Available online at www.sciencedirect.com
ScienceDirect
Procedia Engineering 147 (2016) 799 – 805
Procedia Engineering
www.elsevier.com/locate/procedia

11th conference of the International Sports Engineering Association, ISEA 2016

From problem to solution: Developing a personalized smartphone application for recreational runners following a three-step design approach

Steven Vos[a,b]*, Mark Janssen[a,b], Jos Goudsmit[a], Coen Lauwerijssen[c] & Aarnout Brombacher[b]

[a]*Fontys University of Applied Sciences – School of Sport Studies, Theo Koomenlaan 3, 5644HZ Eindhoven, The Netherlands*
[b]*Eindhoven University of Technology – Department of Industrial Design, De Zaale, 5612AJ Eindhoven, The Netherlands*
[c]*2M Engineering Ltd., John F Kennedylaan 3, 5555XC Valkenswaard, The Netherlands*

Abstract

The aim of this paper is to design and test a smartphone application which supports personalized running experiences for less experienced runners. As a result of a multidisciplinary three-step design approach *Inspirun* was developed. *Inspirun* is a personalized running-application for Android smartphones that aims to fill the gap between running on your own (static) schedule, and having a personal trainer that accommodates the schedule to your needs and profile. With the use of GPS and Bluetooth heart rate monitor support, a user's progress gets tracked. The application adjusts the training schedule after each training session, motivating the runner without a real life coach. Results from three user studies are promising; participants were very satisfied with the personalized approach, both in the profiling and de adaptation of their training scheme.

Peer-review under responsibility of the organizing committee of ISEA 2016

Keywords: Recreational running; personalized smartphone application; industrial design; three-step approach

1. Introduction

Recent developments in ICT and sensor technology have made it possible to study the physical aspects of human behavior on a 24/7 basis. This has resulted in an exponential increase in availability and use of physical activity related smartphone applications and activity trackers [1-3]. In spite of these many applications, research in the field of sports is, in this context, rather new and only very little research has been published. Moreover, the focus is rather on performance related aspects and sports related monitoring devices are mainly based on underlying data models and design propositions directly derived from elite and competitive sports with a strong focus on training activities where "more is better" [4]. Intelligent systems in sports have the potential to contribute to the reduction of physical inactivity, however, designing electronic monitoring and coaching devices for recreational sports participants requires a distinctive envisioning of societal and personal needs.

This paper wants to contribute to the body of research on the design of intelligent systems in recreational sports. It analysis the development of a running related intelligent system providing feedback, automatic adaptation of training schemes and coaching for recreational runners (the context of this paper). A three-step multidisciplinary design approach will be applied. First, an overview is provided of empirical literature regarding running and the use of smartphone applications and other electronic devices. A rationale for the development of a running related smartphone application will be provided. Second, the approach used to design *Inspirun*, a personalized smartphone application for recreational runners, will be introduced. Third, the developed running application will be presented and conclusions and implications will be discussed.

1.1. Running as an expression of unorganized sports activities with a health related focus

Physical inactivity is a growing public health concern. Although scholars consistently put emphasis on the role of physical activity in preventing diseases and reducing mortality [5-8], these and other health related arguments seem to be inadequate to

* Corresponding author. Tel.: +31 610583996.
E-mail address: steven.vos@fontys.nl

1877-7058
Peer-review under responsibility of the organizing committee of ISEA 2016
doi:10.1016/j.proeng.2016.06.311

convince large groups of people to be more physically active. Yet, incentives such as social interaction, competition and fun, which can be considered as drivers for involvement in sports and physical activity, are key elements of individual sports such as running [9]. Running is one of the most popular forms of sports participation in Western-Europe with approximately 50 million participants [10]. This is consistent with a more general development towards more recreational and unorganized forms of sports, such as running, cycling and recreational walking [9,11,12]. These sports have in common that they (i) have a health related focus, (ii) impose very few restrictions on age, (iii) require no specific infrastructure, and (iv) can be practiced independent of time and place [13,14]. Moreover, running attracts a diversity of running participants in terms of socio-demographic variables and motives such as health, freedom, social experience, fun and performance enhancement [10,12,15]. A considerable number of them are 'less experienced' sports participants. The flip side of the coin is a high drop-out rate due to injuries and motivational lacks. Due to the shift from a sporting activity which was originally practiced in private track and field clubs to huge masses running individual or in small groups [16], personalized guidance and support is losing ground, often resulting in drop-out due to injuries or demotivation [17-20]. With regard to novice running substantial efforts, in terms of guidance, are necessary. This is crucial from different perspectives (including sustainability, health improvement, motivation, sustainable sports participation, etc.) and could have a considerable impact on vitality, active living and public health [14].

