Towards Effective Interventive Health Applications: On the Problem of User Triggering

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Abstract. Extensive studies show that regular physical activity is one of the crucial factors to determine one's prolonged health and wellbeing. But although this knowledge is fairly widespread, many people still fail to meet the WHO recommendations for the weekly average of physical activity. While the reasons for this shortcoming are manifold, a lack of motivation on the one hand and a lack of awareness on the other may be considered to be the two main culprits. Interventive fitness and health applications, being both pervasive and persuasive, may help to counteract this problem by assisting the user during her daily routine in finding both the required motivation and good opportunities for being physically active. This contribution focuses on one of the main challenges of such applications, namely the identification of situations which are suited for notifying ("triggering") the user of a chance for physical activity.

Keywords: Interventive health · Pervasive applications · Persuasive technologies · Physical activity · User interfaces

1 Physical Activity and Health

Studies show that a minimum of 15 min of physical activity a day will significantly reduce all-cause mortality [1]. Consequently, the World Health Organization (abbr. WHO) recommends that "*Adults aged 18–64 should do at least* 150 min *of moderate-intensity aerobic physical activity throughout the week or do at least* 75 min *of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity*" [2]. By using the terms "moderate-intensity" and "vigorous-intensity", the WHO refers to the Metabolic Equivalent of Task (abbr. MET) classification of physical activities. This convention assigns intensity values ("MET-values") to different types of physical activities, thereby arranging them in a hierarchy that ranges from the least intense physical activity - sleeping with a MET-value of 0.9 - to the most intense physical activity - running at 22.5 km/h (14 mi/h) with a MET-value of 23. The intensities of all other types of physical activity, such as dancing, gardening, or playing a musical instrument, lie somewhere in between those two extremes [3]. When referring to "moderate-intensity activities", the WHO means activities with a MET-value in between 3.0 and 6.0, and analogously, a "vigorous-intensity activity" is anything

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with a MET-value of above 6.0. According to this classification, a few examples of moderate-intensity physical activities would be brisk walking (MET 3.8), practicing Tai-Chi (MET 4.0), and mowing the lawn with an electric mower (MET 5.5). In other words: the WHO recommendations for the minimum amount of physical activity per day could already be reached by accelerating one's pace on the way to the bus stop in the morning and the evening, and by investing a few minutes into Tai-Chi exercises during the lunch break or after work.

As such, it may be considered somewhat surprising that a significant – apparently growing – part of the population fails to meet the WHO recommendations. According to Hallal et al. "*roughly three of every ten individuals aged 15 years or older - about 1.5 billion people - do not reach present physical activity recommendations*" and "*the situation in adolescents is even more worrying, with a worldwide estimate that four of every five adolescents aged 13–15 years do not meet present guidelines*" [4]. This prevalence of physical inactivity, especially among adolescents, is prone to negatively affect not just the life of individuals, but the state of societies as a whole. Janssen calculated that in 2009, "*the total annual economic burden of physical inactivity in Canadian adults was $6.8 billion*", which equaled almost 4 % of that year's total Canadian health care costs [5]. Pratt et al. point out that the surprising low number of publications on the matter in recent years is probably due to the fact that at least in North America, Australia, and Europe, the awareness for the fact that the physical inactivity of their populace induces a financial burden on these societies has become widespread enough [6]. So, what is stopping so many people from not even reaching the low-end goals?

In several studies conducted among a total of 17,000 Australian adults, the top three barriers to being physically active were found to be a lack of time, a lack of ability, and a lack of motivation, in this order [7]. In the light of the previously made considerations that the WHO recommendations for physical activity can be reached fairly easily by simply integrating a few moderate-intensity physical activities in one's daily routine, it must be concluded that for the majority of non-active individuals, either a lack of awareness or a lack of motivation (or both) are the actual problems. Here, "lack of awareness" means that while most people probably have knowledge of the fact that physical inactivity is bad for them, they may not be aware of how small the amount of physical activity actually is that is required in order to profit from associated health benefits. Furthermore, many may not be aware that physical activity is not only helpful for fighting obesity, but also to reduce the risks of suffering from heart diseases, high blood pressure, diabetes, and certain types of cancer [8]. In this regard, both the lack-of-ability and lack-of-time arguments may be based on the misconception that reaching physical activity goals implies having to endure highly stressful tasks such as the dreaded 10-mile runs.

