SELF REGULATION BY RECREATIONAL RUNNERS WITH WEARABLE TECHNOLOGY: A MIXED-METHOD LITERATURE REVIEW

Inez Rabea Ross

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UNIVERSITY OF TWENTE.

Faculty of Behavioural, Management, and Social Sciences

Master Programme Positive Psychology and Technology

Student Number: 1199668

Examined by:

1st Dr. M. L. Noordzij

2nd Dr. P. M. ten Klooster

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Abstract

Introduction: Wearable technology is prevalent in the western society as a useful tool for self regulation since it became affordable. Simultaneously, recreational running as an individual and feasible type of sport increased, however, registering a high number of dropout rates. Self regulation assisted by wearable technology could bring about changes in terms of setting and achieving running goals. To address the knowledge gap regarding psychological patterns in this topic, three research questions were formulated. On their basis (i) predictors for the usage of wearable technology by recreational runners, (ii) the reason to use technology during running, and (iii) the presence of references in (i) and (ii) to the constructs elaborated in the Self-Determination Theory (SDT): autonomy, competence, and relatedness will be identified.

Methods: Literature was searched via two different databases: EBSCOhost and Scopus. The PICOS framework was used to identify relevant terms and concepts. A total amount of 13 papers met the inclusion criteria and were thoroughly analyzed in this mixed-method review.

Results: Ten studies pointed out predictors for usage, half of them have found either technical- or runner-related predictors that affect the possibility for recreational runners using technology. Nine papers stated reasons to use technology during running. Four of them in a quantitative and six in a qualitative way, whereby one paper offered both data. Runners' reasons are wide-ranging but related to three categories: 'tracking personalized training data', 'increasing running motivation', and 'improving performance'. Overall, there appeared to be a noteworthy connection between predictors and reasons for technology usage and the constructs elaborated in the SDT, in particular with respect to autonomy and competence.

Discussion: The focus of recent studies included in this review concentrated on psychological aspects. In contrast to physical health benefits from running with devices, research with reference to well-being still needs to be further integrated in the field of wearable technology. Nevertheless, 10 papers concentrated on the fit between technology and the user, illustrating that technology designers and researchers in the area of running already work for the same aim: individual's physical *and* mental health. Additionally, nine papers addressed runners' perspectives on self regulation supported by technology. The elaborated interplay of physical and mental health leads to the conclusion that the psychological research area for the usage of technology for running has recently been growing. Concerning the psychological perspective on running with technology, further research is still needed.

Keywords: self regulation, recreational running, wearable technology, technology adoption, mobile health (mHealth), well-being, self-determination theory (SDT)

Table of Contents

Self Regulation by Recreational Runners with Wearable Technology

The present thesis describes a review about self regulation by recreational runners with wearable technology. *Self regulation* serves as an umbrella term for the ability to act due to willpower which refers to desired behavioural changes and, consequentially, increasing *well-being* (Bandura, 1991; Sniehotta, 2009). *Wearable technology* on the other hand, defines as a helpful tool for tracking leisure physical activities, which availability and use has grown rapidly in the contemporary western society (Clermont et al., 2020; Pobiruchin et al., 2017; Wiesner et al., 2018). At the same time, *recreational running* became one of the most popular types of sport (Clermont et al., 2020; Janssen et al., 2017, 2020; Wiesner et al., 2018). Nevertheless, high dropout rates in running have been observed, in particular because of a lack of motivation (Hänsel et al., 2015; Janssen et al., 2020; Vos et al., 2016). Motives for running are manifold and concern both intrinsic and extrinsic motivation categories that are able to influence behaviour. These two types of motivation categories are, however, not similarly connotated with well-being (Hänsel et al., 2015; Teixeira et al., 2012). Behavioural forms of self regulation due to their connection to well-being should therefore receive attention with reference to technology's contribution for setting and achieving running goals. The leading focus of this thesis is to identify relevant peer reviewed articles about runners using technology. The aim is to elaborate predictors for usage, reasons to use wearables in practice, and their respective presence of references to the constructs: autonomy, competence, and relatedness elaborated in the *Self-Determination Theory* (SDT) (Deci & Ryan, 2000, 2002, 2008). Thereby, the topics' focus of recent research will be explored through identifying psychological patterns related to runners' usage of technology for self regulation.

Recreational Running

Regular physical activity prevents lifestyle diseases such as type 2 diabetes or cardiovascular diseases. Moreover, it has a positive impact on mental health, is socially acclaimed, and improves our quality of life (Feng & Agosto, 2019; He et al., 2013). Reasons for exercising are accordingly numerous (biologically, mentally, and socially) and applicable for running (Shipway & Holloway, 2016). Health-related sports that are individually feasible like recreational running have recorded large growth in recent years (Clermont et al., 2020; Janssen et al., 2017; Wiesner et al., 2018). According to Kuru (2016a), recreational runners differ from competitive ones through exercising less than four times per week. Around 10% of the western population participates in that upturn (Janssen et al., 2020; Scheerder, Breedveld, & Borgers, 2015; Vos et al., 2014). In addition, without requiring much equipment, running as a full body cardiovascular exercise is characterized as easily practicable (Feng & Agosto, 2019). Furthermore, no specific infrastructure is needed and with no restriction concerning the place or time, running potentially attracts diverse people (He et al., 2013; Janssen et al., 2017, 2020).

Motivation for Running

Motivation for running is very individual. Runners mentioned physical benefits like becoming fitter or losing weight, psychological motives in order to clear the mind, or achievement reasons due to rising to a challenge while participating in competitions (Bell & Stephenson 2014; Cypryańska & Nezlek, 2019; Dallinga et al., 2015). Furthermore, social experience while running with others is considered as important (Scheerder, Breedveld, & Borgers, 2015). These findings are confirmed through the four categories (physical, psychological, achievement, and social) in the Motivations of Marathoners Scale developed by Ogles and Masters (2003) that is applicable for recreational runners. Motivation for running is versatile, however, it turns out that aspiration at the beginning of recreational running is not sustainable for everyone and a lack of motivation effects contrary (Hänsel et al., 2015; Janssen et al., 2020; Stubbs et al., 2016). Personalized support or guidance by for instance a professional coach is lacking since less people are participating in running clubs and prefer jogging individually (Janssen et al., 2017, 2020). The consequence of this results in stopping due to injuries but predominantly because of demotivation (Vos et al., 2016).

Classified in *intrinsic* and *extrinsic categories*, motivation includes internal enjoyment with a direct positive influence on well-being but also external influences like regulation by others or identification. However, both originally external forms of motivation can transform to intrinsic one's while being more autonomous, endorse the need of personal competence, and being consistent with one's self-perception (Hänsel et al., 2015; Teixeira et al., 2012). Research is mixed whether intrinsic or extrinsic motivation has a greater impact on short-term performance. Nevertheless, the importance of intrinsic motivation for sustained running behaviour because of its association with skill development (Hagger, Chatzisarantis, & Harris, 2006) is unanimously supported (Mullan & Markland, 1997; Senecal & Whitehead, 2018).