1.2. Wearable self-tracking products – smartphone applications

Consistent with the development towards more recreational and unorganized sports participation, there has been an exponential increase in the availability and use of sports and health related monitoring devices, such as smartphone applications, activity trackers and sports watches [1,2]. In the last decade sports participation has grown extensively, and the market has reacted to this evolution by providing sports goods and services [20,21]. Within this market, especially expenditures on wearable monitoring devices and self-tracking products are rising [14,22]. Indeed, the sporting goods industry has embraced technology in developing products that could monitor, motivate and coach people to become and keep being active [5]. This is consistent with a more general trend of self-monitoring health-outcomes, often referred to as Quantified Self [24].

Smartphone applications have several advantages in their potential to become a powerful tool to promote and stimulate physical activity [1,7,14]. Among others, they have a large reach and are easy accessible, users can carry them and access data anywhere and anytime, they can provide feedback opportunities, global positioning system data can be used, etc. [1,7]. Though smartphone can be considered as interesting platforms for (e-)coaching [25], most of the fitness and health related apps (only) provide feedback on performance, while tailored guidance is limited [2].

A smartphone is a non-specific sporting good, but when using a sport-related application it turns a general used product (non specific) into a sporting good [23]. Yet, literature regarding the use of smart phone applications by novice runners (and sports in general) is scarce. There is ample evidence that these applications have positive effects on sustainable sports participation. Some recent studies in the Netherlands showed that about 50% to 60% of the participants in open and recreational running events use running related smartphone applications [7,14,23]. This use shows a negative relation with running distance, running frequency and running experience [23]. The most used functionality is the tracking of distance and speed. The monitoring of heart rate and the use of personalized training schemes within these smartphone applications is limited [23,26]. A study among participants in a recreational running event, showed that users of running-related smartphone applications are (i) more likely to be more physically active and feel and live healthier, and (ii) have a higher intention to maintain their running behavior [7]. Although no causal relation was studied, these results are encouraging to further explore the possibilities of smartphone applications for sustainable participation in running.

1.3. Designing a personalized smartphone application for recreational runners

Inspirun, a personalized running-application for Android smartphones was developed for several reasons. First, cross-sectional user studies have shown that novice and less experienced runners run individual, without guidance. Moreover, these runners more often use smartphone applications than sports watches [14,23]. Second, smartphones provide a platform for developers to design third-party applications which can target specific groups, and have many advantages from both a users and a public perspective. Third, findings from previous studies suggest that the use of smartphone applications can contribute to the promotion of running and physical activity [7,14,23,24]. Fourth, technological solutions should take into account the variation in perspectives of individual runners: research has revealed that typologies of sports participants (based on motives and psychographic variables) can be distinguished which can be related to differences in needs, (running) perceptions, usage of products and services, etc. [14,27,28].

The main challenge however, is to design a running-related smartphone application which is able to tackle the two most important reasons for drop-put in running among recreational runners; i.e. injuries and motivational lacks. This requires a design approach which is different compared to the research and design tradition behind most existing sports related smartphone applications and watches which focus on performance related aspects and are mainly based on underlying data models and design propositions directly derived from elite and competitive sports. Understanding the crossovers between personal (psychological, physiological, etc.), social (social support from family, peers, etc.), and environmental factors (setting, context, culture, policy, etc.) is key for the design and provision of products and services targeting mass sports participation and/or physical activity. Most of the existing design methodologies often have an unidisciplinary approach , although many user-driven research methods have been developed in the last decades [29- 33]. Hence, the aim of this paper is to design a smartphone application which supports personalized running experiences and provides feedback, automatic adapted training schemes and coaching for less experienced runners. A multidisciplinary approach (combination of quantitative, qualitative and design strategy methods) will be followed which is suitable in developing personalized intelligent systems for recreational sports.

