Fitness Applications for Home-based Training

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Recent technological advances have created enormous opportunities for developing applications which support training from home, particularly for older adults that are often socially more isolated, physically less active, and with fewer chances of training in a gym. In this article, we review the current fitness applications and their features alongside the design challenges and opportunities of fitness applications for trainees at home.

Introduction

Physical activity, especially in the form of structured exercises, not only helps to improve physical function, but has also been linked to positive outcomes in social and mental well-being [1]. However, for several groups of people (such as older adults with physical and cognitive limitations, or postpartum women), regular training - and especially regular training at gym or outdoor - may be inconvenient or impossible.

In this paper, we review how technology can (and does) facilitate training from home, how it can motivate people to begin and maintain an active lifestyle, and how it can be effective in achieving results (such as better strength and balance). Because older adults represent such a specific and important class of people for which home training may be the most convenient (and sometimes only) option, we specifically analyze research and applications based on their suitability for older adults. Besides discussing current technologies and research, we also underline limitations and research gaps in IT-based home training solutions in general and for older adults in particular.

Home-based fitness applications

With the purpose of analyzing home fitness apps in practice and revealing any emerging classes of applications, we set to analyze the type of support that is currently implemented in commercial fitness applications. In what follows, we describe the selection criteria, the design dimensions and literature considered in the analysis, and the emerging application archetypes.

Selection strategy

We screened **524 of the most popular (highest number of downloads and active users)** *health and fitness* applications in the app stores for the following platforms: Android and iOS (*mobile*, 167 apps; category: health & fitness), Windows and Mac (*desktop*, 167 apps; category: health & fitness), and Nintendo and Xbox (*gaming console*, 190 apps; category: music & fitness). The selection was done using popular apps charts for each platform (Android: “Top Apps”; iOS: “Popular apps”; Windows: “Top Apps”; Mac: “Popular apps”; Xbox and Wii: all games screened) from Italy as of June 2015, and includes both *free* and *paid* applications. We focused on this set of applications as it represents the solutions that users are more exposed to, and which have more visibility.

From this initial set, we excluded i) the applications which were not related to fitness, and ii) older and free-tier versions of apps already evaluated as part of the same list (to avoid duplicates). As a result, **we included 200 fitness applications** (100 *mobile* apps, 60 *desktop apps* and 40 *console apps*) in our analysis, coded by two experts with an inter-coder agreement of 94%.

Design dimensions

The effectiveness of home-based training programs for older adults has been the subject of recent reviews [2, 3, 4]. Chase [3] evaluated physical activity interventions for older adults and demonstrated that interventions do not need to be face-to-face to be effective. Müller et al. [2], in a review of interventions with and without technology, determined that internet-based interventions can be also effective and economically viable. The lessons learned from the literature and our exploration of current fitness applications highlight a set of common design aspects:

- **Interaction Design** refers to the technology (software and hardware) used to deliver the training program and to interact with the fitness application.
- **Coaching and tailoring** refers instead to the type of instructions, feedback and assessment that are given throughout the training, and how it is customized to fit the trainees needs and abilities.
- **Monitoring and sensing** denotes the mechanisms employed to measure performance indicators relevant to the training program.
- **Persuasion and motivation** discusses instead, how the various applications and devices encourage trainees to start and continue exercising.

We take the findings from these previous meta-reviews, along with the relevant literature from the HCI community for each of the dimensions under consideration, to derive design recommendations and analyse their adoption in current fitness applications.

Application archetypes

Three general classes of applications emerged when looking at the type of support implemented for each of the design dimensions, each focusing on a specific aspect:

- **Training apps**: The distinctive feature of this class of applications is *exercise prescription*. Not all training apps support monitoring or feedback, but they all provide explicit training programs.
- **Tracking apps**: Applications that don't offer training programs, but rather *focus on tracking* various aspects of user activity (e.g., steps, distance, elevation; 88%) and physiological indicators (e.g., heart rate, respiration; 44%) are included in this category.
- **Fitness games**: These apps involve physical activities in a game context, without necessarily following a training program (only 35% have a training program). A distinctive aspect is the *use of competition, comparison and cooperation persuasion* strategies (91%), which generally is the highest among the three classes of apps.

