Continuous Wellness Tracking with Firstbeat – Usability, User Experience, and Subjective Wellness Impact

Timo Partala(✉), Laura Saar, Minna Männikkö, Maarit Karhula, and Tuulevi Aschan

South-Eastern Finland University of Applied Sciences, Patteristonkatu 3, 50100 Mikkeli, Finland
{timo.partala,laura.saar,minna.mannikko,maarit.karhula,
tuulevi.aschan}@xamk.fi

Abstract. Current wellness technologies are capable of monitoring wellness related parameters even 24 h a day for multiple days. The aim of the current research was to study the usability, user experience, and wellbeing impact of the wellness analysis Firstbeat, which is based on continuous measurement of heart rate variability (HRV) and user activity. 42 persons in working life participated in an intervention study, in which their wellbeing was continuously monitored for 3–7 days and they received a detailed wellness report and a personal plan for improvement. In a follow-up questionnaire, the participants reported good usability and user experience for the system, as well as significantly reduced stress and increased self-esteem, while no significant changes were observed in the other measured aspects related to subjective wellbeing. The results suggest that the usage of continuous wellness measurement systems using electrodes in the chest area, such as Firstbeat, can be experienced positively by their users. Further research is needed on effective methods for utilizing the rich information from the measurements in achieving lasting positive changes in lifestyle.

Keywords: Wellbeing · Wellness technology · Firstbeat · Heart Rate Variability · Usability · User experience

1 Introduction

With recent technological advances, continuous wellness measurements have become feasible for prolonged periods of time, while still preserving good measurement accuracy. As many commercially available wellness technologies can provide valid measurements, the focus of research has shifted to also include issues such information presentation, user experience, user acceptance, motivating the user, and wellness impacts of the technology. Given the large worldwide potential of wellness technology, the number of studies focusing on these issues from the user's perspective is still relatively small.

Previous studies of heart rate monitors and activity trackers have reported both positive and negative user experiences. For example, Preusse et al. [1] found and analyzed various different usability and user acceptance related challenges with commonly used

G. M. P. O'Hare et al. (Eds.): MobiHealth 2019, LNICST 320, pp. 281–293, 2020.
https://doi.org/10.1007/978-3-030-49289-2_22

activity trackers. In contrast, Karapanos et al. [2] presented examples of how activity trackers can support positive user experiences, by better supporting the users' psychological needs. For example, they can enhance the feelings of autonomy by providing people more control of their exercising or relatedness by connecting family members to joint healthy activities. Meyer et al. [3] recently found that high levels of usability and comfort were associated with the usage of clip, wristband, and mobile app based activity trackers by the users. Oh and Lee [4] identified both positive and negative user experience issues related to existing activity trackers and other quantified self technologies. The identified issues were related to user input, design, sharing and privacy, data visualization, and data accuracy, among other things.

Ahtinen et al. [5] studied using common heart rate monitors in exercising from a user experience perspective. Their results suggested relatively good usability, but only moderate motivating impact for exercising. The findings by Ehmen et al. [6] indicate fairly high acceptance and qualitative user experience in response to two popular wellness systems using heart rate monitor belts. However, their participants also reported a number usability problems related to both systems. An early version of the Firstbeat wellness analysis using heart rate variability and activity tracking was also found to be time-consuming and expensive by mobile workers [7]. In addition, sleep sensing devices (based on both heart rate monitoring and accelerometers) have been found to provide useful and objective feedback that is beneficial to their users [8].

The subjective wellness impacts of modern heart rate variability based wellness technologies such as the Firstbeat system have not been extensively studied. Instead, the focus has been on the validation of the technology in measuring, for example, stress and recovery, as well as in utilizing those measures in scientific studies (see Sect. 2.3). The aim of this study was to report experiences of a wellness intervention utilizing the Firstbeat wellness analysis, which is based on continuous measurements of heart rate variability and user activity. Specifically, the aim was to study usability, user experience, and subjective wellbeing impact of the analysis and its technological solution in a sample of people in working life. We were particularly interested in understanding user experiences related to continuous wellness measurements over multiple days, and whether it is possible to obtain lasting positive effects on subjective wellbeing by means of a single wellness intervention.