Summarizing this chapter, we find that the WHO recommendations for physical activity could be met fairly easily by slightly adjusting one's daily routine, but that a lack of motivation and a lack of awareness seem to keep many people from achieving this. Methods for effectively counteracting this problem should thus be able to motivate people on the one hand, and to highlight opportunities for a few minutes of medium-intensity activity on the other.

2 Pervasive Applications for Health

Since the introduction of the first iPhone in 2007, smartphones have become incredibly prevalent. More than 1.4 billion new devices have been sold in 2015 alone [9]. In a similar manner, the introduction of the first Apple Watch in 2015 had a significant impact on the wearable market and helped it grow by 170 % in comparison to the previous year, up to almost 80 million units sold in 2015 [10]. Smartphones and wearables are different to classic laptops, desktops, and video game consoles in that they accompany their users throughout the entire day. This characteristic of being almost always readily available to interact with the user is called "pervasiveness" and smartphones and wearables are a huge step towards pervasive computing, as originally envisioned by Weiser in 1991 [11].

As we have pointed out before, their pervasive nature makes smartphones and wearables ideal tools for technology-based health-related interventions [12]. Frequently reminding the user of the necessity of doing (or not-doing) something specific increases the likelihood of her actually showing the desired behavior. Social sciences have coined the term "nudging" for this kind of friendly reinforcement [13]. There are a growing number of smartphone applications that aim to stimulate and support "healthy behavior" during the day by "nudging" the user. Examples include applications meant to ensure that the user is drinking a sufficient amount of water in order to avoid dehydration[1], and applications that want to ensure that the user stays compliant to her goal of quitting smoking[2].

The stimulation of a sufficient amount of physical activity throughout the day is one of the main features of the Apple Watch. The so-called "Activity App" of the device uses three concentric colored rings to visualize the user's daily progress in the categories "Move", "Stand", and "Exercise". For the red-colored Move-ring, the user initially specifies the extra amount of calories that she wants to burn during the day besides her basal metabolic rate. The goal represented by the green Exercise-ring is to achieve a total of at least 30 min of at-least medium-intensity physical activity. And finally, the blue Stand-ring is filled if the user manages to stand or walk for at least sixty consecutive seconds in at least twelve different hours of the day. The device relies on its built-in inertial sensors for the assessment of all of these values. The images of Fig. 1 show the Activity App in different stages.

The Apple Watch and its Activity App represent a milestone towards effective technology-based health interventions. The Move-ring enables users to set personal goals for the day. The Exercise-ring only fills if the watch detects at least medium-intensity physical activities, thus making it easier for the user to identify relevant physical activities. And finally, the Stand-ring frequently encourages – *nudges*, if you will – the user to interrupt her prolonged sitting. The corresponding "Time to stand!" message (see Fig. 1) comes with a little beep and a soft vibration of the device, a friendly reminder to be physically active. However, in its current state, the Activity App of the Apple Watch also has several shortcomings.

[1] "Plant Nanny" by Fourdesire, available for iOS, Android, and Windows Phone.
[2] "Smoke Free" by David Crane, available for iOS and Android.

Fig. 1. Apple Watch Activity App screens.

Leaving aside reports on inaccurate activity detection, one of the main problems of the Activity App is certainly the way that the "Time to stand!" feature is implemented. The notification comes once every hour, more specifically ten minutes before the next hour if the user has not been very active during the last. The application does not differentiate between contextual situations and as such it also tries to activate users sitting in meetings, movie theatres, or those driving a car. This "stubbornness" is prone to irritate and eventually annoy users and may ultimately lead to them entirely disabling the feature. In this regard, it must be subsumed that the Activity App does nothing to assist the user in identifying opportunities for being active; it merely functions as a frequent and possibly ill-timed reminder that activity is important.