These archetypes are illustrated in Figure 1, and discussed in detail in the following sections. For each archetype, we particularly analyse its specific focus area.

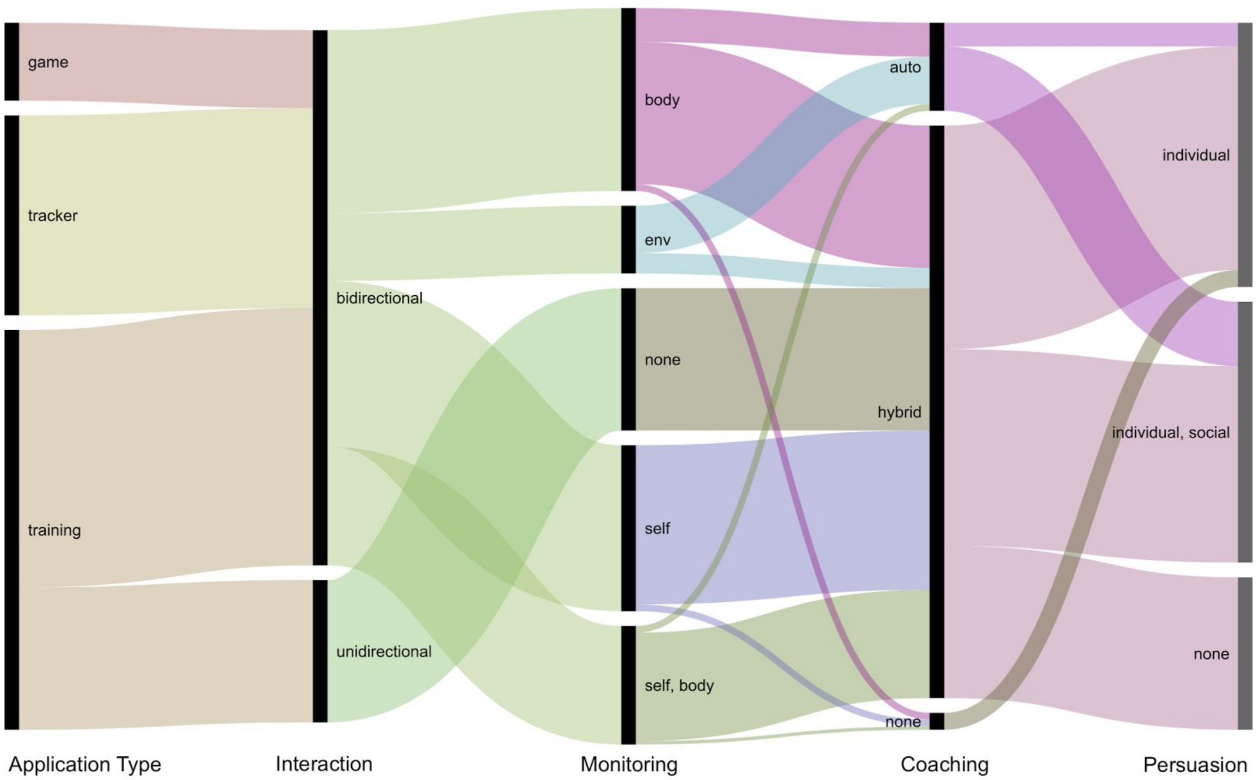


Figure 1 - Alluvial chart illustrating common patterns in fitness application (archetypes)

Interaction Design

The special abilities of older adults, along with level of education and access to technology, are of particular importance in the design of technology-based physical activity interventions. As discussed by Müller et al [2], the effectiveness of such interventions is ultimately related to the ability of the older adult to follow the training program using the technological instrument, thus calling for a better understanding of the underlying components of the interactive fitness applications.