2 Method

2.1 Participants

The participants were 42 volunteers (30 females and 12 males) participating actively in working life during the study. The average age of the participants was 44.3 years (range 27–65 years). 24 participants had a lower or higher university degree and 18 participants did not have a university degree. 35 participants were employees and seven participants were entrepreneurs in organizations participating in our wellness related projects. The organizations were: a bank, an accounting office, two mass transit companies, a media company, a municipal organization, an advertising agency, a beauty salon, a child welfare organization, an engineering company, and several micro companies represented by their entrepreneurs. All the participants were geographically from Finland, and all the

materials, instructions, and questionnaires were delivered in the native language of the participants (Finnish). As an incentive, the participants received the wellness analysis and a personal plan for improvement free of charge.

The 42 participants included in the final data analysis reported that they used the Firstbeat system successfully and that they did not use any other wellness technologies during the intervention period. 31 participants chose the most common Firstbeat measurement period of three days and 11 participants chose an optional longer measurement period of 4–7 days. On average, the participants used the measurement technology for 3.5 days. The average time between receiving the report and personal plan from the intervention and filling in the follow-up questionnaire was 44.7 days. Previous studies on wellness technologies (e.g. [5]) report positive effects lasting for several weeks, and the current study also aimed at investigating the possible lasting effects of the intervention by aiming the evaluation period (time before the follow-up questionnaire) at 4–8 weeks.

2.2 Procedure

The implementation of the study was carried out within two projects at South-Eastern Finland University of Applied Sciences. Both projects aimed at studying methods for improving the wellbeing of employees and entrepreneurs of the participating companies by using wellness technology. The researchers and authors of this paper were completely independent of Firstbeat technologies. The goal of the Firstbeat intervention was to give the project participants tools for improving their own wellbeing through improved wellness related self-knowledge.

An information session was organized in each company, in which volunteer participants from each company were given detailed instructions for carrying out the analysis successfully, including the placement of the electrodes. In case of micro companies with only one participant, the same information was provided in a personal meeting. All the participants were told that their participation is fully voluntary and information from the wellness measurements, as well as information from the follow-up questionnaire is treated confidentially. The information from the wellness measurements was to only visible to participants themselves and the wellness specialist, who organized the study and gave personal feedback to participants.

Shortly after the measurements were carried out, group meetings (employees) or personal meetings (entrepreneurs) were organized to help the participants in interpreting their results and setting personal goals in order to improve their well-being. The participants received their wellness reports using encrypted e-mail or on paper before the meetings. In the meetings, the participants were presented with basic information about autonomic nervous system (e.g. the functions of the sympathetic and parasympathetic nervous system), heart rate variability, the importance of exercise, and the various analyses presented in their Firstbeat reports were explained in detail. Finally, the participants received personal advice in setting their wellness goals according to the Firstbeat method, described in the next section.

2.3 The Firstbeat Wellness Analysis

The Firstbeat wellness analysis aims at providing meaningful physiological information that helps people improve their overall well-being and performance. It is based on heart rate variability (HRV) and motion sensor measurements. The analysis and the measurement technology is based on more than 15 years of development. The system is used by many organizations worldwide to improve the wellbeing of their personnel and it has also been used in numerous scientific physiological studies to study stress and recovery, as well as physical activity, oxygen intake, and energy expenditure [e.g. 9, 10].

Heart rate variability has been shown to be associated with stress and recovery. Generally, a low variability in heartbeats indicates that the body is under stress from, for example, exercise or psychological events. In contrast, a higher variability in heartbeats usually means that the body has a strong ability to tolerate stress or is recovering from prior stress. By accurately measuring HRV it possible to gain an understanding of the state of the autonomic nervous system at any given moment. The Firstbeat Bodyguard 2 measurement device used in the Firstbeat wellness analysis has been shown to provide an accurate method for long term HRV monitoring during daily life [11].