2. Methods

A three-step approach was used (see Figure 1). First, profiles of runners were developed (i.e., profiling). Second, in several multidisciplinary iterations essential features for the application development were distinguished, and the running-application was co-created with different experts and tailored to the needs of runners (i.e., designing). Third, the application was validated in context and qualitative feedback on the system was collected in user studies (i.e., validating).

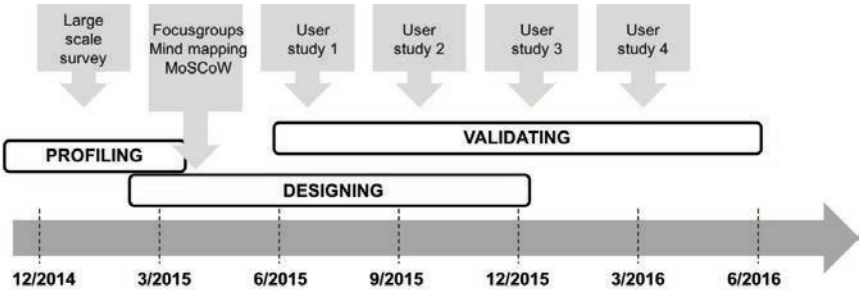

Fig. 1. *Inspirun* study design: a three-step approach

2.1. Profiling

Based on detailed web-based survey data, collected among over 12.500 runners in the Eindhoven area (i.e., the Eindhoven Running Study (ERS)), profiles of runners were constructed based on psychographic characteristics. This approach was previously applied in large scale studies in Belgium [27,28]. The runners in the ERS were recruited mainly via open and recreational running events. These events can be considered as one of the sole settings in which both the group of individual and unorganized runners and the group of (club) organized runners can be targeted at the same time. A standardized online questionnaire, based on the Leuven Running Survey 2009 [34] was used to collect information on socio-demographic characteristics, running characteristics, and psychographic characteristics (such as motives and attitudes regarding running). A k-means clustering algorithm was applied to scale scores, which were derived from a principal components analysis on a set of 25 items regarding perceptions, opinions and motivation towards running (i.e., the psychographic characteristics). Based upon this PCA-analysis the items were grouped into four psychographic five-point scales, namely (1) running as a sports that is easy to practice (α= 0.750 , M= 4.2; SD=0.67; 4 items) , (2) perceived advantages of running (α= 0.866 , M= 4.0; SD=0.48; 13 items), (3) individual motives for quitting (α= 0.704 , M= 3.1; SD=0.79; 4 items), and (4) social motives for quitting (α= 0.845 , M= 1.6; SD= 0.71; 4 items) . Next, the resulting profiles, based on event runners, were cross validated among individual runners in daily urban environments via a questionnaire approach.

2.2. Designing

The essential features for the application development were distinguished in multidisciplinary iterations, using qualitative research methods. First, five focus groups [35] with runners (group size 5-10 participants) were conducted in winter 2014 -spring 2015. The objectives were threefold: (i) validating the constructed running profiles, (ii) review pro's and con's of smartphone applications and sports watches, and (iii) discuss desired features of the most ideal running application. The group dynamic was stimulated by the use of cards displaying the different runner profiles. Second, five mind mapping sessions with professionals and senior students from different disciplines (psychology, human movement sciences, industrial design and engineering) were organized in winter 2014 - spring 2015, on different locations. During these sessions the MoSCoW method was applied to define the essential features of the smartphone application [36,37]. As a result of the multidisciplinary iterations, the user requirements specifications were defined. Next, a first functional and esthetic design for the user interface was created, incorporating all the user screens and the logical order between these. This formed, after review, the starting point of the implementation project in which an end-user ready product was developed.