With the notion of design guidelines discussed in the literature, and the top rated apps in the online stores, we identified three different aspects to the design of interactive training applications:

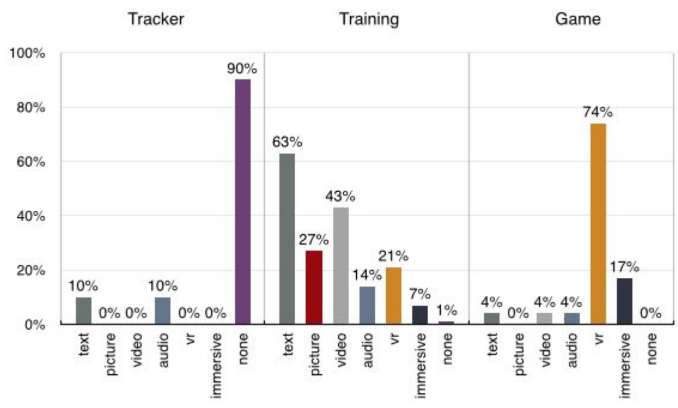
- **Direction of the interaction:** *unidirectional* denotes training programs with plain pre-recorded exercises which its function does not require user feedback, and *bidirectional* denotes training programs which utilize user feedback before and during the training for the purpose of monitoring and tailoring the training program.
- **Input type**: describes how the user interacts with the medium: this is *indirect* when the user action needs to be translated to provide the input (e.g., using a mouse pointing device); *direct*, when the action does not need translation (e.g., using a touch-enabled device); *natural,* when the input components are invisible and the interaction happens by using natural gestures (e.g., posture recognition in MS Kinect); and
- **Training output**: refers to how the training is represented (text, illustrations, audio, video and virtual and immersive environments).

Exercise programs delivered via workout DVDs, represent a large percentage of desktop apps (67%) and provide *unidirectional* access to training programs. In this setting, trainees have access to static exercise instructions with no feedback (from the medium) on their performance. Despite this limitation, in a study with 237 community-dwelling older adults, this class of solutions demonstrated to produce meaningful gains in physical function [5]. On the other hand, training applications in mobile and console platforms rely more prominently on *bidirectional access*, providing not only training instructions but also the possibility of logging activities and reflecting on training performance (mobile 84%, console 100%).

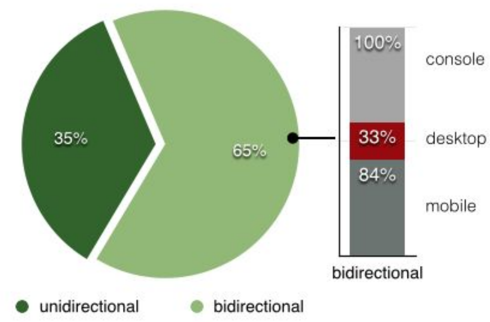
Research on human computer interaction points to *direct input*, like the one provided by touch-enabled mobile devices as being more accessible for older adults [6, 7], compared to *indirect input* found in most desktop applications which rely on mouse and keyboard. Indeed, touch-enabled applications designed especially for older adults have been shown to work in remote training settings [8]. Applications in game consoles, instead, rely on sensors such as the MS Kinect (https://www.microsoft.com/en-us/ kinectforwindows/) and the Wii Remote (http://www.nintendo.com/wiiu/) that offer *natural input* capabilities. A study by Pham [9] has shown that older adults interacting with the mixed controllers (gestures and buttons) found in Nintendo Wii, require less learning time and perform better, compared to the ones based on gesture-recognition-only found in Xbox Kinect. Nonetheless, the same study reports a preference of older adults towards gesture-recognition controllers due to perceived benefit in performing more physical movements.