The package given to each participants contained the Firstbeat Bodyguard 2 measuring device, two leaflets of instructions, and disposable electrodes (Fig. 1). The participants were also given plenty of extra electrodes (in addition to those pictured below) to be able to replace them more than once per day, if necessary. The Firstbeat wellness system uses an electrocardiogram (ECG) with two electrodes to produce the heart rate variability measurements. The electrode attached to the recording device was placed on the right side of the body just beneath the collar bone. The second electrode was placed on the rib cage on the lower left side of the body. The measurement and recording started

Fig. 1. The contents of the wellness analysis package given to each participant.

automatically after both electrodes were attached to the body. The device also included a motion sensor to estimate the amount of exercise and energy expenditure.

The system included a loadable battery with a battery life of at least six days and a recording capacity of about 20 days of wellness data. The weight of the system was 24 g. Its sampling resolution in measuring heart rate variability was 1000 Hz. The resolution of the motion sensor was 12.5 Hz. The battery of the device could be loaded by connecting the measurement unit of the device to a standard USB port of a computer. The USB connection was also used to transfer the data stored on the device for the Firstbeat software.

When the participants started using the analysis, they received an e-mail with a link to the Firstbeat startup questionnaire. They were asked to give a self-evaluation related to their exercise, eating, alcohol consumption, stress, recovery, sleeping, health, and wellbeing. They also received a link to a web diary, which they could use on their computers or smart phones. For each measurement day, they were instructed to mark their work periods, sleeping periods, exercise periods, and any other meaningful activities, as well as any medicine taken and doses of alcohol consumed.

The Firstbeat measurement device is intended to be worn day and night except when it would come into contact with water. Typically, the participants of the current study removed the devices once a day for a short period when they took a shower and replaced the electrodes. The participants were instructed to use the wellness analysis for at least one rest day – or a less stressful working day – and two working days, which is the standard procedure for a Firstbeat analysis.

After they had completed the measurement period, the participants received a full Firstbeat wellness report (2018 version) with at least seven pages. The first page of the report repeated the participant's answers in the self-evaluation questionnaire. On pages two to four (for a three day measurement), the results from the wellness analysis were presented separately for each day of measurement. Each page presented the amount and percentage of stress, recovery, and physical exercise periods during the day. In addition, a timeline of stress, recovery, and physical activity periods was presented augmented with the participant's diary notes. Furthermore, the following information was provided: amount of recovery during work; amount and quality of recovery during sleep (Fig. 2); length of light, moderate, and vigorous physical activity; energy expenditure; and steps taken during the day. Overall scores on a scale of 0–100 were also presented for balance of stress and recovery, restorative effect of sleep (Fig. 2), and positive health effects of exercise.

On page five, a summary over the whole measurement period was presented. It included a timeline of stress, recovery, and physical activity during the whole measurement period. Daily scores and overall scores (0–100) over the whole measurements period were also presented for balance of stress and recovery, recovery during sleep, and health effects of exercise. A summary view of exercise and energy expenditure was also presented. Finally, an overall wellness score (0–100) was presented taking into account all the measured wellness aspects.

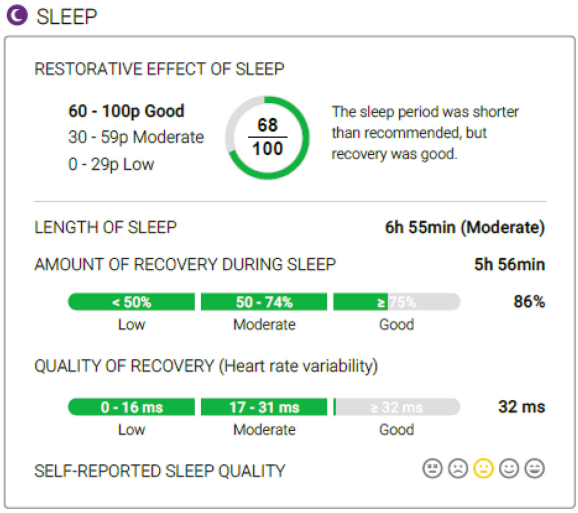

Fig. 2. A sample infobox from the report presenting an analysis of one night's sleep.