Based on the SDT, every person pursues the accomplishment of three fundamental psychological needs in order to increase well-being and feelings of vitality: autonomy, competence, and relatedness. *Autonomy* describes the need to control one's behaviour and having the sense of alternatives, *competence* designates the need to overcome challenges and to be effective, and *relatedness* describes the need to be socially accepted and to feel connected (Deci & Ryan, 2000, 2002, 2008). The three constructs thereby determine the degree of individual's intrinsic motivation (Cypryańska & Nezlek, 2019; Hänsel et al., 2015).

According to Teixeira et al. (2012), a lack of intrinsic motivation often results in high dropout rates. Still, regulation and identification as extrinsic forms can be decisive for the more externally motivated runners who are in need of feedback and support for beginning and remaining with sports. There are numerous studies showing that social factors like comparison and competitions are becoming successful drivers for healthy behaviour changes since rising self-motivation through awareness and belonging (Ananthanarayan & Siek, 2012; Bandura, 1977; Festinger, 1954; Ledger & McCaffrey, 2014; Rashotte, 2007). Furthermore, in line with the SDT, participating in competitions without necessarily winning them can be considered as a self-chosen goal in a social context. Achieving this goal results in increased performance *and* well-being. The positive effect can even be improved while focusing on the personal fastest time or the place among the other participants (Cypryańska & Nezlek, 2019).

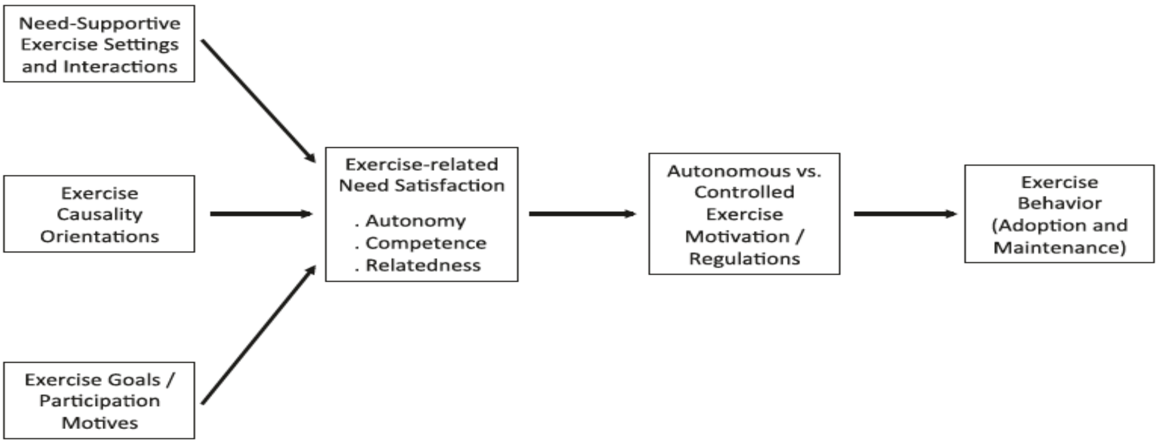

Figure 1. General SDT process model for exercise behaviour.

Note. Reprinted from "Exercise, physical activity, and self-determination theory: a systematic review," by P. J. Teixeira, E. V. Carraça, D. Markland, M. N. Silva, & R. M. Ryan, 2012, *International journal of behavioral nutrition and physical activity*, 9(1), 78, page 4. Copyright [2012] by Teixeira et al.; licensee BioMed Central Ltd. Reprinted with permission.

Wearable Running Technology

Wearable devices for monitoring health and fitness such as smart watches, fitness bands, activity trackers, sport watches, GPS trackers, heart rate monitors, or running apps on mobile phones increasingly came on the market in the last few years. They are considered as an ongoing trend (Clermont et al., 2020; Pobiruchin et al., 2017; Wiesner et al., 2018). Wearables can be defined as "lightweight, sensor-based devices that are worn close to or on the surface of the skin, where they detect, analyse, and transmit information concerning several internal and external variables to an external device (...)," (Düking et al., 2016, p. 2). Therefore, they are playing an important role in areas regarding sports or healthcare (Aliverti, 2017; Feng & Agosto, 2019; Willy, 2018). During the past years, several, progressively becoming smaller, commercial, high-end technology devices were distributed millionfold (125,3m wearable devices in 2018, excluding smartphones, estimated by the International Data Corporation in 2019 (Du, Chen, & Wu, 2019)). They are seamlessly monitoring biometric data ideally suited to acquire training performances (Camomilla et al., 2018; Hänsel et al., 2015; Steinhubl, Muse, & Topol, 2015). Health and fitness categories are representing with around 30% the largest share of *mobile health* (*mHealth*) technology (Janssen et al., 2017; Krebs & Duncan, 2015; Rich & Miah, 2017). Even low-price products are convincing by delivering adequate measurements in assessing running analyses (Case et al., 2015; Diaz et al., 2016; Pobiruchin et al., 2017; Willy, 2018; Xie et al.,2018). Consumers trust their devices and keep them tracking their activities synchronized (Schüll, 2016; Wiesner et al., 2018). Regardless runners' level of competition, wearables were used since they became affordable for non-professionals (Janssen et al., 2020; Kuru, 2016a; Lee & Drake, 2013). According to Clermont et al. (2020) and Pobiruchin et al. (2017), around 75% of runners use technology for recording their distances, increasing motivation, or for optimizing their training.

Self Regulation with Wearable Technology

Taken into account that behaviour can be considered as reflecting feedback monitoring, self regulation is a phased process and requires individual's motivation to influence behaviour. Determining, working towards, and achieving self-imposed goals due to own willpower (and, hence, intrinsically done) has thereby important implications for well-being (Bandura, 1991; Sniehotta, 2009). Following Sniehotta, planning as a self regulatory tool is essential for acquiring new behavioural patterns and aimed for the purpose to change in a desired direction but is pointless without constantly monitoring the resulting behaviour.

Recording activities with devices assists the user in self-monitoring, planning, and setting goals as part of self regulation (Stragier, Vanden Abeele, & De Marez, 2018). Additionally, since offering feedback and, thereby, opportunities for support and competition, technology may function as motivator. Several studies corroborated the positive influence from mobile phones on becoming more active (Bort-Roig et al., 2014; Fanning, Mullen, & McAuley, 2012; Foster et al., 2013; Stephens & Allen, 2013). Making oneself aware of mastering experiences like reaching appropriate goals is maintaining self-efficacy (Cau et al., 2019; Clermont et al., 2020; Edmunds, Ntoumanis, & Duda, 2006). Moreover, wearables measure subjective physical markers and potentially prevent users from suboptimal training and related negative health consequences. Therewith, persistent motivation for self regulation towards the desired direction is more likely (Düking et al., 2016; Hänsel et al., 2015).