In terms of output, there are no formal studies on which representation is more effective. Aalbers et al. [4] discusses this aspect further and concludes that it is not clear what mechanism of delivery can be considered more effective. However we understand from research in multimodal interfaces that combination of formats is preferable (e.g., combinations of visual and audio, or visual and haptic), especially when they compensate declines in perception skills [10, 7]. In fact, mobile fitness applications designed with the specific goal of facilitating remote training do in fact use a combination, with text (73%) and videos (53%) as dominant formats. Instead, applications in game platforms, due to the tracking capability of the sensors, deliver training instructions via virtual and immersive environments.

A summary of design considerations and current practices is shown in Figure 2.



Training output in each app class



Bidirectional access in each platform

Design considerations

- Unidirectional training programs can be effective, however there might be differences in adherence (see persuasion and motivation).
- Direct input devices are more accessible to older adults.
- Combination of training output formats can help to compensate declines in perception skills.

Design in practice

- Training applications offer the most diverse output with text (63%) and video (43%) at the top. Games prominently use virtual (74%) and immersive (17%) environments. Most trackers do not offer training programs (90%).
- Training apps, primarily desktop (67%), are notoriously unidirectional in that the program does not require the user to provide feedback to function. Mobile and console games are often bidirectional, partly due to the use of the sensing capabilities of these platforms.

Figure 2 - Interaction design in fitness applications

Sensing and Monitoring

Different types of instruments can be used to capture relevant training data, and at a high-level we can describe them in terms of:

- **The sensing method**: referring to *how* the data is collected, from self-reported data to specialized sensors (wearable or environmental), and
- **The aspect observed**: referring to *what* is being collected, e.g., general activity, physiological indicators or detailed motion patterns.

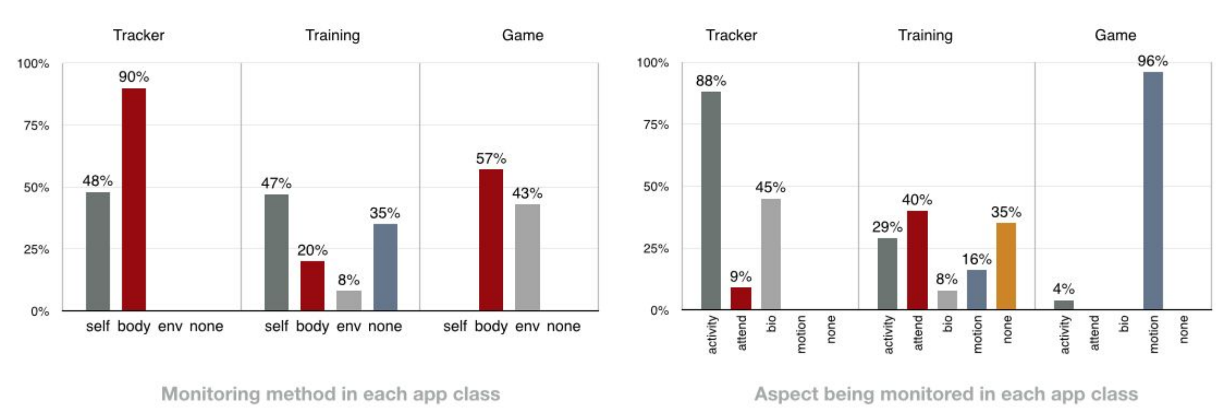
The choice for the instrument typically depends on the type of activity to be performed (e.g., indoor, outdoor), the aspects to be measured and the level of accuracy needed [11].

Self-reported questionnaires can be used to inquire trainees about their performance and adherence to the training and also their overall physical activity and wellbeing. Many applications (47% of trackers and training apps) rely on this instrument given its ability to capture training-related data without the need of specialized sensors. Self report is also used in research trials due to its ability to easily collect data from a large number of people without affecting participant's behavior during the experiment [12]. However, self reporting is time consuming and can be a complex cognitive task, especially for target groups with memory limitations such as older adults [12], which could lead to misreporting [2]. In addition, from the trainee's perspective, entering health data manually can lead to a decline in the usage of the application [13].

