitful for digital coach developers in providing products that better meet the users' needs and desires. First, regarding the known issue of pre-race anxiety, the digital coaches could be implemented with features that aim to reduce this by for example presenting the training history in a positive way to boost the confidence that the user has trained properly. Also, drawing from sports psychology, the digital coach could communicate supportive and calming messages to the user on the days preceding the race. Second, as for the communication during the training sessions and competition, the digital coaches should be designed for glanceability. In other words, the things that the users want to and need to see at different moments of their training and race should be well examined. The information should also be presented in a way that is quickly and easily understandable for the user. Third, to boost the confidence and present the value of using the digital coach, it could present the progress in technique or other measures and further provide an illustration on how this improvement will probably translate into actual performance. For example, the digital coach could present the progress in technique or fitness from the start of the use until the current moment and estimate how much this has increased the ability of the user, for example, by presenting the estimated improvement in a 10km ski or run.

As a theoretical contribution, this study extends the previous research on digital coaching by including a psychological element of self-efficacy to the study. The results support the previous research (Feltz 1988) highlighting the role of performance-based information as a source of self-efficacy information. To our knowledge this is the first study to measure psychological effects of digital coaching for cross-country skiers as well as in the athlete target group in general. Therefore, it provides important insights in to this previously little researched topic by acting as a groundwork for future IS studies. This study also contributes to the research on sport psychology by providing new insight and thus encouraging researchers to study the psychological effects of digital coaching and sport technology in general. From a practical point of view the results of this study offer insights to sport technology companies to further understand the positive and negative effects of digital coaching, particularly as it relates to athletes and their self-efficacy. This may assist sport technology companies in further developing products that meet the needs of this particular target group and make them a more attractive purchase. Besides bringing new insight from the IS perspective, we hope these findings would encourage athletes and coaches to consider the possibility of integrating digital coaching into their training program.

6 Limitations and future research

This study has a few notable limitations. Firstly, the size of the study sample was relatively small consisting of 38 participants. Secondly, there was a difference between the number of participants in intervention and control group. Thirdly, the athletes' self-efficacy for using technology was not taken into consideration in this study. Fourthly, the intervention period was approximately one month, which is relatively short. This limits the findings only to relatively short-term effects. Therefore, in the future similar studies should be conducted with more longitudinal study setting. Regardless of these limitations, statistically significant differences were found in both groups. However, in future it would be interesting to do similar studies with a larger data set which could enable studying the effects at a construct level. Lastly, the digital coach selected for this research was specifically designed for cross-country skiers. There are somewhat different types of digital coaching devices in the market which are meant for different target groups. Since this particular device was designed for cross-country skiing purposes, it should not be assumed that these results are directly applicable to other types of digital coach devices that may focus on other types of feedback and assistance. Because the level of a person's cross-country skiing technique plays such a major role in performance, the results of this study may also not be directly comparable to other sports.

Since this study was an exploratory study regarding the digital coaching in self-efficacy context in an athletic setting, this study is hoping to inspire future studies regarding the topic. As highlighted in previous research (Winstein and Schmidt, 1990), there might be differences for the use and effects between athletes and people who are doing sports more casually. Therefore, it would be interesting to do a similar study with the Racefox Ski application and to compare the results between experienced skiers and less experienced skiers. The future topics could also be related to testing the effects of digital coaching in other types of target groups as well as with other types of devices and applications as well as in other sports. Also, qualitative studies could be done regarding the topic in order to deepen the understanding of digital coaching effects especially from the users' point of views. This would bring important knowledge also to the sport technology companies on how to design and modify their digital coaching devices and applications to better meet the needs and wants of different target groups.

References.

Bandura, A. (1977). "Self-efficacy: Toward a unifying theory of behavioral change." *Psychological Review* 84 (2), 191-215.

Bandura, A. (1982) "Self-efficacy mechanism in human agency." *American Psychologist* 37, 122-147.

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice-Hall

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Bandura, A. (1998). "Health promotion from the perspective of social cognitive theory." *Psychology and Health* 13 (4), 623–649.

Beauchamp, M. R. and M. A. Eys (2007). *Group dynamics in exercise and sport psychology – Contemporary themes*. New York, NY: Routledge.

Chan, C. B., Ryan, D. A. and C. Tudor-Locke (2004). "Health benefits of a pedometer-based physical activity intervention in sedentary workers." *Preventive Medicine* 39 (6), 1215-1222.

Düking P., Hotho A., Holmberg H-C, Fuss F. and Sperlich B. (2016) "Comparison of Non-Invasive Individual Monitoring of the Training and Health of Athletes with Commercially Available Wearable Technologies." *Frontiers in Physiology* 7 (71), 1-11.

Faghri, P. D., Omokaro, C., Parker, C., Nichols, E., Gustavesen, S. and E. Blozie (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.

Feltz, D. and C. Lirgg (2001). "Self-efficacy beliefs of athletes, teams, and coaches." In R. Singer, H. Hausenblas & C. Janelle (Eds.) *Handbook of Sport Psychology*, 2nd ed. (340-361). New York: John Wiley & Sons.

Finnish Sports Federation (2011) *Kansallinen liikuntatutkimus 2009-2010: Aikuis- ja senioriliikunta. [National Sports Survey 2009-2010]* Report, Finnish Sports Federation, Helsinki, Finland.