Another shortcoming of the Activity App regards user motivation. The goal of closing the three activity rings each day will certainly appeal to the intrinsically motivated and studies conducted with one of the Apple Watch's competitors in the market, the Fitbit wristband, showed that wearables and their ability to quantify physical activities can indeed have a long lasting positive effect on the physical activity of their users [14]. In direct comparison, the increasing effects of pure reminders – such as the Apple Watch's "Time to stand!" messages – seem to last for only a few days [15]. However, we need to ask the question if the mere quantification of activity is also a sufficiently large motivator to those that do not enjoy physical activity for its own sake.

3 Overcoming Physical Activity Barriers

Indeed, the problem of how to encourage the not-intrinsically-motivated for more physical activity is heavily debated. In recent years, the industry tried to improve the motivational appeal of its fitness trackers and healthy living applications with the widespread integration of gamification mechanics [16], although the actual effectiveness of gamification in this context remains questionable [17]. The incredible commercial success of the Wii Sports game for Nintendo's TV-screen based console Wii [12], released in late 2006, sparked a significant amount of research on so-called exergames – video games that require the user to be physically active in order to advance in the game – and on the question, whether or not these exergames can effectively motivate users for physical activity. But although it has been found that such games are motivating to many users in the short-term [18], long-term studies that prove a lasting effect are still hard to come by.

In order for interventive health applications to be effective, they need to be provided with the means to be able to overcome the barriers for the desired activities. The psychologist BJ Fogg created the "Fogg Behavior Model" (abbr. FBM) through which he explains the factors that decide, whether or not someone will show an intended behavior. According to Fogg, in order for a person to behave in a specific way, that person must "*(1) be sufficiently motivated, (2) have the ability to perform the behavior, and (3) be triggered to perform the behavior. These three factors must occur at the same moment, else the behavior will not happen"* [19]. The FBM explains that motivation and ability can compensate one another within certain limits. If a person is highly motivated for doing something specific, she may do it although she finds the task itself difficult or unpleasing. An example for this might be someone attending evening classes in addition to a stressful day job in hopes of obtaining a higher degree. On the contrary, if something is very easy to do, the person in question may still show the target behavior although her motivation for doing so is actually low. The final element in the FBM is the creation of awareness, represented by an activating mechanism called a "trigger". Fogg states that "*a trigger is something that tells people to perform a behavior now*" and goes on to point out that "*in fact, for behaviors where people are already above the activation threshold – meaning they have sufficient motivation and ability – a trigger is all that's required*" [19].

The FBM is a great tool for understanding the requirements for effective interventive health applications, or more specifically, for understanding the necessities for making people be more physically active. In the previously mentioned survey by Owen et al. [7], the main reasons given for sedentary behavior were "I have no time", followed by "I am not physically able", and finally "I do not want to". Leaving aside the possibility of a response bias that may have led to the "no time" argument instead of the "no motivation" argument placing first, we find in either case that the main factors that keep people from being physically active are well reflected by the components of the FBM: (1) we need to find ways of motivating users, especially those that do not take joy in physical activity, (2) we need to make it as easy as possible for users to be physically active, especially in regard to the time that needs to be invested, and finally, (3) we need to trigger users when both motivation and ability are sufficiently high (and ideally only then). Fogg explains that such an opportune moment to persuade was called a καιρός ("*kairos")* in ancient Greek.

When we consider the features of contemporary devices and applications meant for promoting their users' health and fitness – and in early 2016, the Apple Watch must be counted among the most advanced of these – we find that although the progress made towards effective interventive health measures is clear, the state of the art still falls short of the actual goal. There are elements meant to motivate –quantification of physical activities and gamification – but it is at least questionable, whether these also have an effect on the actual problem group, namely those that endure physical activity rather than enjoying it. However, as can be learned from the FBM, a lack of motivation can at least in part be compensated through a sufficiently high ability. In other words: if we can find ways of making physical activity easy and simple enough, the motivational problem may indeed turn out to be a secondary one.

Fogg lists several elements of simplicity. Some of them, such as the investment of money and brain cycles, will usually not be obstacles to physical activity, leaving the investment of time, the required physical effort, a possible social deviance, and the question of whether or not it is a non-routine task to determine, whether the activity in question is considered easy to do by the user. In the first chapter, we found that both of the arguments that state "I cannot", namely the self-perceived "lack of time" and "lack of physical ability", are oftentimes actually a lack of awareness: awareness in regard to how (comparably) little time and effort must be invested to profit from health benefits. In order to promote physical activity, these two "I cannot" arguments must thus be countered at an opportune moment – a kairos moment – with a friendly but determined "yes you can, if you do it now and here".