On page six they, together with a wellness specialist, set personal goals for improving their well-being by choosing from sixteen predefined goals related to stress management, sleep and recovery, exercise, and nutrition (e.g. "I will attempt to go to bed early enough to get enough sleep"). They also had a possibility to define their own personal goals. A sample report in English is available on Firstbeat website [12].

2.4 Questionnaire

The main research method for collecting data from the participants concerning the wellness intervention was an electronic questionnaire. It consisted of three main methods: System Usability Scale, AttrakDiff2, and a subjective wellbeing questionnaire.

On the first page on the questionnaire, the general instructions for the questionnaire were presented to the participant. The participant was instructed to input his/her participant number sent in an invitation e-mail by the researcher, who conducted the wellness analysis. On the second page of the questionnaire, the participant was asked to report demographic information and information related to the usage of the wellness measurement device. Specifically, the participant was asked to report his/her gender, age, education level from six alternatives, profession, occupation, and whether they work as an employee or an entrepreneur. Moreover, the participants reported the number of days they used the device to record their wellness parameters and the numbers of days passed since they read the report and made their personal plans.

System Usability Scale. The widely used System Usability Scale (SUS) method was used as the method for evaluating the perceived usability of the Firstbeat system. On the third page of the questionnaire the participant was asked to complete SUS in its original form using a 1–5 Likert scale as suggested by Brooke [13]. At the end of the page, the participants also had a possibility to give qualitative comments about the usability of the Firstbeat system and the usability problems they encountered.

AttrakDiff2. On page four of the questionnaire, the AttrakDiff2 method suggested by Hassenzahl [14] was used as the method to study user experiences. The four central concepts of Hassenzahl's user experience model were studied using seven-point semantic differential scales. The concepts were: pragmatic quality (quality of use from a task-oriented perspective), hedonic quality: identification (how well the system allows the user to relate to it), hedonic quality: stimulation (how well the system fulfills the stimulation needs of the user), and attractiveness (overall impression and judgement of the system). Each concept was studied using seven scales, thus the number of scales in the questionnaire was 28. The participants also had a possibility to give qualitative comments about the user experience of the system.

Subjective Wellbeing Questionnaire. On page five, the aim was to examine the subjective wellbeing effects of the current intervention briefly, yet as holistically as possible. A brief questionnaire probing 15 central aspects of subjective wellbeing was constructed for the purposes of the current study. Many of the concepts were taken from the wellness related concepts of WHOQOL-BREF [15], which is a cross-culturally validated quality of life assessment. Drawing from the self-determination theory and studies highlighting psychological needs and emotions as important correlates of subjective wellbeing [16–19], further wellbeing related concepts were identified for the questionnaire.

Each statement on page five of the questionnaire began with: "After using the Firstbeat system and reading the report – when compared to time before using the system – I have felt…" and the statements ended with the endings presented in Table 1 below. Each

Table 1. The wellbeing aspects in the study and the corresponding statement endings.

Wellbeing aspect	Statement ending
Physical health	…myself physically healthy
Bodily pain	…physical pain
Sleep quality	…that I sleep well
Stress	…myself stressed
Autonomy	…that my actions are autonomous
Competence	…that I can successfully complete different tasks and projects
Relatedness	…that I have positive social relationships
Self-esteem	…that I have high self-esteem
Positive emotions	…positive emotions such as joy, pride, or interest
Negative emotions	…negative emotions such as worry, sadness, or anxiety
Meaningful life	…that I lead a purposeful and meaningful life
Optimism	…that I am optimistic about the future
Active lifestyle	…that my lifestyle is active
Energy	…myself energetic
Depression	…myself depressed

statement was studied using a 1–7 scale with the following anchors: 1 = less than before – 4 = as much as before – 7 = more than before. In addition, the participants could leave any free-form qualitative comments about the wellness aspects of the intervention.