2.3. Validating

The application was validated in context and qualitative feedback on the system was collected in three user studies (n=28) in spring – winter 2015. In these user studies different versions of the application were evaluated and tested, using participative action research [38]. In user study 1, the first version (version 0.1) of the application was tested. A questionnaire with open-ended questions were used to gather qualitative data on five dimensions derived from the Mobile Application Rating Scale (MARS) [39]: (i) functionality, (ii) engagement, (iii) aesthetics, (iv) information and (v) app specific features. Based on the results of user study 1 the application was improved to a version 0.2. In user study 2 the same approach was used. Version 0.2 was tested and results form the open-ended questions were structured according to the earlier mentioned dimensions. Further improvements were implemented in version 0.3. The third user study focused especially on the novelty of the application. Features tested were: (i) match between provided training and running level and (ii) match between running profile and runner. In spring 2016 a larger scale validation study (n=100) will be enrolled using a quantitative intervention design (user study 4). Participants use the app for a period of 8-10 weeks and complete at least a full trainings schedule of 20 sessions. Before, during and after this period, motivation and perceived advantages with regard running and to the use of app will be monitored over time. After completing a full trainings scheme, MARS will be used to measure quality of the application regarding the same five categories as previously used.

3. Results

3.1. Profiling

The cluster analysis on the scale scores resulted in four groups of runners: (i) social competitive runners, (ii) individual fitness runners, (iii) individual competitive runners, and (iv) social runners. Table 1 gives an overview of the main characteristics of these four groups of runners, revealing considerable differences in drivers, context, intensity and perceptions of running. This typology is consistent with previous studies based on large scale survey data. Differences in psychographic profiles were found to determine (i) participation in running, (ii) use and consumption of running related products and services, and (iii) training and guidance needs [27,28]. In order to be able to profile runners (based on psychographic characteristics) via the smartphone application, the original set of 25 items was reduced, using psychometric modelling, to a set of 12 dichotomous choices followed by a check question. In the five focus groups with runners in the designing phase (group size 5-10 participants) the constructed running profiles were validated, resulting in a strong match between the profiling and the perceptions of runners of their runner identity and experiences.

Table 1. Characteristics of four different types of runners

Characteristics	Social competitive runners	Individual fitness runners	Individual competitive runners	Social runners
Main driver	Competition	Health	Performance	Running together
Main running context	Sports club	Individual	Individual	Running community/friends
Intensity	High	Low / moderate	High	Low
Ease of practice	Low	High	High	Low
Perceived advantages of running	Moderate	High	High	Moderate
Individual motives for quitting	Low	High	High	Moderate/high
Social motives for quitting	High	Low	Low	High

3.2. Designing – essential features

The focus groups and the multidisciplinary iterations with professionals resulted in a list of six essential features: (i) start or improve running in a healthy and fun way, (ii) personalized training schedules that fits runners profiles, (iii) scheduling has to take in to account runners' work-life balance, (iv) tailored feedback on progress while running (cf. runners profiles), (v) a combination of perceived intensity and body feedback (heart rate), GPS data (distance, location, route, time) to adjust selected training scheme for the next training session, and (iv) capture data which can be used for monitoring.

3.3. Designing – personalized training schedules

The application was developed to provide less experienced runners guidance to run in a sustainable and healthy manner. In order to be able to design an application which supports personalized running experiences and provides tailored feedback and coaching, the runners' profile starting level, goal setting, personal training schedule, monitoring (GPS and hearth rate) and feedback are all combined and implemented in the application. Furthermore, a personal running workload profile (PWP) is constructed. The PWP is adjusted after every training session according to the actual running performance. The application uses algorithms to learn from each training. This PWP is used to set and advice the runners' running speed for the next training session. Hence, every (suggested) training is personalized and tailored feedback and coaching is provided in line with the psychographic profile. For example, individual competitive runners get feedback about their performance and are stimulated to achieve their targets, while social runners will receive more positive feedback and less performance related information.