Summary and Research Question

Considering the presented ascertainment above, recreational running increasingly attracts people. Meanwhile, a large number of devices suited for running and, thereby, supporting users' physical health is on the market. However, running additionally implies psychological aspects and not both types of motivation categories are necessarily leading to well-being. Though, originally extrinsic forms of regulation can transform to intrinsic one's provided that autonomy, competence, and consistence with self-perception is given. Self regulation by reference to technology's contribution may therefore serve as a bridge to both: physical health (in terms of sustained aspiration) and well-being for recreational runners.

The present review aims to highlight the (compared to physical or motivational research in running) underrepresented psychological view. Since runners use technology noticeably often, this review will carve out patterns regarding runners' self regulation by considering the SDT for providing a psychological picture. In order to approach the review's aim as measurable entities about psychological findings, three sub questions were formulated:

1) What are predictors for the usage of wearable technology by recreational runners?
2) What main themes can be found regarding reasons to use technology during running?
3) How are the explored predictors and the findings regarding reasons for usage related to the constructs: autonomy, competence, and relatedness elaborated in the SDT?

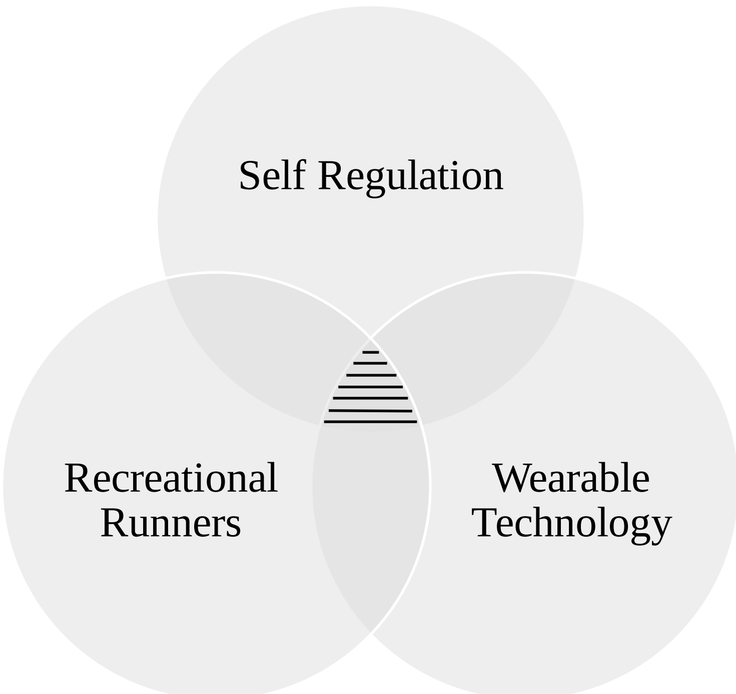

Figure 2. Charting the aim of this literature review in order to answer the research question, displayed through the striped area: 'What psychological patterns can be found in the recent research about self regulation due to the use of wearable technology by recreational runners?'.

Methods

Search Strategy and Selection Criteria

To assess the present *mixed-method* research about self regulation by recreational runners with wearable technology, a systematic review was conducted to explore existing literature. The *PICOS* (*Population, Interest, Context, Outcomes, Study type*) framework was used to identify relevant terms and concepts (Robinson, Saldanha, & Mckoy, 2011). The search took place in April 2020 and was carried out within two different databases: EBSCOhost (PsycArticles, Psychology and Behavioral Sciences Collection, & PsycInfo) and Scopus. Since EBSCOhost constitutes a database specifically for behavioural research, articles were suitable, however, the main aspect of this thesis is in fact technical. Therefore, Scopus created a second database in order to include other sciences than solely psychology. Considering in particular the multidisciplinary nature of this review, Scopus offered important complementary knowledge, covering for example relevant outlets such as the *Journal of Medical Internet Research* (*JMIR*) and the *JMIR mHealth and uHealth*.

Several combinations of terms were tried to find appropriate papers. This was due to the fact that the topic contains a large number of possible technical terms and many different sub-concepts for the umbrella term self regulation, especially after initial research. The very first search words used were ‘wearable technology’, ‘recreational runners’, and ‘self regulation’, all combined with the Boolean operator ‘AND’. There were no results in both databases using this search string. The terms ‘wearable technology’ AND ‘runners’ AND ‘tracking’ yielded one duplicate hit in EBSCOhost and three in Scopus (see Appendix A).

Since it is assumed that runners use wearable technology for planning and perfecting their performances, the special terms ‘self regulation’ and ‘tracking’ are redundant. The terms ‘tech*’ OR ‘wear*’ AND ‘runner’ led again to the duplicate hit and one other article in EBSCOhost but to 3.635 hits in Scopus. Therefore, the terms regarding technology were expanded with ‘smart’ OR ‘app’ in both databases. In order to limit the results in Scopus to the health-related sector, the term ‘mHealth’ was added. In EBSCOhost 100 hits resulted but in Scopus only six hits, wherefore the health-related term was expanded with ‘well-being’ OR ‘support’ OR ‘trust’ OR ‘adopt*’ OR ‘accept*’, resulting in 492 hits. Added to the hits in EBSCOhost, 592 articles resulted. The following final search strings were used:

EBSCOhost: (tech* OR wear* OR smart OR app) AND (runner)

Scopus: (tech* OR wear* OR smart OR app) AND (runner)
AND (mHealth OR well-being OR support OR trust OR adopt* OR accept*)

Further selection was accomplished by including only academic publications and original empirical studies characterized by the peer review process. Meta-analyses from reviews or essays offered important information for this thesis but were excluded in consideration of answering the research question, resulting in 371 hits, 67 retrieved from EBSCOhost and 304 from Scopus. In order to narrow down the results, two clearly defined criteria were established: First, only articles in English were considered, due to their high reach. Second, to avoid multiple potentially outdated wearable technology used by the runners, studies published earlier than 2015 were excluded. These criteria reduced the number of papers in both databases to 132, 20 retrieved from EBSCOhost and 112 from Scopus.

In addition, the *snowball-method* was applied in order to detect other relevant studies. Therefore, the reference lists from the suitable articles were scanned, leading to another six papers. As displayed in Figure 3, all 138 articles were screened using their abstract whether they entail useful information about the review's topic. Since 118 hits were excluded because they were nontechnically, not about recreational runners, or not related to mHealth it was decided to only include papers which titles or abstracts had a direct association to the key terms: *wearables*, *runners*, and *mHealth*, resulting in 20 abstracts that fulfilled the inclusion criteria. Screening for duplicates leaded to the exclusion of two records. After reading 18 full-text articles, five additional papers were excluded considering the research question's content.