2.5 Data Analysis

Data from SUS was analyzed according to the original instructions [13] including reverse scoring, and calculating an overall score from 0 to 100. The results were interpreted using the adjective scale suggested by Bangor et al. [20]. The results from the AttrakDiff2 questionnaire using seven point semantic differential scales were transferred to a scale from −3 to 3, displayed visually and averaged by the four user experience components in Hassenzahl's model [14]. For the wellbeing data, one sample t-tests were used to determine statistically, whether the ratings for the different subjective wellbeing related aspects differed significantly from the middle point of the scale, which suggested that no change in relation to the wellbeing related aspect has taken place.

3 Results

3.1 Usability

The average SUS score for the Firstbeat wellness analysis was 76.7 (range 45–100). According to the adjective scale for SUS developed by Bangor et al. [20], this result indicated 'good' usability. More specifically, the score was between what is typically perceived as 'good' (mean 71.4) and 'excellent' (mean 85.5).

3.2 User Experience

The results for the AttrakDiff2 components studying different aspects of user experience are presented in Fig. 3. The averaged user experience ratings were on the positive side of the scale for all four concepts, and there were no significant differences between the means.

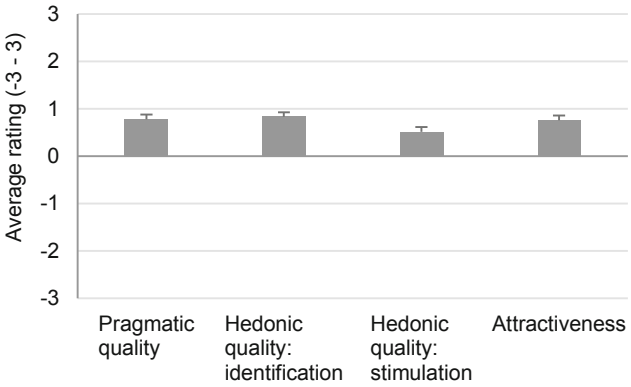

Fig. 3. Mean ratings and standard errors of the means for the central user experience concepts.

The detailed results from all of the AttrakDiff2 scales are presented in Fig. 4. Almost all of the single ratings were on the positive side of the scale, however, the system was seen as a bit technical and also quite a bit undemanding instead of being able to provide positive challenge. When giving this rating, the participants were possibly thinking of the easy usability of the system instead of the challenge posed by the analysis as a whole (e.g. the measurement started automatically when the electrodes were attached). Positive adjectives associated with the system included: good, motivating, novel, professional, and presentable.