A number of individual runner factors were taken into account. Starting with the runners' current level in running, ranging from beginner with no (or limited) running experience, to experienced runner, able to run 60 minutes straight. The next step was to select running goals ranging from being able to run 5K straight to improving the runners' 10K performance. Based on these two parameters a training schedule was chosen. Every schedule starts with three running sessions which are used to test the runner. The body feedback (heart rate), GPS-data (running speed) and perception of the intensity of the training (RPE-score) of these first sessions are used to create a PWP. This individual workload profile is used to personalize the training sessions (according to the monitored variables). Generally adapted training principles were taken into account in designing the training schedules [40-42]. Schedules consist of 20 training sessions in which variation and progression, according to the set goals, were the most important principles. Both distance training and interval training were used as training types. All training sessions ranged from moderate and vigorous intensities corresponding with perceived intensity levels 6 to 8 (based on RPE score on a 1-10 scale). Individuality and progression of the training were guaranteed by using personal RPE-score to define the individual running speed and heart rate. All this information was used to construct the training blocks within each training session.

The PWP was created through matching the monitored data, heart rate, mean running speed of the training blocks and perceived intensity, with the prescribed data. Adjustments within the personal running workload profile are made according to the last 6 training sessions. When starting a training session the runners' perceived fitness at that moment is asked, in case the runner indicates that he feels not fit, the training intensity for that session is adjusted to a lower intensity level. In order to guide the runner to meet the prescribed training, feedback during the training session is based on the difference between the monitored heart rate and the prescribed heart rate from the PWP. The feedback is given in running speed. For instance, when the runners' heart rate is higher than prescribed, the runner is told to slow down a little. After each training session the runner has to indicate the perceived intensity level. The provided score is matched with the monitored data and taken as input and (as stated before) used together with body feedback and GPS-data to adjust the PWP.

3.4. Designing – end-user ready product

The implementation started with reverse engineering the API of the undocumented heart rate monitor (Wahoo TICKR X), followed by setting up the database structure to contain all training schedules and personal information. Step by step the various screens were added and tested, and specifications and user design modified along the process. After completion of the first alpha prototype for Android smartphones, three user studies were conducted, which input was used again to improve the application.

Inspirun is built with the Ionic Framework, and therefore is essentially a browser application, making heavy use of JavaScript and AngularJS. In addition, D3 is used for rendering vector graphics. A training session (see above) is the main ingredient for the *Inspirun* application. It bundles a considerable amount of sub-components together in order to provide an easy and intuitive interface to the entire training functionality of the application. A training session can only be started when there is an active GPS signal and connection to the Bluetooth heart rate monitor (see Figure 2).

Fig. 2. The Inspirun personalized running coach

The smallest pieces of information of a registered training are the data points. These are snapshots of an active training session, taken every 10 seconds. A data point stores vital information such as heart rate, running speed and GPS coordinates. In order to determine the block route, all data points coordinates are joined in an array of blocks. These blocks are subsequently combined in schemes. Schemes determine what kind of blocks each training consists of, how long these blocks are and the training intensity of the blocks. Each intensity level of a user is linked to both running speed and heart rate. Given an intensity profile and training results, *Inspirun* calculates how precisely a runner followed his personal schedule, or rather, how compliant he was to the target speed and heart rate per training block.

The training schedule is the combination of multiple training sessions, the associated blocks of that training, and a snapshot of the current user profile. With this information the runner may be presented an overview of the training to be done. In addition, this allows easy retrieval of target speed and heart rate at any moment during the training.

3.5. Validating

The main results of the three user studies are provided in Table 2. The majority of the participants were positive about the personal approach and expect that this app will have a positive effect on their motivation and ability to run. In the user studies, both experienced and unexperienced runners have participated (n=28). In user study 1, participants used version 0.1 of *Inspirun*. The results (see Table 2) were categorized according to the five dimensions (based on MARS) [39], which resulted in a number of improvements in version 0.2: (i) greater accuracy in running speed, (ii) implementation of sound and spoken feedback matching the psychographic profiles, (iii) ability to pause and abort a training session, (iv) more clear overview of the training session and (iv) several minor technical issues were solved. Next, experienced runners and researchers participated in user study 2. Again open-ended questions were categorized and as resulted in following improvements: (i) alignment between spoken feedback/information and provided training intensity, (ii) being able to scroll through full training history, and (iii) training session adapts PRP when you choose the 'not fit' option. The third user study was aimed especially on the fifth dimension: app specific features. Only some minor bug fixes like: pausing the music was not aligned with spoken feedback, volume of spoken feedback varies randomly and some crashes when saving training sessions needed to be fixed. In spring 2016 a version 1.0 will be released, results from user study 3 will be implemented.