In the light of the previously made considerations that low motivation can in part be compensated by simplicity, helping the user to identify good opportunities for being active, and possibly even telling her how to be active, seems to be key for the design of effective interventive applications to promote physical ability. In this regard, the stubborn "Time to stand!" reminder of the Apple Watch that comes every hour, regardless of the actual situation that the user is in, might be considered a first step in the general right direction and by chance, it may sometimes even be successful. But much more often it will not. What effective interventive applications rather need are mechanisms to allow them to precisely identify opportune situations – kairoi – when both motivation and, more importantly, ability are sufficiently high and when it is thus meaningful to activate – trigger – the user. And while basic versions of these user triggering mechanisms might concentrate on identifying opportunities for being active in which the user is not occupied in any other way, more advanced versions should also elaborate on the exact way of activity and possibly even point out its benefits, such as in: "There is a bus at the stop, which will wait for another three minutes. If you accelerate your pace now, you will be home 20 min early."

The identification of opportunities suited for physical activity that integrate smoothly into the user's daily routine, meaning that they are as simple as possible to perform, is the core element for the design of effective means to promote physical activity. In the next chapter, we will discuss a possible architecture for such systems and present the evaluation results of its first prototypical implementation.

4 An Architecture for Effective User Triggering

First and foremost, effective triggering requires an understanding of the user and her situation. Even if a person is highly motivated to comply, asking her for as little as to stand up may be asking too much in certain situations – left alone asking for a medium-intensity physical activity such as taking a brisk walk around the block. As such, the first requirement for devices and applications that intend to promote physical activities pervasively during the day is the ability to assess the state of the user and of her surrounding as precisely as possible. Where is the user, when is her next appointment? The second necessity is to then make sense of the bits of information that have been gathered. If the GPS module states that the user is in her office but according to the system clock, it is late Monday evening, does this mean that the user is "working"? Or is this already "spare time"? The third and final challenge lies in understanding the user: Is this a good moment for reaching out to her? Will she consider the proposed activity to be simple enough, and will she be sufficiently motivated?

By arranging these three questions in the given order, answering them becomes increasingly user (and task) dependent. While information about the state of the user's environment can be assessed independently of any knowledge of the subject itself, the implications that come from putting these facts together are already dependent on the individual user. For assessing that the user is "at work", for example, we need to have knowledge about where "at work" is. Finally, anticipation of how the user will react to a triggering attempt at a given moment can only succeed if intimate knowledge about the user's behavior patterns and preferences is taken into account. These behavior patterns and preferences are in turn dependent on the target behavior that the trigger tries to provoke: at a given moment, the user's motivation and ability to drink a glass of water will oftentimes be different from her motivation and ability to run around the block.

Regardless of the actual user and task at hand, however, we find that in accordance to the FBM, a triggering attempt will be successful if – and only if – the user's motivation and (self-perceived) ability to perform the respective task are sufficiently high at that very moment. The designers of devices and applications for interventive health aiming to provoke certain types of behavior, such as episodes of medium-intensity physical activity, need to take this into account when they intend to increase the effectiveness of their products.

Figure 2 shows an abstraction of an effective triggering mechanism. This six-step cycle is centered on the question, whether or not to trigger the user and includes the following phases:

1. **User Decision-Making:** The cycle starts with the user who has just received a triggering notification through her device or application, for instance asking her to perform a specific kind of medium-intensity physical activity. During this phase, the user decides whether or not to show the target behavior, a decision based on her motivation and ability for performing the requested activity at the moment of the triggering attempt. This phase is a black box to the system – only its consequences can be observed.