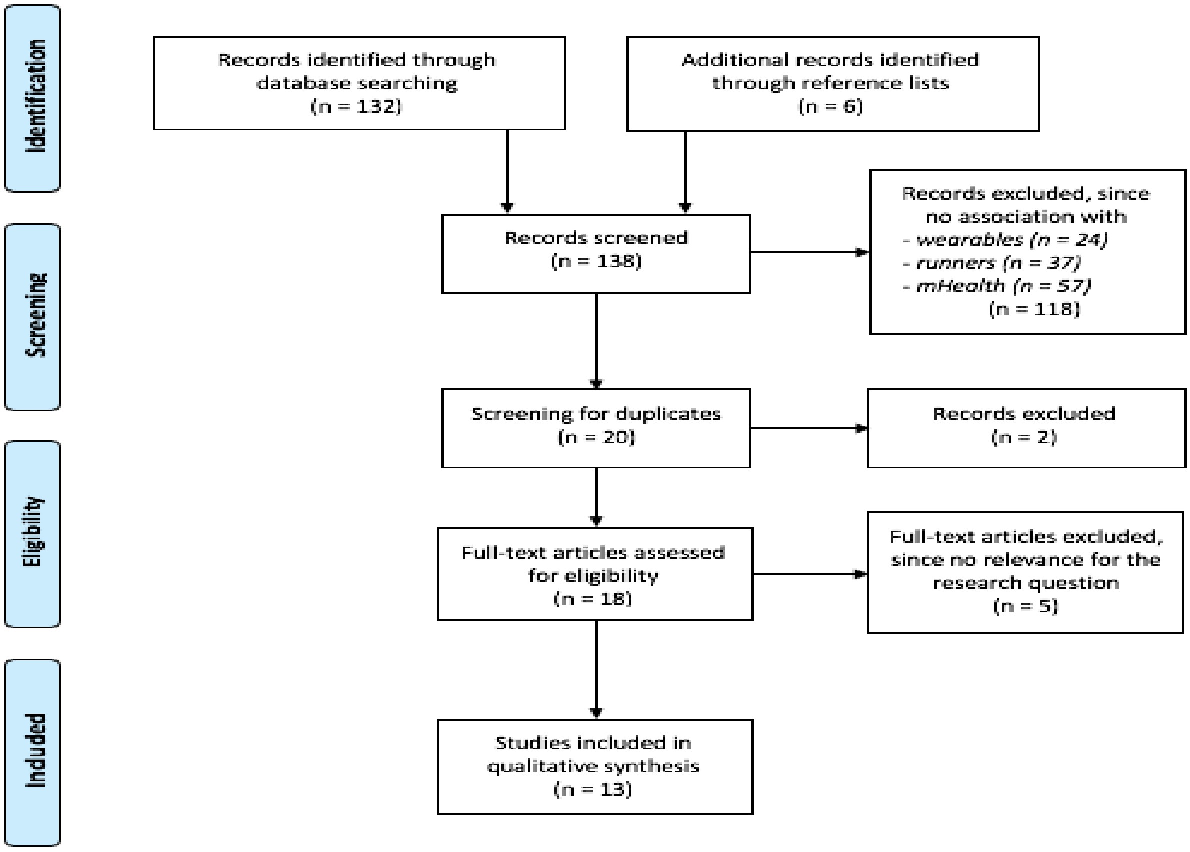

Figure 3. Flow chart displaying the selection process of the included articles for this review.

Procedure and Analysis

Based on the reported search strategy and the selection criteria, there were 13 studies describing findings relevant for the research question that were carefully selected. All of them were read completely and deductively analysed relating the first two research sub questions. The first sub question was analysed in a qualitative way. For the second sub question quantitative data was implied but main parts were pointed out in a qualitative way. Considering the third sub question, the qualitative information retrieved from the first and the second sub question was analysed.

All included papers were screened regarding possible predictors for technology usage in order to answer the first sub question. Two categories of predictors appeared entitled ‘technological design’ and ‘runners’ characteristics’, since the included papers addressed either the technology or the runner as predicator for technology usage. Concepts of the mentioned predictors were displayed in a table.

In order to answer the second sub question, every paper included in this review was analysed to identify runners’ stated reasons to use technology. Both types of results (quantitative and qualitative) were presented in form of three different categories: ‘tracking personalized training data’, ‘increasing running motivation’, and ‘improving performance’. These categories were originally retrieved from the papers offering quantitative data but were also applicable for the qualitative data. Quantitative data was summarized in a table. In order to emphasize the qualitative data, one quotation was selected (for integrity, see Appendix B).

The third sub question is intertwined with the other ones. The gained qualitative data from the first two sub questions was analysed to assess the need satisfaction regarding autonomy, competence, and relatedness. Therefore, the construct definitions (see page 5) from Deci and Ryan (2000, 2002, 2008) were used to identify associations. Autonomy, competence, and relatedness were identified in (i) the predictors for technology usage and (ii) the quotations of the recreational runners. Since working with qualitative data, an independent person was consulted for double coding in order to calculate Cohen’s kappa. With $\kappa = .63$ inter-rater reliability can be considered as substantial. The following general rule was applied: “_ > .81 – Almost Perfect, _ > .61 – Substantial, _ > .41 – Moderate, _ > .21 – Fair, _ < .20 – Slight, and _ < .00 – Poor” (Landis & Koch, 1977, p.165). The qualitative data from (i) and (ii) (which was analysed to identify associations with need satisfaction) resulted in items representing the respective construct elaborated in the SDT. These items were displayed in a table in relation to their construct for providing an overview. Finally, the items’ distribution to the constructs: autonomy, competence, and relatedness were summarized in a table.

Results

Predictors for the Usage of Technology

In 10 out of the 13 papers (76.9%, see also Table 1) a predictor was mentioned. Half of the articles reported themes related to the category ‘technological design’ like personalization, accuracy, or motivation as predictor. The other half offered information concerning ‘runners’ characteristics’ regarding socio-demographic, performance-related, or psychographic variables and its prediction for technology usage.