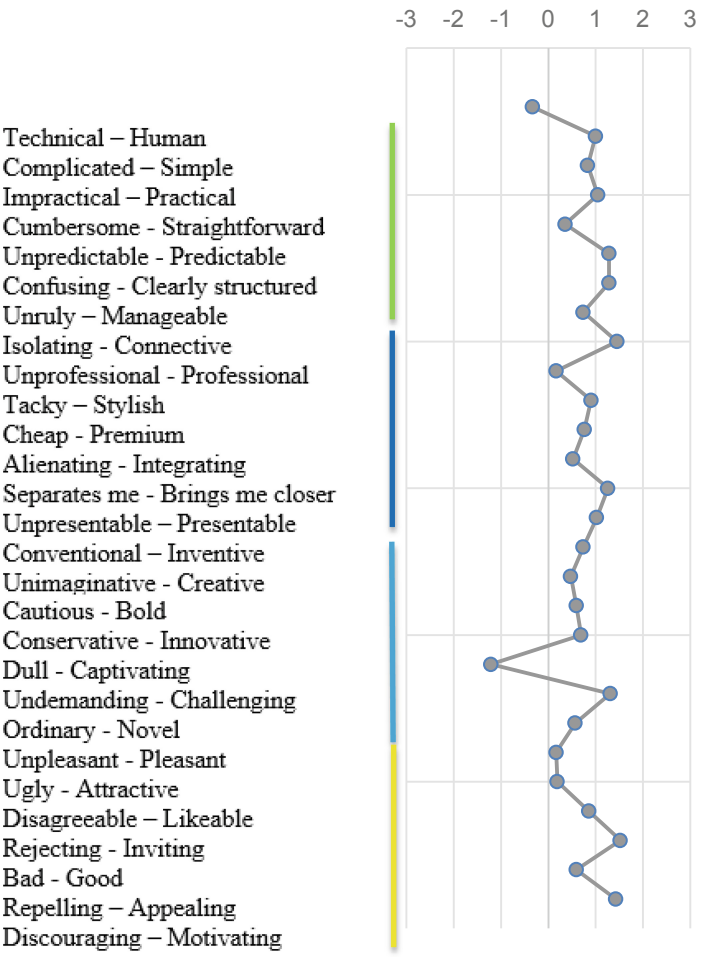

Fig. 4. Mean ratings for the 28 AttrakDiff2 scales (colors indicate components of user experience: green = pragmatic quality; blue = hedonic quality, identification; light blue = hedonic quality, stimulation; yellow = attractiveness). (Color figure online)

3.3 Subjective Wellbeing

The results from the subjective wellbeing questionnaire are presented in Table 2 below (scale: 1 = less than before – 4 = as much as before – 7 = more than before).

Table 2. Mean ratings and standard errors of the means for the different aspects of subjective wellbeing.

Wellbeing aspect	Mean (SEM)
Physical health	4.02 (.09)
Bodily pain	3.93 (.06)
Sleep quality	4.10 (.15)
Stress	3.71 (.11)
Autonomy	4.00 (.11)
Competence	4.10 (.10)
Relatedness	4.07 (.06)
Self-esteem	4.19 (.09)
Positive emotions	4.17 (.10)
Negative emotions	3.88 (.10)
Meaningful life	4.21 (.12)
Optimism	4.17 (.11)
Active lifestyle	4.19 (.12)
Energy	4.12 (.10)
Depression	3.83 (.12)

The statistical analysis revealed that the participants evaluated that they have felt significantly less stressed after using the system and reading the report than before usage ($t = 2.6$, $p = .012$). The participants also rated their self-esteem as higher after the intervention than before it ($t = 2.0$, $p = .044$). The other ratings did not differ significantly from the center point of the scale (suggesting no significant changes).

3.4 Qualitative Comments

The qualitative comments gathered in the questionnaire were largely in line with the quantitative results. There were no major usability problems highlighted by the users. Single comments were given about skin irritation with the electrodes, lack of indication when the device is fully loaded, and the usability of making diary entries.

The qualitative comments for the wellbeing effects of the system included a variety of different comments ranging from being aware of the wellness aspects to be improved, but not making any changes in lifestyle, to putting the set goals into action and noticing wellness improvements. Thus, there seemed to be a lot of variation in the participants' reactions to the results and the goals set at the end of the analysis.

4 Discussion

In the current study, usability, user experience, and subjective wellbeing impact were measured in response to an intervention implemented using the Firstbeat wellness system. In a working life sample of participants, the results suggested good usability for the system, as it received a SUS score of 76.7 out of 100. The results also suggested above average user experience in all measured aspects: pragmatic quality, hedonic quality (identification), hedonic quality (stimulation), and attractiveness. Thus, system was evaluated to have a good balance of hedonic and pragmatic qualities (self-orientation and task-orientation) [14]. Finally, the participants reported reduced subjective stress and higher self-esteem after the wellness intervention. Stress-related visualizations form a central part of the Firstbeat report, and the current results suggest that the participants of the current study were indeed able to use that information to reduce their stress levels in practice. However, it should be noted that the results suggested no significant changes for 13 of the 15 studied aspects related to subjective wellbeing.

Many previous studies [e.g. 1, 5–7] have pointed out usability barriers in the adoption of wellness technology, especially in technologies utilizing physiological wellness measurements. The current results suggest that Firstbeat has been successful in avoiding any major usability problems, and the minimalistic user interaction is simple enough for users in a working age population. Regarding user experience, the current results are in line with [6], who reported positive user experiences for heart rate monitor belts. The current results suggest that continuous mobile wellness measurements – even if they use electrodes, which are somewhat invasive and in constant physical contact with the user – can be well accepted by their users and even evoke a positive user experience.