Table 2. Results of three user studies sorted by the dimensions derived from the Mobile Application Rating Scale [38]

	User study 1	**User study 2**	**User study 3**
N	10	6	12
User type	Experienced / unexperienced runners	Experienced runners / researchers	Novice runners
Date	04/2015-06/2015	09/2015	12/2015
Engagement	- Satisfaction with personalized approach - Feedback on running speed is good but only provided through visual and vibration cues on the smartphone, audio feedback is	- Spoken instructions and feedback are appraised. - Instruction at the start of a training block and feedback during a training block are mixed up in some cases.	- When listening to music in the background the pause is not consistent with the spoken feedback. - Satisfaction with provided information while running

	lacking. - The next training is planned 'today' - The runner has to fill his user credentials every time		
Functionality	- Easy to use application - Several technical issues: o Running speed accuracy is not consistent o Pairing the heart rate monitor o In some cases 'starting training' freezes the application	- Good compliance with other tracking apps and devices for Heart rate and running speed. - The application blocks when submitting the training session and the data gets lost	- Easy to use as a starting runner - Some issues in saving training sessions.
Aesthetics	- Feedback timer during running is too small - Pause button during running is too small - The visual representation of the training session is not logic to the runner - Modern 'Look and Feel'	- Scaling problems on a couple of screens. (training overview and RPE screen after training)	
Information	- More textual explanation is needed for several functions (test sessions,		
App Specific features:	- What if running type changes over time? - Test training sessions were incorrect engineered	- Some technical issues according to the calculations for the runners profile - Only the last 10 training sessions are available in the history section.	- Running type has consistent outcome - Provided training schedule match running level - Satisfaction with guidance for running speed and heart rate - Targets for heart rate and running speed seems consistent with running level.

4. Conclusion

In conclusion, this paper showed that intelligent systems such as smartphone applications can have a key role in stimulating physical activity and sustainable sports participation. However, this requires more differentiated and effective approaches to target recreational and less experienced participants and a distinctive envisioning of societal and personal needs. Understanding the crossovers between personal (psychological, physiological, etc.), social (social support from family, peers, etc.), and environmental factors (setting, context, culture, policy, etc.) requires a multidisciplinary approach which is key for the design and provision of products and services targeting mass sports participation. The professionals involved in the designing phase were positive about the complementarity between disciplines, and participants in the user studies emphasized that the personal approach would have a positive affect on their motivation (i.e., reduction of motivational drop-out). Moreover, the majority of the participants have indicated that the app guided them in running at a lower intensity (i.e., prevention of injuries). Nevertheless, more work needs to be done, and more evidence is needed (about the efficiency and effectivity), to further improve the design approach which was suggested in this paper.

The novelty of *Inspirun*, an intelligent system for recreational runners, is the combination of a personalized coaching approach with the automatic adjustment of training schemes based on biofeedback and GPS-data Results from three user studies are promising; participants were very satisfied with the personalized approach, both in the profiling and de adaptation of their training scheme. It is suggested that applications, in terms of monitoring sports performance and targeted guidance, can have an impact on sports participation, vitality and active living in urban environments. However, further research is needed to study long-term affects of a personalized sports related smartphone application such as *Inspirun*.