Sensing technologies have advanced to the point that we can wear and use devices with sophisticated capabilities. Wearable sensors, and other types of body-fixed sensors, can now measure indicators such as general activity level (e.g., Fitibit: http://www.fitbit.com/, Nike Fuelband: http://www.nike.com/us/en_us/c/ nikeplus-fuel, Misfit: http://misfit.com/, Striiv: http://www.striiv.com/), quality of sleep (e.g., Fitbit, jawbone: https://jawbone.com), heart-rate (e.g., Polar FT4: http://www.polar.com/en/products/get_active/fitness_ crosstraining/FT4), and even breathing quality (Spire: http://spire.io), enabling advanced monitoring capabilities. Such objective measures are desirable to get a more precise picture about the progress in non face-to-face interventions [2]. These sensors usually come with a companion application as well as programmatic interfaces (API) that enable their integration with third party systems. Moreover, built-in sensors (activity tracker and heart-beat) embedded into smart watches (e.g., Android Wear: https://www.android.com/wear/ and Apple Watch: https://www.apple.com/watch/) and on top of wearable operating systems enable developers to add sensing to their apps. Yet, only 20% of the training apps and 90% of trackers which we have analyzed support integration with wearable or built-in sensors and the remaining rely on self-report data. In terms of perception of these sensing technologies, a two-week study with 8 older adults reported no usability issues but a negative change in the attitude (in 5 participants) due to accuracy limitations in measuring some daily activities (e.g., walking in a treadmill), being uncomfortable to wear, and being considered a waste of time [14]. Indeed, the level of accuracy of these devices might not render them appropriate for all scenarios (e.g., clinical trials), as demonstrated in a study [15] with pedometers.

Environmental sensors and advanced motion sensing devices such as MS Kinect and Nintendo Wii Remote enable more advanced performance tracking capabilities and also better suits for trainee's at home. A central aspect of these capabilities is the body motion tracking, which its reliability and accuracy has been demonstrated in a research experiment [16]. Environmental sensors can also measure physiological data. For example, the new MS Kinect provides touch-free heart-rate measurement (by scanning the skin surface of the trainee), with an accuracy within *a* few beats per minute (http://support.xbox.com/en-US/xbox-one/ games/xbox-fitness-faq) under good conditions.

A summary of design considerations and current practices is shown in Figure 3.



Design considerations

- Self-reports can be used to collect data from users without sophisticated sensing technology. However it is time-consuming and can be a complex cognitive task, especially for target groups with memory limitations such as older adults.
- Long term usage of sensing devices can be discouraged by limitations in measuring daily activities of older adults (e.g., walking on a treadmill) and being uncomfortable to wear.
- Environmental sensors are effective and can render the interaction more natural.

Design in practice

- Body-fixed sensors (wearable) are widely used in trackers (90%), while self-reporting is more popular in training apps (47%). In games, we see body-fixed (57%) as well as environmental (43%) sensors.
- Trackers support mostly training activity (activity, 88%) and physiological data (bio, 45%). In training apps, tracking is more diverse but attendance logging is the most popular (attendance, 40%). Console games extensively use motion sensors to track actual movements (motion, 96%)

Figure 3 -Sensing and monitoring in fitness applications

Coaching and Tailoring

The *coaching* process is commonly described by a series of phases before, during and after the training: i) identifying the needs, abilities, desires and goals of trainees, ii) prescribing a tailored training plan, iii) providing support by monitoring the progress of trainees, and iv) modifying the training plan accordingly [17]. Technology can provide different levels of support in this process, from entirely human to fully automatic (virtual) coaching. For the trainees at home, studies have shown that coaching, either by a human or virtual coach, not only makes the training more effective and safe, but also more engaging [18, 19].