2. **Attempt Monitoring:** After the triggering attempt, the user will either behave in the intended way, or not. In any case, in order to improve the effectiveness of the system and reach a higher triggering precision, the user's reaction to the trigger should be monitored.
3. **Information Gathering:** This step of the triggering process consists of the collection of any kind of information that might be helpful to improving the accuracy of the two subsequent steps. It involves the gathering of information that can be picked up by the triggering device itself (e.g., sensory data), but also data coming from other sources such as external devices or applications, especially web services (which, for instance, can deliver information on the local weather). This phase is largely independent of the user and the target behavior.
4. **Information Reasoning:** In this phase, the mechanism needs to make sense of the raw data that has been gathered during the previous step of the process. The aim of this step is to categorize the current situation as precisely as possible. There is a certain user-dependence in this step. For example, to be able to state that the user is "at home", knowledge is required about where "home" is. Consequently, the system needs to provide ways for gathering user input, for instance a configuration menu.
5. **Triggering Decision:** This is where the system decides, whether or not it is meaningful to try to trigger the user. This step is highly dependent on the user and the intended target behavior, more precisely on the question, whether the system assumes that the user's motivation and ability to show the target behavior are sufficiently high given the recognized situation. In other words: whether the system believes to have recognized a "kairos moment" for triggering the user. If the system answers this question with "yes" (believing in a sufficiently high probability for a successful triggering attempt), it continues with step 6 of the process. Otherwise, if it believes a triggering attempt is likely to fail in the current situation, it returns to step 3 and restarts the "gathering-reasoning-decision"-loop.
6. **Trigger Delivery:** If the system has decided that a triggering attempt is worthwhile, it needs to select a modality for delivering the trigger. This selection is again dependent on the user and the situation. A user that is already moving might neither notice a text message nor a vibration of the device, but may pick up a sound. Likewise, the system should of course never try to notify a user with hearing impairments using this modality. The final task of the process is the actual delivery of the trigger and – if possible – the assurance that it has been received. This is where the cycle ends and begins anew.

This description of the process is far from being exhaustive and the implementation of such a system requires various additional design decisions, whereby the majority of open questions are related to the "information gathering → information reasoning → triggering decision"-loop (steps 3 to 5). One of these questions is what kind of information should be gathered during step 3 as the basis for the categorization of situations in step 4 which, in turn, is the foundation for the triggering decisions made during step 5. Whether or not to trigger depends on whether or not the system believes the user's motivation and ability to be high enough, so the information gathered during step 3 should be suited to provide the answers to these questions. As a related problem, gathering information will usually require resources such as processing power and – for

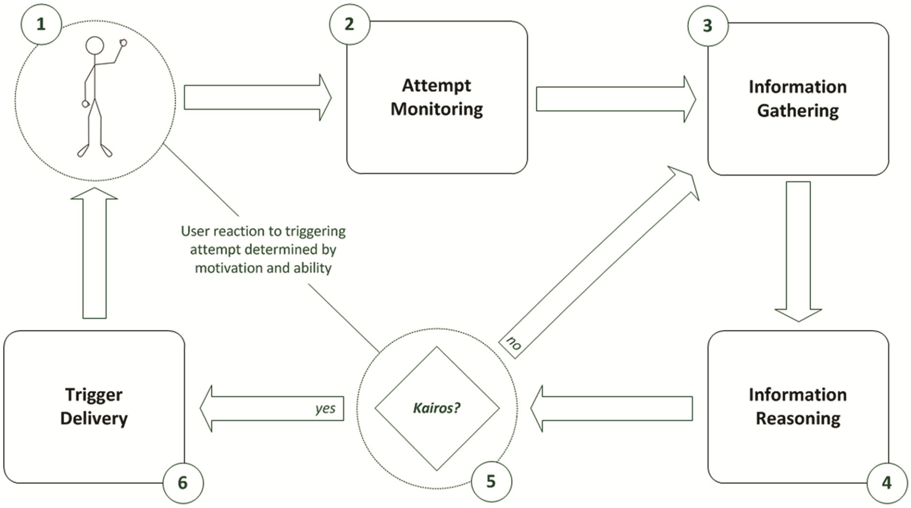

Fig. 2. Triggering process

mobile devices – battery, and in most cases, these resources will be limited. Consequently, since interventive devices and applications must be pervasive and accompany their users throughout their entire day in order for them to be most effective, there needs to be a certain management of such limited resources. Constantly gathering data and reasoning about it will usually not be an option. A workaround may be a timer that wakes the entire loop – or parts of it – in fixed intervals, but this harbors the danger of missing valuable knowledge and/or good triggering opportunities.