On the other hand, the reported changes in subjective wellbeing were relatively small and only some of the participants reported making relevant changes in lifestyle based on the results. These results highlight the difficulty of translating wellness related awareness and goal setting into behavior that actually enhances holistic wellbeing. Consolvo et al. [21] divide design efforts of wellness technology into four chapters: collecting behavioral data, providing self-monitoring feedback, supporting goal-setting, and moving forward. The first three chapters have been mainly well considered in the design of the Firstbeat system, while the greatest challenges seems to be in achieving changes in the users' lifestyles and lasting improvements in wellbeing. Continuous wellness measurements can provide accurate information, but plain awareness of one's physiological state or setting goals may not be enough for achieving lasting effects [22].

Consolvo et al. [21] suggested that moving forward in wellbeing includes, for example, assessing the user's progress, and supporting the user over her lifespan. These could also be key elements in the context of continuous well-being measurements and the Firstbeat system. Possible topics for future research include studying the patterns of using the Firstbeat system over a longer period of time, when the use is initiated by the user her/himself. In addition, effective persuasive technologies [23] could be applied in addition to the Firstbeat analysis with the goal of achieving more positive changes in wellbeing related experiences and behavior.

The limitations of the current study should also be discussed. The participants of the current study were on average middle-aged and participating in working life, thus the results are not directly generalizable to other groups, for example, students or the

elderly. The participants also come from a limited geographical region in Finland, in other regions there might be different cultural factors affecting the perceptions of the system. Finally, within the limits of the current research it was possible to carry out a single wellness intervention and study the usage of one wellness analysis and the related technological solution. Thus, it was not possible to make comparisons between different systems or study possible benefits of recurrent use of the Firstbeat analysis.

Overall, the current results provide a clear picture about the wellness intervention studied. The results confirm that it is possible for users to be monitored for even about 24 h per day by a wearable device measuring heart rate variability and activity, and still have positive user experiences related to the technology. The participants of the current intervention also reported significantly reduced stress and improved self-esteem after the intervention. The assessment of user progress and long-term support [21], as well as persuasive technology [23] may be key additions to the Firstbeat approach on the road towards even more effective and holistic improvements in wellbeing.

Acknowledgments. The authors would like to thank all the companies and individuals who participated in the current study. This research was carried out within three projects. The DIDIVE and Tiedosta projects were funded by Häme and South Savo Centres for Economic Development, Transport and the Environment from the European Social Fund (projects S20895 and S20924), respectively. The Smart Well-being and Food Services for the Future project was funded by the Regional Council of South Savo from the European Regional Development Fund (project A72562).

References

1. Preusse, K.C., Mitzner, T.L., Fausset, C.B., Rogers, W.A.: Older adults' acceptance of activity trackers. J. Appl. Gerontol. **36**(2), 127–155 (2017)
2. Karapanos, E., Gouveia, R., Hassenzahl, M., Forlizzi, J.: Wellbeing in the making: peoples' experiences with wearable activity trackers. Psychol. Well-Being **6**(1), 1–17 (2016). https://doi.org/10.1186/s13612-016-0042-6
3. Meyer, J., Fortmann, J., Wasmann, M., Heuten, W.: Making lifelogging usable: design guidelines for activity trackers. In: He, X., Luo, S., Tao, D., Xu, C., Yang, J., Hasan, M.A. (eds.) MMM 2015. LNCS, vol. 8936, pp. 323–334. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-14442-9_39
4. Oh, J., Lee, U.: Exploring UX issues in quantified self technologies. In: Proceedings of Eighth International Conference on Mobile Computing and Ubiquitous Networking (ICMU 2015), pp. 53–59 (2015)
5. Ahtinen, A., Mäntyjärvi, J., Häkkilä, J.: Using heart rate monitors for personal wellness – the user experience perspective. In: Proceedings of Engineering in Medicine and Biology Society (EMBS 2008), pp. 1591–1597 (2008)
6. Ehmen, H., Haesner, M., Steinke, I., Dorn, M., Gövercin, M., Steinhagen, E.: Comparison of four different mobile devices for measuring heart rate and ECG with respect to aspects of usability and acceptance by older people. Appl. Ergon. **43**(3), 582–587 (2012)
7. Hyrkkänen, U., Vartiainen, M.: Heart rate variability measurements in mobile work. In: Eriksson-Backa, K., Luoma, A., Krook, E. (eds.) WIS 2012. CCIS, vol. 313, pp. 60–67. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-32850-3_6
8. Ravichandran, R., Sien, S.W., Patel, S.N., Kientz, J.A., Pina, L.R.: Making sense of sleep sensors: how sleep sensing technologies support and undermine sleep health. In: Proceedings of the Human Factors in Computing Systems (CHI 2017), pp. 6864–6875 (2017)