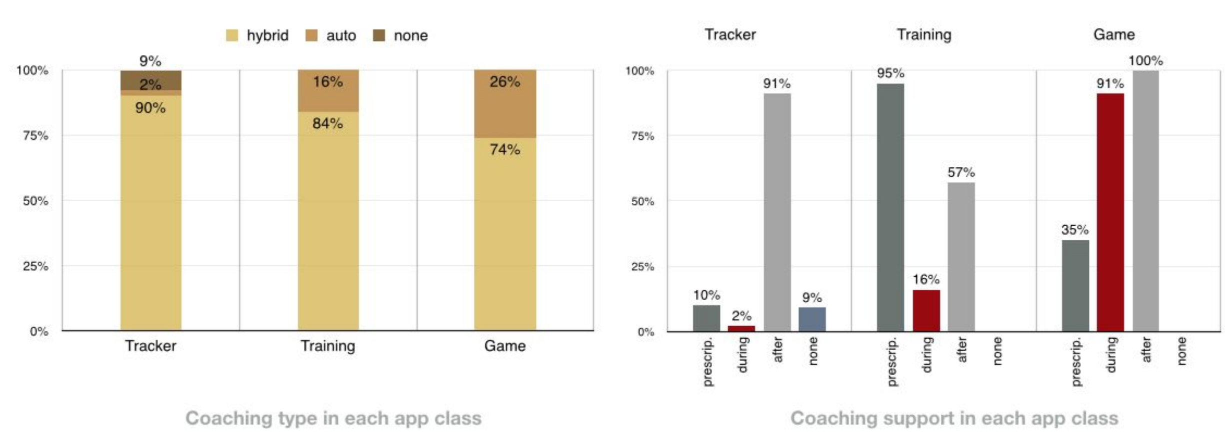
Support for coaching begins with solutions where coaching is provided by a human, and technology essentially acts as a communication tool. An example of such setting was experimented [20] with low-income postnatal women, where SMS messages were used to deliver tailored instructions and to get feedback, resulting in prolonging the duration of physical activity of the target trainees. Indeed, in a review of physical interventions by Muller et al. [2], such low-tech solutions are considered as valid alternatives to increase physical activity in low income older adults. The human coach does not only provide information and feedback, but also exercise knowledge, encouragement and emotional support while the trainee goes through exercising sessions [21].

Technology can also assist the human coach in monitoring and tailoring the training program. Fitness applications nowadays (e.g., Fitbit, Nike+) come with sensors or feedback mechanisms that facilitate the monitoring by a coach or the trainee itself. Tailoring training programs are also supported by dashboards that assist human coaches in tuning the plans based on trainees performance (e.g., http://gymcentral.net). This aspect has shown to be particularly important in a review of 12 internet-based interventions [4], where interventions with tailored information have resulted in lower attrition rate per month (2.7%) compared to those with generic information (6.6%). Furthermore, we should note that the role of the Coach can be played by the trainee itself or an expert. In our analysis, the human factor in the coaching mechanism was the trainee itself in most of the cases. Only 3% of the training applications provided an expert support (a human expert except the trainee itself).

We discovered that a few applications (~2%) rely on "virtual coaches" instead of human coaches. Virtual coaches are pre-programmed or smart machines and applications that monitor, prescribe and tailor the training program for the trainees [22]. An example of such solution was experimented by Steffen et al. [23], who developed a personalized exercise trainer for the elderly using a wearable sensor that detects the movement of the user while exercising, automatically tuning the exercise level, and providing audio feedbacks during the exercise. The authors of this study however did not formally evaluated the system but report on positive feedback from the older adults. More formal studies, such as Watson et al. [24] compared the effect of a fitness application with virtual coaching, with respect to applications without coaching, and concluded that the trainees with a virtual coach adhered longer to the training program. However, coaching in this form does not provide the social support that a human coach can provide**.** Indeed, studies express the need for a real coach [21], especially when dealing with sensitive trainees such as older adults [25].

To cope with the aforementioned shortcomings and barriers Thórisson [22], experimented with "Reactive Virtual Trainer" which, unlike the conventional virtual trainer, is creative and provides emotional and psychological support to the trainees similar to a human coach and tailors the fitness program according to the physical and emotional states of the trainees. However, Thórisson proposes that although the RVT is pre-programmed by a human expert, yet it can not substitute a human coach in critical cases since the precision of such technologies is not accurate enough and longitudinal user studies is required to measure the long term effect of RVT in a training program.