References

[1] Fanning J, Mullen SP, McAuley E. Increasing physical activity with mobile devices: a meta-analysis. J Med Internet Res 2012, 14(6):e161.
[2] Middelweerd A, Mollee JS, van der Wal C, Brug J, Te Velde SJ. Apps to promote physical activity among adults: a review and content analysis. Int J Behav Nutr Phys Act 2014, 11(1):97.
[3] West JH, Hall PC, Hanson CL, Barnes MD, Giraud-Carrier C, Barrett J: There's an app for that: content analysis of paid health and fitness apps. Journal of medical Internet research 2012, 14(3):e72.
[4] Peeters M, Megens C. Experiential Design Landscapes. How to Design for behaviour change towards an active lifestyle? Eindhoven: Eindhoven University of Technology; 2014.
[5] Chakravarty EF, Hubert HB, Krishnan E, Bruce BB, Lingala VB, Fries JF. Lifestyle risk factors predict disability and death in healthy aging adults. Am J Med. 2012;125(2):190–7.
[6] Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc. 2011;43(7):1334–59.
[7] Dallinga JM, Mennes M, Alpay L, Bijwaard H, de la Faille-Deutekom, Marije Baart. App use, physical activity and healthy lifestyle: a cross sectional study. BMC Public Health 2015, 15(1):833.
[8] Blair SN, Kohl HW, Paffenbarger RS, Clark DG, Cooper KH, Gibbons LW. Physical fitness and all-cause mortality. A prospective study of healthy men and