We have implemented a comparably simple version of this mechanism as an Android background service and evaluated it with ten persons for a total of two weeks. Of the original ten test users, three dropped out during the evaluation, leaving us with seven complete data sets. The triggering mechanism used simple text messages in order to encourage users to play the mobile exergame Twostone[3]. Every fifteen minutes, our prototypical application activated itself to gather input from six sources of information. Based on these, it then decided whether or not to try and activate the user. The decision finding mechanism was realized as a decision tree. Table 1 details the parameters that were considered during the information gathering phase (step 3) of the process.

The evaluation of our triggering mechanism was split into two phases, each lasting a single week. During the initial learning phase, the decision tree was relearned after each triggering attempt, regardless of whether successful or not. Furthermore, in order to gather a sufficiently large set of examples, the user was not only being triggered when

[3] Twostone is a mobile exergame developed at the TU Darmstadt, Germany, currently only available for Android devices. It is the successor of the game PacStudent that we introduced earlier [12], and requires players to run from virtual enemies while collecting virtual resources. Although Twostone is a location-based game, it allows players to create their own game levels and can thus be played almost anywhere. Twostone can be downloaded for free from the Google Play Store.

Table 1. Information gathering parameters

ID	Type	Source	Values
1	Day	System	{Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday}
2	Hour	System	{00:00, 00:30, 01:00, …, 22:30, 23:00, 23:30}
3	Location	GPS	{at_home, at_work, other_1, other_2, else}
4	Movement	Accelerometer/GPS	{resting, moving, moving_fast, moving_very-fast}
5	Temperature	openweathermap.org	{<−5 °C, −5 °C to +5 °C, +6 °C to +15 °C, +16 °C to +25 °C, >+25 °C}
6	Weather	openweathermap.org	73 different weather conditions[a]

[a]See http://openweathermap.org/weather-conditions for details (accessed 2016-02-26).

the attempt was likely to be successful, but also whenever an unknown situation occurred, and occasionally even when previous triggering attempts had failed during the recognized situation. This resulted in a significant amount of unsuccessful triggering attempts during the first week, which required some patience and dedication on part of the test users. In order to somewhat ease the strain on the users, they were able to specify times and locations when the system should not try to trigger them, i.e., during the night or while being at work. Nevertheless, three out of the ten original participants dropped out during this phase of the evaluation. During the second week of the evaluation, the decision tree constructed during the first week was kept fixed. Triggering attempts were limited to those situations when they were considered likely to be successful.

The results of this little test run were promising. After the second week of the evaluation, we asked the test users to rate a couple of statements with a score anywhere between 1 (no agreement at all) and 10 (total agreement). The arithmetic mean of the scoring of the statement “I found the triggering mechanism helpful” was close to 7, very similar to the mean score of the statement “The timing of the second week’s triggers was mostly meaningful”. As expected, the triggering mechanism was also found to be significantly more annoying during the first week (with a mean score of about 5) than during the second week (with a mean score of about 2). This indicates that “learning” triggers that adapt to the user’s preferences may result in a higher acceptance than unintelligent triggering mechanisms that stubbornly try to activate their users in fixed intervals or at fixed locations.

5 Conclusions and Future Work

Interventive applications for health have the potential to increase the amount of medium-intensity physical activities of their users by helping them to identify good opportunities for such. However, the currently available devices and applications fall short of this task – even the most advanced of them resort to stubbornly reminding their users in fixed intervals that they should be more active. In this contribution, we have presented an abstract architecture for more effective interventive health applications and discussed the promising evaluation results of a first, simple implementation. We are currently working on more sophisticated prototypes that, among other things, will take into account a larger array of parameters and should thus be able to differentiate situations more precisely. We hope that this will help to identify good triggering opportunities more reliably and to thus create highly effective triggering systems able to significantly increase the daily amount of the medium- and high-intensity physical activities of their users.