Table 1

Ten Studies Providing Concepts Regarding the Categories ‘Technological Design’ and ‘Runners’ Characteristics’ as Predictors for Technology Usage by Runners

Responsible author, Year	Sample size	Predictors for technology usage by runners	
	n	Technological design	Runners’ characteristics
Asimakopoulos, 2017	34	Seven guidelines	
Clermont, 2020	327	Runners’ four preferences	
Dallinga, 2015	4179		Sex and running frequency
Feng, 2019	182	Four major categories	
Janssen, 2017	2172		Age and running preference
Janssen, 2020	3276		Four types of runners
Kuru, 2016a	28	Three meta categories	
Kuru, 2016b	30	Five main domains	
Rupp, 2016	95		Technological trust
Wiesner, 2018	617		Age and running distance

Technological Design

Concerning widening the possibility for usage, the technology needs to meet different requirements. One main aspect mentioned by every author from the included papers is the level of *personalization* (Asimakopoulos, Asimakopoulos, & Spillers, 2017; Clermont et al., 2020; Feng & Agosto, 2019; Kuru, 2016a; Kuru 2016b). Users reported the importance to be able to determine the activity themselves and that the technology desirably needs to understand individual patterns (Clermont et al., 2020, Kuru 2016a). Moreover, *accuracy* regarding data collection is equally often mentioned as personalization by the included papers (Asimakopoulos, Asimakopoulos, & Spillers, 2017; Clermont et al., 2020; Feng & Agosto, 2019; Kuru, 2016a; Kuru 2016b). Accuracy was pointed out to be crucial in order to improve performance and to use the collected data in a wise manner (Clermont et al., 2020; Feng &

Agosto, 2019). Furthermore, many runners appreciated the device to be *motivating* due to providing constructive feedback (Asimakopoulos, Asimakopoulos, & Spillers, 2017; Feng & Agosto, 2019). In addition, *social interaction functions* were pointed out to be welcome (Asimakopoulos, Asimakopoulos, & Spillers, 2017; Feng & Agosto, 2019; Kuru, 2016a). Concerning *privacy*, the device needs to manage personal information in compliance with users' set interoperability (Feng & Agosto, 2019; Kuru 2016b). Further, the device should be *comfortable to wear* (Clermont et al., 2020; Kuru, 2016a) and at best *looking great* (Feng & Agosto, 2019).

Runners' Characteristics

Runners are not equally likely to use wearable technology. According to Rupp et al. (2016), users' *technological trust* and *intrinsic motivation* (in particular regarding the constructs autonomy and competence) were decisive and, hence, predicted the desire of continued usage of the wearable devise. Wiesner et al. (2018) stated that technology usage is associated with younger runners (30-39 years) and less likely for runners aged 60 to 69 years. Furthermore, relay marathon and marathon runners were more likely to use technology compared to half-marathon runners. Different findings were pointed out regarding the use of running apps. Dallinga et al. (2015) mentioned app-users were more often female and trained less often per year. Janssen et al. (2017), however, stated that users were more often aged 35 years or younger, more often ran individually, scored higher on individual motives for quitting, and were more likely to participate in only one running event per year. Nevertheless, the authors agreed with Dallinga et al. (2015), pointing out that app-users often reported running as not their main sport. Janssen et al. (2020) differed between four types of runners and, therewith, united the findings from Dallinga et al. (2015) and Janssen et al. (2017). The authors reported 'casual individual runners' as commonest app-users. Compared to the other three types, they are the least identifying with running, are most susceptible in quitting, have lower scores for competition, consist of more women, and are often aged 35 years or younger. They run mostly 5 or 10km, report running as not their main sport, are less experienced, train less frequently, and run more individually. Regarding the use of sport watches, Janssen et al. (2017) reported runners were more often aged 36 years or older and more likely to be members in running clubs. Furthermore, they participated more often (2-4 times per year) in organized running events and trained at least twice a week. Janssen et al. (2020), stated 'devoted runners', 'individual competitive runners', and 'social competitive runners' were more often using sport watches. 'Devoted runners' in contrast to 'casual individual runners' are often aged 45 years or older and the most experienced, they score high on long and frequented training sessions and participate in a number of events even though they are, again, less competitive. ‘Individual competitive runners’ compared to ‘casual individual runners’ identify more with running and are less likely to quit, consist of more men having long training distances, high frequencies, and participate in more events in a competitive manner. ‘Social competitive runners’ in contrast to ‘individual competitive runners’ are scoring the lowest on running individually and are often members in clubs. Regarding technology usage in general, ‘individual competitive runners’ are the most likely to adopt a device.

Reasons to Use Technology during Running

Nine out of all 13 studies (69.2%) appeared to be suitable for providing information regarding runners’ reasons to use technology. Four of these nine studies (44.4%, see also Table 2) offered insight in runners’ reasons in a quantitative way, meanwhile six papers (66.7%) provide qualitative data, and one study (11.1%) offered both. Regarding the quantitative findings, all four papers stated that wearables’ ability to ‘tracking personalized training data’ to be most important. One study cited ‘increasing running motivation’ and one article reported ‘improving performance’ as being the second most relevant reason. Two studies, however, did not present data for every three categories.

Table 2

Four Studies Providing Quantitative Data Regarding the Categories ‘Tracking Personalized Training Data’, ‘Increasing Running Motivation’, and ‘Improving Performance’ Displaying Runners’ Reasons to Use Technology

Responsible author, Year	Sample size	Runners reasons to use technology (n, %)		
	n	Track training	Increase motivation	Improve performance
Clermont, 2020	327	271 (82.9)	25 (7.6)	16 (4.9)
Feng, 2019	182	155 (85.2)	128 (70.3)	146 (80.2)
Janssen, 2020	3276	2581 (78.8)		557 (17.0)
Wiesner, 2018	617	554 (89.8)	210 (34.0)	

Note. Distribution displaying the respective category chosen by runners out of a multiple section.

Tracking Personalized Training Data

Qualitative findings to the category ‘tracking personalized training data’ registered high importance for the runners using technology and covered many benefits. It can be noted high *body interest* and engagement with the wearable in every included quotation. Having an idea about the own physical effort and ability of discipline was stated as useful by recreational runners (Esmonde, 2019; Hardey, 2019; Kuru, 2016a; Tholander & Nylander, 2015). Therewith, *body listening* increased while using a wearable that is monitoring in an objective way (Esmonde, 2019; Kuru, 2016a; Tholander & Nylander, 2015). Technology's assistance helped the user to preserve the body and, thereby, counteracts underestimation of physical exertion (Kuru, 2016a). Furthermore, tracking training data allows to share them and, consequently, to receive cheaper insurances (Hardey, 2019).

> [it's] like a mirroring of the feeling I am aiming for, that is why I use a heart-rate monitor. Like a confirmation about how it feels when I breathe. (Tholander & Nylander, 2015, p. 2916a)

Increasing Running Motivation

Concerning 'increasing running motivation', attention in every included quotation is on the devices' ability to *motivate* the user due to guiding the process and setting goals (Asimakopoulos, Asimakopoulos, & Spillers, 2017; Hardey, 2019; Tholander & Nylander, 2015). Moreover, technology enhanced the individual performance of the runner that, in turn, strengthened incentive (Asimakopoulos, Asimakopoulos, & Spillers, 2017). Setting targets perennially and having the possibility to *monitor the process* helped the user maintaining everyday training and keeping motivated (Tholander & Nylander, 2015). Integrating furthermore the mind and not solely the body in the fitness experience considered mental health in addition (Hardey, 2019).