Halson, S., Peake, J. and Sullivan, J. (2016). "Wearable Technology for Athletes: Information Overload and Pseudoscience?." International Journal of Sports Physiology and Performance, 11(6), 705–706.

Jowett, S. and D. Lavallee (2007). *Social psychology in sport*. Champaign, IL: Human Kinetics.

Kang, M., Marshall, S. J., Barreira, T. V. and J. O. Lee (2009). "Effect of pedometer-based physical activity interventions: a meta-analysis." *Research Quarterly for Exercise and sport* 80 (3),648-655.

Kari, T., Kettunen, E., Moilanen, P. and L. Frank (2017a). "Wellness Technology Use in Everyday Life: A Diary Study." In: *The 30th Bled eConference "Digital Transformation – From Connecting Things to Transforming Our Lives"*, Bled, Slovenia: University of Maribor, p. 279-294.

Kari, T., Koivunen, S., Frank, L., Makkonen, M. and P. Moilanen (2016). "Critical experiences during the implementation of a self-tracking technology". In: *The proceedings of the 20th Pacific Asia Conference on Information Systems (PACIS)*, 27.6.-1.7.2016 (16 pages). Chiayi, Taiwan: AIS.

Kari, T., Koivunen, S., Frank, L., Makkonen, M., and P. Moilanen (2017b). "The expected and perceived well-being effects of short-term self-tracking technology use." *International Journal of Networking and Virtual Organisations* 17 (4), 354-370.

Kettunen, E. and T. Kari (2018). "Can Sport and Wellness Technology be My Personal Trainer?: Teenagers and Digital Coaching." *In the 31th Bled eConference. Digital Transformation : Meeting the Challenges*", Bled, Slovenia: University of Maribor, p. 463-476.

Kranz, M., Möller, A., Hammerla, N., Diewald, S., Roalter, L., Ploetz, T. and P. Olivier (2013). "The mobile fitness coach: Towards individualized skill assessment using personalized mobile devices." *Pervasive and Mobile Computing* 9, 203-215.

Lane, A., Terry, P. and C. Karageorghis (1995). "Antecedents of multidimensional competitive state anxiety and self-confidence in duathletes." *Perceptual and Motor Skills* 80, 911-919.

Liebermann, D., Katz, L., Hughes, M., Bartlett, R., McClements, J. and I. Franks (2002). "Advances in the application of information technology to sport performance." *Journal of Sports Sciences*, 20 (10), 755-769.

Locke, E. A. and G. P. Latham, G (2002). "Building a practically useful theory of goal setting and task motivation: A 35-year odyssey." *American Psychologist* 57 (9), 705-717.

Miyamoto, S. W., Henderson, S., Young, H. M., Pande, A. and J. J. Han (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), e5.

Martens, R., Vealey, R. S. and D. Burton (1990). *Competitive anxiety in sport.* Champaign, IL: Human Kinetics.

Moritz, S., Feltz, D., Fahrbach, K. and D. Mack (2000) "The relation of self-efficacy measures to sport performance: A meta-analytic review." Research Quarterly for Exercise and Sport 71 (3), 280-294.

Racefox (2018) Racefox Ski. URL: https://racefox.se/ski#!sv-ski. (visited on 05/29/2018).

Šamija, I., Sporis, G. and K. Šamija (2016). "Self-efficacy scale construction n and validation in swimming." *Acta Kinesiologica* 10, 33-37.

Schmidt, B., Benchea, S., Eichin, R. and C. Meurisch (2015). "Fitness tracker or digital personal coach: how to personalize training." In: *The 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and ACM International Symposium on Wearable Computers*, 7.-11.9.2017. Osaka, Japan: ACM. p. 1063-1067.

Shields, C. and L. Brawley (2006) "Preferring Proxy-agency:Impact on Self-efficacy for Exercise." *Journal of Health Psychology* 11 (6), 904-914.

Shilts, M. K., Horowitz, M. and M. S. Townsend (2004). "Goal setting as a strategy for dietary and physical activity behavior change: a review of the literature*."American Journal of Health Promotion* 19 (2), 81-93.

Wang, J. B., Cataldo, J. K., Ayala, G. X., Natarajan, L., Cadmus-Bertram, L. A., White, M. M., …and J. P. Pierce. (2016). "Mobile and wearable device features that matter in promoting physical activity." *Journal of Mobile Technology in Medicine* 5 (2), 2-11.

Warraich, M. U. (2016). "Wellness Routines with Wearable Activity Trackers: A Systematic Review." *In: The 10th Mediterranean Conference on Information Systems (MCIS),* Paphos, Cyprus.

Wilcoxon, F. (1945). "Individual Comparisons by Ranking Methods. *Biometrics Bulleting* 1 (6),80-83.

Winstein, C. and R. Schmidt (1990). "Reduced Frequency of Knowledge of Results Enhances Motor Skill Learning." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 16, 677-691.

Xiao, X., Hedman, J., Tan, F., Tan, C-W., Clemmensen, T., Lim, E., Henningsson, S., Mukkamala, R., Vatrapu, R. and J. van Hillegersberg (2017) "Sports Digitalization: A Review and A Research Agenda". *In: ICIS 2017*, Proceedings. 6.

Yardley, L., Morrison, L., Bradbury, K. and I. Muller (2015) "The person-based approach to intervention development: Application to digital health-related behavior change interventions." *Journal of Medical Internet Research* 17 (1), e30