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References

1. Wen, C.P., Wai, J.P.M., Tsai, M.K., Yang, Y.C., Cheng, T.Y.D., Lee, M.C., Chan, H.T., Tsao, C.K., Tsai, S.P., Wu, X.: Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. Lancet **378**(9798), 1244–1253 (2011)
2. World Health Organization: Global Recommendations on Physical Activity for Health. WHO Press, Geneva (2010)
3. Ainsworth, B.E., Haskell, W.L., Herrmann, S.D., Meckes, N., Bassett, D.R., Tudor-Locke, C., Greer, J.L., Vezina, J., Whitt-Glover, M.C., Leon, A.S.: 2011 Compendium of Physical Activities: a second update of codes and MET values. Med. Sci. Sports Exerc. **43**(8), 1575–1581 (2011). American College of Sports Medicine
4. Hallal, P.C., Andersen, L.B., Bull, F.C., Guthold, R., Haskell, W.L., Ekelund, U.: Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet **380**(9838), 247–257 (2012)
5. Janssen, I.: Health care costs of physical inactivity in Canadian adults. Appl. Physiol. Nutr. Metab. **37**(4), 803–806 (2012)
6. Pratt, M., Norris, J., Lobelo, F., Roux, L., Wang, G.: The cost of physical inactivity: moving into the 21st century. Br. J. Sports Med. **48**(3), 171–173 (2014)
7. Owen, N., Bauman, A.: The descriptive epidemiology of a sedentary lifestyle in adult Australians. Int. Epidemiol. Assoc. **21**(2), 305–310 (1992)
8. Lee, I.M., Shiroma, E.J., Lobelo, F., Puska, P., Blair, S.N., Katzmarzyk, P.T.: Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet **380**(9838), 219–229 (2012)
9. IDC Press Release: The Worldwide Wearables Market Leaps 126.9 % in the Fourth Quarter and 171.6 % in 2015, According to IDC, 2 February 2016. http://www.idc.com/getdoc.jsp?containerId=prUS41037416. Accessed 26 Feb 2016
10. IDC Press Release: Apple, Huawei, and Xiaomi Finish 2015 with Above Average Year-Over-Year Growth, as Worldwide Smartphone Shipments Surpass 1.4 Billion for the Year, According to IDC, 27 January 2016. http://www.idc.com/getdoc.jsp?containerId=prUS40980416. Accessed 26 Jan 2016
11. Weiser, M.: The computer for the 21st century. Sci. Am. **265**(3), 94–104 (1991)
12. Dutz, T., Hardy, S., Knöll, M., Göbel, S., Steinmetz, R.: User interfaces of mobile exergames. In: Kurosu, M. (ed.) HCI 2014, Part III. LNCS, vol. 8512, pp. 244–255. Springer, Heidelberg (2014)

13. Thaler, R.H., Sunstein, C.R.: Nudge: Improving Decisions about Health, Wealth, and Happiness. Yale University Press, New Haven (2008)
14. Cadmus-Bertram, L.A., Marcus, B.H., Patterson, R.E., Parker, B.A., Morey, B.L.: Randomized trial of a Fitbit-based physical activity intervention for women. Am. J. Prev. Med. **49**(3), 414–418 (2015)
15. Wang, J.B., Cadmus-Bertram, L.A., Natarajan, L., White, M.M., Madanat, H., Nichols, J.F., Ayala, G.X., Pierce, J.P.: Wearable sensor/device (Fitbit One) and SMS text-messaging prompts to increase physical activity in overweight and obese adults: a randomized controlled trial. Telemed. e-Health **21**(10), 782–792 (2015)
16. Lister, C., West, J.H., Cannon, B., Sax, T., Brodegard, D.: Just a fad? Gamification in health and fitness apps. JMIR Serious Games **2**(2), e9 (2014)
17. Zuckerman, O., Gal-Oz, A.: Deconstructing gamification: evaluating the effectiveness of continuous measurement, virtual rewards, and social comparison for promoting physical activity. Pers. Ubiquit. Comput. **18**(7), 1705–1719 (2014)
18. Hardy, S., Göbel, S., Gutjahr, M., Wiemeyer, J., Steinmetz, R.: Adaptation model for indoor exergames. Int. J. Comput. Sci. Sport **11**(1), 73–85 (2012)
19. Fogg, B.J.: A behavior model for persuasive design. In: Proceedings of the 4th International Conference on Persuasive Technology. ACM (2009)