> I can do exercise without Fitbit, but the actions would be less engaging with partial success—the feedback from Fitbit motivates and guides me to do better and keep going. (Asimakopoulos, Asimakopoulos, & Spillers, 2017, p. 7)

Improving Performance

All included quotations related to 'improving performance' showed runners' training development (Feng & Agosto, 2019; Hardey, 2019; Kuru, 2016a; Tholander & Nylander, 2015). The devices are able to *illustrate the reached progress* in speed or distance but also regarding advanced features like cadence or accelerate. Runners attached considerable importance on these detailed improvements (Kuru, 2016a). Moreover, different appreciated ways of improvement were found. The user is regulating the training twice: on one hand *increasing efficiency* and on the other *decreasing physical effort* (Tholander & Nylander, 2015). In addition, running's and the devices' ability to improve body sensation and mood were highlighted and the wearable was categorized as 'natural approach' (Hardey, 2019).

> Well, what you want to see is, I mean, exertion in relation to your speed is where you strive for an improvement … either make your running more efficient so that you can run faster with less exertion, or improve your 'engine' so that you can run faster at lower heart-rate. (Tholander & Nylander, 2015, p. 2916b)

Reference to Autonomy, Competence, and Relatedness

In total, 12 out of all 13 articles (92.3%) emphasized a connection to at least one construct. Nine studies concerned to the predictors, six articles to the quotations, and three papers offered data regarding both results. In total, 20 items (see also Table 3) appeared.

Table 3

Presence of Reference in (i) the Predictors for Technology Usage and (ii) the Quotations of the Recreational Runners to the Constructs: Autonomy, Competence, and Relatedness

Responsible author, Year, Page number	Items representing the respective construct		
	Autonomy	Competence	Relatedness
Predictors			
Asimakopolos, 2017	Let the user determine	Providing boundaries	Sense of sociability
Clermont, 2020	Understand patterns	Accuracy	
Feng, 2019	Smart tracking	Improve performance	
Janssen, 2017	Run individually	Training for events	Member in a club
Janssen, 2020	Run individually	Training for events	Member in a club
Kuru, 2016a	Personalization	Accuracy	Connectivity
Kuru, 2016b	Personalization	Usefulness	Connectivity
Rupp, 2016	Autonomy	Competence	
Wiesner, 2018		Longer distances	Organized events
Quotations			
Asimakopoulos, 2017, p. 7	Can exercise without	Guides me to do better	
Esmonde, 2019, p. 812	I should not be		
Feng, 2019, p. 9	Tracker helps me	Increasing my speed	
Hardey, 2019, p. 996	I enjoy running	Pay attention every day	I see other runners
Hardey, 2019 p. 997	Showed me	Pushed me forward	Talking to a buddy
Hardey, 2019 p. 1000		How disciplined I can be	Linked to the database
Kuru, 2016a, p. 854a	To control it	I am doing low runs	
Kuru, 2016a, p. 854b	I care a lot about	Need to improve it	
Tholander, 2015, p. 2916a	Mirroring the feeling		
Tholander, 2015, p. 2916b	Either […] or	More efficient	
Tholander, 2015, p. 2917	That is what you do	Everyday practice	

In total, nine out of the 20 items (45%) were retrieved from the predictors, and 11 items (55%) from the quotations, which will further be considered in order to get weighted results, see also Table 4.

Table 4

Distribution of the Retrieved Items from (i) the Predictors and (ii) the Quotations to the Constructs: Autonomy, Competence, and Relatedness

		Predictors (*n* = 9)	Quotations (*n* = 11)	Total (*n* = 20)
Autonomy, Competence, Relatedness	n (%)	5 (55.6)	2 (18.2)	7 (35)
Autonomy, Competence	n (%)	8 (88.9)	7 (63.6)	15 (75)
Autonomy	n (%)	8 (88.9)	10 (90.9)	18 (90)
Competence	n (%)	9 (100)	9 (81.8)	17 (85)
Relatedness	n (%)	6 (66.7)	3 (27.7)	9 (45)

Discussion

The present literature review was conducted to thoroughly explore the recent research regarding self regulation with wearable technology by recreational runners from a psychological perspective. Since runners use technology noticeably often, it was decided to focus on relevant insights in specific predictors that are encouraging usage. Two categories appeared: ‘technological design’ (personalization, accuracy, motivation, interaction, privacy, comfort, and good-look) and ‘runners’ characteristics’ (technological trust, intrinsic motivation, socio-demographic, performance-related, and psychographic variables). In addition, runners’ reasons to use wearable technology in practice were of interest. The three categories were: ‘tracking personalized training data’, ‘increasing running motivation’, and ‘improving performance’. Exercising continuously requires motivation that is, however, not necessarily leading to well-being. Therefore, self regulation’s contribution to well-being was examined in (i) the predictors and (ii) the quotations by applying the construct definitions (see page 5) from the SDT. A clear connection of (i) and (ii) to the SDT appeared, particularly regarding autonomy and competence but with reference to (i) also concerning relatedness.

Discussion of Main Findings

In line with Morgan-Thomas and Veloutsou (2013) and Pobiruchin et al. (2017), the level of personalization and accuracy regarding data collection of wearables were identified as crucial. Pobiruchin et al. (2017) indicated that *perceived usefulness* is a decisive predictor for wearable technology adoption and, according to Przybylski et al. (2014), their absence leads to product frustration. Furthermore, and according to Hänsel et al. (2015), many runners appreciated the device to be motivating and socially interactional. Runners' statements concerning the importance of privacy confirmed the findings from Puri et al. (2017). Technologies' advantages regarding self regulation (individual help with planning and achieving goals) appeared to have a huge influence due to setting appropriate milestones in terms of remaining motivated. Regarding runners' characteristics and, in accordance with Morgan-Thomas and Veloutsou (2013), runners need to trust the technology. Pobiruchin et al. (2017) confirmed the reviews' findings in reporting that the chance to adopt devices is smaller for runners of 60 years or older. Beyond the runners' world, according to Nelson et al. (2020), crucial for the adoption up to a state of *embodiment* is adjustment to the wearable. These findings seemed to be coherent since older people did not grow up with these types of technology. As also observed by Pobiruchin et al. (2017), different findings for runners are found regarding age, sex, and the level of performance with reference to the device category. Moreover, in line with Arnott (2008), McGehee et al. (2003), and Wicker et al. (2012), different categories of technology appear to attract specific types of runners in terms of training frequency and the level of involvement. One explanation could be that being more involved in running leads to higher exchange with other runners and the technology they use. Running individually instead yields to using the smartphone that the runner did already own.