women. JAMA 1989, 262(17): 2395-401.
[9] Scheerder J, Breedveld K, Borgers J. Running Across Europe: The Rise and Size of One of the Largest Sport Markets. Basingstoke: Palgrave Macmillan; 2015.
[10] Breedveld K, Scheerder J, Borgers J. Running across Europe: The way forward. In: Scheerder J, Breedveld K, Borgers J, editors. Running Across Europe: The Rise and Size of One of the Largest Sport Markets. Basingstoke: Palgrave Macmillan; 2015..p. 241-264.
[11] Scheerder J, Vos S, Taks, M. Expenditures on sport apparel. Creating consumer profiles through interval regression modelling. European Sport Management Quarterly 2011; 11(3): 251-74.
[12] Borgers J, Scheerder J, Vos S. Belgium (Flanders): Trends and governance in Running. In: Scheerder J, Breedveld K, Borgers J, editors. Running Across Europe: The Rise and Size of One of the Largest Sport Markets. Basingstoke: Palgrave Macmillan; 2015..p. 28-58.
[13] Borgers J, Vanreusel B, Vos S, Forsberg P, Scheerder J. Expenditures on sport apparel. Light sport facilities to foster sports participation? A case study on the use of bark running tracks. International Journal of Sport Policy 2015; DOI: 10.1080/19406940.2015.1116458.
[14] Vos S, Janssen M, Goudsmit J, Bovens J, Lauwerijssen C. Creating light and personalised running experiences: an app development study. In: Proceedings of the European Sport Management Conference 2015 September 9-12; Dublin (Ireland): EASM; 2015. Available from http://www.easm.net/2015-2/
[15] Fosberg P. Denmark: Running for the sake of running? A profile and segmentation of Danish Runners. In: Scheerder J, Breedveld K, Borgers J, editors. Running Across Europe: The Rise and Size of One of the Largest Sport Markets. Basingstoke: Palgrave Macmillan; 2015.p. 59-80.
[16] Van Bottenburg M. A second wave of running? Sport Marketing Europe 2006: 26-30.
[17] Bredeweg SW, Zijlstra S, Bessem B, Buist I: The effectiveness of a preconditioning programme on preventing running-related injuries in novice runners: a randomised controlled trial. Br J Sports Med 2012, 46(12):865-870.
[18] Buist I, Bredeweg SW, Bessem B, van Mechelen W, Lemmink KA, Diercks RL: Incidence and risk factors of running-related injuries during preparation for a 4-mile recreational running event. Br J Sports Med 2010, 44(8):598-604.
[19] Buist I, Bredeweg SW, Lemmink KA, van Mechelen W, Diercks RL: Predictors of running-related injuries in novice runners enrolled in a systematic training program: a prospective cohort study. Am J Sports Med 2010, 38(2):273-280.
[20] Videbæk S, Bueno AM, Nielsen RO, Rasmussen S: Incidence of running-related injuries per 1000 h of running in different types of runners: a systematic review and meta-analysis. Sports medicine 2015, :1-10.
[21] Andreff M, Andreff W. Global trade in sport goods. European Sport Management Quarterly 2009; 9(3): 259-94.
[22] Thibaut E, Vos S, Scheerder J. Hurdles for sport consumption? Determining factors of household sports expenditure. Sport Management Review 2014; 17(4): 444-54.
[23] Janssen M, Scheerder J, Thibaut E, Brombacher A, Vos S. Working paper: Who uses running apps and sport watches? Determinants and consumer profiles of event runners' usage of running related mobile phone applications and sport watches. Eindhoven: Fontys University of Applied Sciences.
[24] Swan M. Sensor mania! the internet of things, wearable computing, objective metrics, and the quantified self 2.0. J Sens Actuator Netw. 2012;1(3):217–53.
[25] Kranz M, Möllerb A, Hammerla N, Diewald S, Plötz T, Olivier P, Roalter L. The mobile fitness coach: Towards individualized skill assessment using personalized mobile devices. Pervasive and Mobile Computing 2013; 9(2): 203-15.
[26] Dallinga J, Deutekom M, Vervoorn C, Mennes M, Bijwaard H. Motives for running and perceived importance of application functionalities: a comparison of fast and slow runners. In: Proceedings of the European Sport Management Conference 2015 September 9-12; Dublin (Ireland): EASM; 2015. Available from http://www.easm.net/2015-2/
[27] Vos S, Scheerder J. Loopsport in veelvoud: naar een typologie van loopsporters. In: Scheerder J, Boen F, editors. Vlaanderen loopt! Sociaal-wetenschappelijk onderzoek naar de loopsportmarkt. Ghent: Academia Press; 2015.p. 267-88.
[28] Vos S, Scheerder J, Boen F, Feys J. A typology of runners. Implications for marketing strategies. In: Proceedings of the European Sport Management Conference 2008 September 10-13; Heidelberg. Heidelberg: EASM; 2008. P. 321-23.
[29] Schuler D, Namioka A. Participatory design: Principles and practices. London: Routledge; 2013.
[30] Leonard D, Rayport JF. Spark innovation through empathic design. Harvard Business Review 1997; 75: 102-15.
[31] Sanders EBN, Stappers PJ. Co-creation and the new landscapes of design. Co-design 2008; 4(1): 5-18.
[32] Sanders EBN. Information, inspiration and co-creation.. In: Proceedings of the 6th International Conference of the European Academy of Design; 2005.
[33] Mattelmäki T. Applying probes – from inspirational notes to collaborative insights. Co-design 2005; 1(2): 83-102.
[34] Scheerder J, Boen F. Vlaanderen loopt! Sociaal-wetenschappelijk onderzoek naar de loopsportmarkt. Gent: Academia Press; 2009.
[35] Morgan DL, Krueger RA. The focus group kit. London: Sage; 1998.
[36] Clegg D, Barker R. Case method. Fast-Track. A RAD approach. Reading: Addison Wesley; 1994.
[37] van Hoof J, Wetzels M, Dooremalen AMC, Wouters EJM, Nieboer M, Sponselee AAM, Eyck AME, van Gorkom PJLM, Zwerts ELM, Peek STM, et al. Technological and architectural solutions for Dutch nursing homes. Results of a multidisciplinary mind mapping session with professional stakeholders. Technology in Society 2014; 36(2): 1-12.
[38] Koshy E, Koshy V, Waterman H. Action research in healthcare. Londen: Sage; 2014.
[39] Stoyanov SR, Hides L, Kavanagh DJ, Zelenko O, Tjondronegoro D, Mani M. Mobile App Rating Scale: A New Tool for Assessing the Quality of Health Mobile Apps. JMIR mHealth uHealth 2015; 3(1): e27
[40] Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee I, Nieman DC, Swain DP. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. Med Sci Sports Exerc. 2011; 43(7): 1334-59.
[41] Manzi V, Bovenzi A, Castagna C, Salimei PS, Volterrani M, Iellamo F. Training-load distribution in endurance runners: Objective versus subjective assessment. Int J of Sports Physiol Perf. 2015; 10(8): 1023-29
[42] Mujika I. Endurance training – science and practice. Vitoria-Gasteiz; 2012