9. Föhr, T., et al.: Physical activity, heart rate variability–based stress and recovery, and subjective stress during a 9-month study period. Scandinavian J. Med. Sci. Sports **27**(6), 612–621 (2017)
10. Hallman, D.M., Ekman, A.H., Lyskov, E.: Changes in physical activity and heart rate variability in chronic neck–shoulder pain: monitoring during work and leisure time. Int. Arch. Occup. Environ. Health **87**(7), 735–744 (2013). https://doi.org/10.1007/s00420-013-0917-2
11. Parak, J., Korhonen, I.: Accuracy of Firstbeat Bodyguard 2 beat-to-beat heart rate monitor. White paper by Firstbeat Technologies Ltd. https://assets.firstbeat.com/firstbeat/uploads/2015/11/white_paper_bodyguard2_final1.pdf. Accessed 2 Sept 2019
12. Firstbeat Technologies: Firstbeat Lifestyle Assessment, Full Report. https://www.firstbeat.com/wp-content/uploads/2015/09/Lifestyle-Assessment-2016-full-report.pdf. Accessed 2 Sept 2019
13. Brooke, J.: SUS-A quick and dirty usability scale. In: Jordan, P.W., Thomas, B., Weerdmeester, B.A., McClelland, I.L. (eds.) Usability Evaluation in Industry, pp. 189–194. Taylor and Francis, London (1996)
14. Hassenzahl, M.: The interplay of beauty, goodness, and usability in interactive products. Hum. Comput. Interact. **19**(4), 319–349 (2004)
15. Whoqol Group: Development of the World Health Organization WHOQOL-BREF quality of life assessment. Psychological medicine **28**(3), 551–558 (1998)
16. Partala, T., Kallinen, A.: Understanding the most satisfying and unsatisfying user experiences: emotions, psychological needs, and context. Interact. Comput. **24**(1), 25–34 (2012)
17. Partala, T., Saari, T.: Understanding the most influential user experiences in successful and unsuccessful technology adoptions. Comput. Hum. Behav. **53**, 381–395 (2015)
18. Ryan, R.M., Deci, E.L.: Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am. Psychol. **55**(1), 68–78 (2000)
19. Sheldon, K.M., Elliot, A.J., Kim, Y., Kasser, T.: What is satisfying about satisfying events? Testing 10 candidate psychological needs. J. Pers. Soc. Psychol. **80**(2), 325–339 (2001)
20. Bangor, A., Kortum, P., Miller, J.: Determining what individual SUS scores mean: adding an adjective rating scale. J. Usability Stud. **4**(3), 114–123 (2009)
21. Consolvo, S., Klasnja, P., McDonald, D.W., Landay, J.A.: Designing for healthy lifestyles: design considerations for mobile technologies to encourage consumer health and wellness. Found. Trends Hum. Comput. Interact. **6**(3–4), 167–315 (2014)
22. Miyamoto, S.W., Henderson, S., Young, H.M., Pande, A., Han, J.J.: 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 uHealth **4**(1), 1–12 (2016)
23. Orji, R., Moffatt, K.: Persuasive technology for health and wellness: state-of-the-art and emerging trends. Health Inform. J. **24**(1), 66–91 (2018)