In line with Lee and Drake (2013), the category 'tracking personalized training data' registered the highest importance for the technology users. Since this category covers many bodily interests for runners, using a wearable is potentially related with tracking training in general. In accordance with Stragier, Vanden Abeele, and De Marez (2018) and Boratto et al. (2018), who examined runners using online fitness communities, integrating the mind in the fitness experience is displayed through 'increasing running motivation'. Findings related to 'improving performance' showed, in line with Mueller et al. (2017), that runners payed special attention on very detailed progresses. Considering that all included papers concerned recreational runners and not professional athletes, the high ratings regarding 'increasing running motivation' can be explained, even though the low number (four) of quantitative studies have limited information value. It was striking though that runners explicitly stated using their wearables for self regulatory aims and perceived the device as indispensable.

A clear connection with the SDT for the predictors for usage, in particular concerning autonomy and competence was corroborated through the findings regarding the SDT and technology acceptance models from Lee, Lee, and Hwang (2015) and Szalma (2014). Taken into account that predictors lead runners to become a technology user, the strong connection to the three psychological constructs that determine exercise behaviour is not surprising.

Nevertheless, runners' quotations confirmed a strong link with autonomy and competence as well. Cypryańska and Nezlek (2019) underlined the importance of autonomy and competence during exercising by examining runners' well-being while participating in races. Concerning the construct relatedness, only a quarter of the items that were retrieved from runners' quotations had a connection. Findings in line with Teixeira et al. (2012), who reported relatedness as a construct that is less mentioned as important in solitary sports. This could be related to the individual nature of running as a sport as opposed to team sports. Further, the devices' ability to connect with other runners might be considered as not that appreciable.

General Interpretation and Future Research

The aim of the present literature review was to gain insight in psychological patterns about self regulation due to the use of wearable technology by recreational runners. The fact that only 13 articles could have been included already exhibits a relevant lack in literature from the psychological perspective. Even though research in running is manifold with reference to physical health and motivational aspects, wearables connection to mental health is still scarce. Nevertheless, the included articles made it possible to provide a first impression in recent practice concerning the *interplay of health* in this developing field.

Regarding physical health, research showed wearable technology as having a positive influence on runner's performance (Cypryańska & Nezlek, 2019; Kamel Boulos & Wheeler, 2007). Furthermore, wearables are able to supervise in order to avoid overtraining (Pilloni, Mulas, & Carta, 2015). Considering the ever-growing health related interest in the western world combined with the ubiquitous connectivity with user-friendly, inexpensive devices provides multiple possibilities for runners in the future (Aliverti, 2017; Sullivan & Lachman, 2016; Xie et al., 2018). Due to monitoring athletic performances, individual's health concerns are counteracting the increasing costs for healthcare (Pantelopoulos & Bourbakis, 2010; Zhang et al., 2015). Newest technologies are capable not only to focus on runner's performance metrics but to profile jogging styles in addition. That can lead to recognizing the very individual fatigue indicators and, therewith, possibly prevent injuries (Napier, Esculier, & Hunt, 2017; Norris, Anderson, & Kenny, 2014; Strohrmann et al., 2012b). Special features for empowering runner's technique afterwards but also in real time are feasible with these technologies (Adams et al., 2016; Jensen & Mueller, 2014; Strohrmann et al., 2012a; Valsted et al., 2017). Moreover, the technical development of *physiological computing* (meaning interacting and learning in a 'smart', collaborative, and symbiotic way with users' preferences as a real-time adaptive system) can be considered as a further driver for continued usage (Fairclough, 2009; Morris & Aguilera, 2012; Tholander & Nylander, 2015).

Motivational research pointed out the advantages of wearable devices in preventing from dropouts due to promoting their achievements (Laranjo et al., 2015; Zhang & Lowry, 2016). Moreover, connecting the athletes with each other is further useful for sharing motivation (Spillers & Asimakopoulos, 2014; Sumartojo et al., 2016). In particular runners as sportively interested people benefit from using technology for assistance (Locke & Latham, 2006). Nevertheless, according to Patel, Asch, and Volpp (2015), wearable devices are potentially able to facilitate athletic behaviour, especially if they are equipped with effective feedback loops but changing behavioural patterns requires human's motivation in addition.

Concerning the review's research question about psychological patterns, physical health benefits and motivational aspects reached through recreational running with wearable technology appeared to be in conjunction with mental health. Following Dallinga et al. (2015), physical activity encouraged through the assistance with running apps resulted in more self-efficacy. According to the authors, this prevents higher dropouts and, moreover, strengthened interaction with others. Important thereby is that the interface of the device is easy to use (Beldad & Hegner, 2018). Knaving et al. (2015) reported nine design guidelines in order to reach *flow* (the optimal activity experience that is intrinsically rewarding). Raising runner's intrinsic motivation by reflecting the personal health instead of persuading changes is considered as important (Esmonde, 2019; Feng & Agosto, 2019; Hänsel et al., 2015; Teixeira et al., 2012). Following Kuru (2016a), the technology should be able to support runners in their enthusiasm and self-awareness before they even realized their need to be coached. Correspondingly, future trackers should not just display individual information but represent the runners' ideal self in terms of injury prevention and emotional satisfaction (Kuru, 2016b). This interplay from physical and mental perception has been highlighted from Tholander and Nylander (2015), who understand wearable technology as acting between athletes' performance and their experiences. The authors distinguished between two senses of performance: the *measured* and the *lived* one that are intertwined since reflexive measurements affect experiences. Beyond the runners' world, following Nelson et al. (2020), the devices' suggestions and users' feelings can generate a 'fracture' and possible resulting distress. Some people experienced awareness discrepancy regarding the measured and the felt sense of self but that does not necessarily need to have a negative effect. Perceiving technology as a 'mother figure' sometimes even improved self regulation (Nelson et al., 2020). However, since offering constant feedback, self-tracking can lead to negative related feelings considering the desire for perfection or the loss of data (Esmonde, 2019).

Consequently, there are runners preferring to run without technology since they want to listen to the feedback of their bodies (Wiesner et al., 2018). According to Janssen et al. (2020), some people feel bothered by monitoring since the strive to simply enjoy running and experiencing the environment. Moreover, Senecal and Whitehead (2018) described *training by feel* to be more suitable to reach consciousness due to moving beyond external rewards. Some groups of runners might know their bodies well since training over years. Nevertheless, for novice runners it can have substantial value to have technology as a ‘bridge’ that brings them to the other side regarding self regulation. Planning training periods and goals, getting constructive feedback, and remaining motivated prevents overtraining and dropouts. Anyway, it is essential to keep pleasure in movement itself and to set appropriate training goals that can be assisted with the aim of technology (Esmonde, 2019). Moreover, self regulation reached by objective feedback through wearable technology over time leads to higher levels of body awareness which is associated with decreased risk factors for injuries and increased well-being (Busch et al., 2018).

The SDT framework already provided guidance for mHealth development that incorporates well-being. Further research regarding the influence on runner’s mental health while training with technology is necessary to make full use of mHealth options.

Strengths and Limitations

The present review has different strengths and limitations. The first important strength is the reviews’ validity and reliability due to the stringent search strategy. Moreover, a whole picture yielded through the mixed-method design. Another strength presents in its exploratory nature. Since making it possible to identify psychological patterns in recent research, the spectrum of possibilities reached the mental health context. First, by identifying predictors that represent the fit between recreational runners and wearable technology, the high usage in this group could have been illuminated. This important finding formed a crucial base that covered two components: It offers foundation for further technical design and, thereby, could have positive implications for runners that have not found the appropriate device yet. On the other hand, gaining information about the remarkable number of runners that are using wearable technology, this elaborated approach (considering devices’ ability to satisfy runners’ needs in terms of personalization, accuracy, motivation, interaction, or comfort), could be transferred to other areas and improve their possibilities. Second, qualitative findings showed runners’ experiences with wearables and made it possible to determine different categories for usage. Furthermore, the quotations illustrated individual perceptions but also important general conclusions regarding self regulation with devices by recreational runners.

The first limitation that needs to be mentioned is one that applies in general for literature reviews: The search strategy leaded to the exclusion of certain papers. Moreover, even though inter-rater reliability is considered substantial (κ = .63), mixed-method reviews are restricted by interpretation. Furthermore, the low number of included articles (n= 13) limited the generalizability. Still, they were representing the most suitable papers for targeting the research question. The stated boundaries were to the detriment of the results in terms of missing studies examining runners' well-being regardless of technology usage. With respect to comparing non-users and users concerning their well-being in running, this review lacks insight. To address the psychological knowledge gap regardless of technology usage, the search string could be expanded with 'running by feel', 'body listening', or 'body trust' for the next review. Nevertheless, despite the restrictions and the related limited significance, the review resulted in important findings for integrating mental health in a former physical area.

Conclusion

The present review offers a noteworthy connection between using wearable technology for self regulatory aims and the SDT. In conclusion, wearables have substantial advantages with regard to physical benefits and well-being concerning the interplay of health. Since referring back to recreational running as a rather small area in life, reservations in terms of quantifying the self or getting addicted to technology should not limit or even prevent technology's possibilities. Nevertheless, collecting personal data needs always be kept confidential and at least under the individuals' control. Considering widespread reservations in psychological health regarding technology usage, this review can form a major step. Rising awareness may lead to key findings in future research and, hence, can have substantial consequences for the mental health domain in manifold matter.

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Appendix A

Search terms ‘wearable technology’ AND ‘runners’ AND ‘tracking’

Duplicate hit in EBSCOhost

- *Runners’ Perspectives on ‘smart’ wearable technology and its use for preventing injury*

Three hits in Scopus

- *‘There’s only so much data you can handle in your life’: accommodating and resisting self-surveillance in women’s running and fitness tracking practices*
- *On the body of the consumer: performance-seeking with wearables and health and fitness apps*
- *Technology adoption, motivational aspects, and privacy concerns of wearables in the german running community: Field study*

Appendix B

Quotations from recreational runners using wearable technology

Tracking Personalized Training Data

> As far as the pace, I think about: how hard am I breathing? How is my heart rate doing? Can I have a conversation with someone if I’m running with someone, or do I feel like I’m dying here? And then I look at the numbers and I’m like, okay, I’m running above a 9-minute mile. I should not be this out of breath. Why do I feel this way? Am I under the weather? Is it more humid today? Did I eat differently last night? The data is this gateway to, like, what did I do that made this number be the way that it is? (Esmonde, 2019, p. 812)

> I actually used my run tracking to get cheaper life insurance [...] they wanted my health data. There’ s all these different variables you have to state and they are linked to this big database, so I joined the dots for them [and] I can prove how disciplined I can be. It’ s sort of your own life insurance [...] that’ s a cool way to have data on yourself. (Hardey, 2019, p. 1000)

> I have been using the HR band for about 1 month. Before that, I was thinking that my HR was low, as I was able to “talk” during fast runs, but then I realized that my HR goes up to 200 bpm, and my average HR is very high. Now, I am doing low-HR runs to control it. (Kuru, 2016a, p. 854a)

> [it’s] like a mirroring of the feeling I am aiming for, that is why I use a heart-rate monitor. Like a confirmation about how it feels when I breathe. (Tholander & Nylander, 2015, p. 2916a)

Increasing Running Motivation

> I can do exercise without Fitbit, but the actions would be less engaging with partial success—the feedback from Fitbit motivates and guides me to do better and keep going. (Asimakopoulos, Asimakopoulos, & Spillers, 2017, p. 7)

> A few years ago I started using Fitbit and RockMyRun. I had been talking to a buddy about my physical alignment as a basis for better performance, and then using apps to track what your body can do. I had been playing around with my running style for while, and this whole thing about wearables kind of pushed me forward. It made my running more efficient, but it also showed me what I had been neglecting – my mind. (Hardey, 2019, p. 997)

> if you do not have any goals that are really important to you, then it is the everyday practice that are the actual goals. They are kind of the product, that is what you do. (Tholander & Nylander, 2015, p. 2917)

Improving Performance

> My activity tracker helps me gauge my progress in increasing my speed. (Feng & Agosto, 2019, p. 9)

> Using my Jawbone encourages me. I often think that before I run things won't go to plan that day. I feel sick. Sometimes I am sick. When I run, I am motivated and I don't get to feeling sick anymore. I start my run. I see other runners. Forget dawdling about and feeling sorry for yourself [...] I enjoy running, I stay in touch with my performance, that's the benefit of my tech. Running is more than running, and I pay attention to it every day. I think wearables give a softer and more natural approach to achieve high-performance [...] achieve a good range of movement and set your mind free. (Hardey, 2019, p. 996)

> I can track my cadence with this watch, which actually I care a lot about. That's why I think this watch is pretty efficient. Cuz I have to increase the number of steps I take when I accelerate. And when the cadence difference between low tempo and high tempo runs is low, I feel that I am not that strong, and I need to improve it. (Kuru, 2016a, p. 854b)

> Well, what you want to see is, I mean, exertion in relation to your speed is where you strive for an improvement … either make your running more efficient so that you can run faster with less exertion, or improve your 'engine' so that you can run faster at lower heart-rate. (Tholander & Nylander, 2015, p. 2916b)