A summary of design considerations and current practices is shown in Figure 4.



Design considerations

- Coaching, either by a human or virtual coach, is preferable over a solution without coaching
- For sensitive training applications and for the older adults population, the presence of a human expert in the loop is recommended.
- Reactive Virtual trainer can provide emotional and psychological support along with the exercise instructions but are not recommended for exercises that require high precision.

Design in practice

- Most apps use hybrid coaching (90%), especially covering the prescription and after training phases.
- Apps in game consoles tend to provide support in real time during the training (91%).
- Training apps in game consoles provide more complete support than mobile apps.

Figure 4 - Coaching in fitness applications

Persuasive Technologies

Programs aiming at promoting physical activity and lifestyle changes incorporate components aiming at increasing adherence and reducing attrition [2] [4]. In technology-based interventions such components can be described in terms of persuasion strategies. Persuasive strategies for home-based training can be grouped in two major categories: i) *individual,* referring to strategies that leverage the individual wills and natural drive and, ii) *social*, referring to strategies that demand the presence of a community of people with the roles of family, supporters and peer trainees [8]. We use this classification to describe a subset of strategies from the work of BJ Fogg [26] that are applicable to home-based training applications:

Individual Persuasion Strategies

- **Reminders and suggestions:** The application reminds trainees of their exercises sessions and suggest better exercising habits.
- **Positive & negative reinforcement:** The application prompts positive or negative comments about the exercising behavior of the trainee to raise awareness.
- **Self-monitoring:** The application provides to trainees, performance monitoring and awareness about their current progress**.**
- **Rewards:** The application praises the trainee by providing virtual badges, medals, awards and recognition upon completion or success on exercising sessions**.**

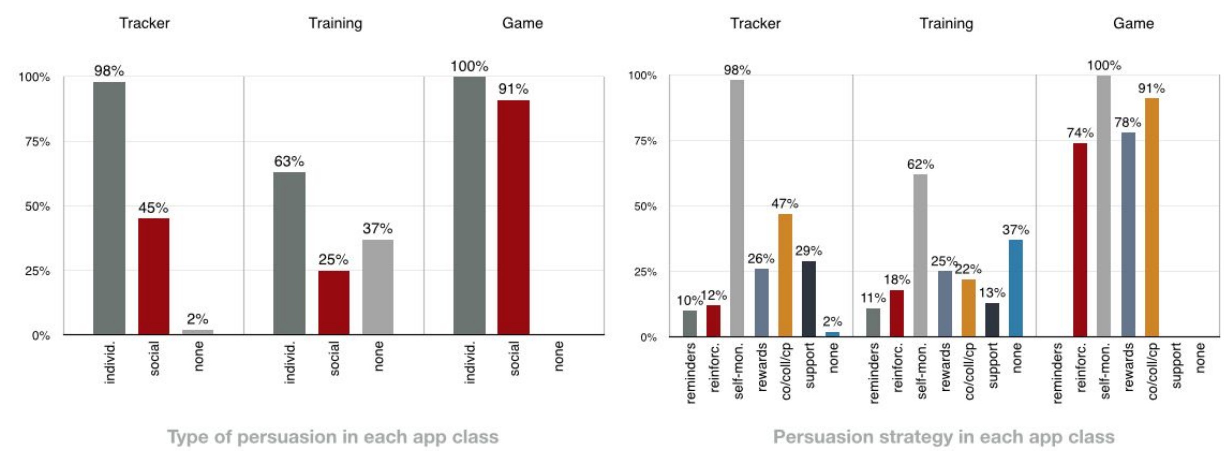
Social Persuasion Strategies

- **Social learning (comparison), cooperation and competition:** The fitness application provides social features that allow trainees to compare their performance with others, collaborate toward common goals, or compete.
- **Social support**: The application provides social features such as messaging and forums enabling trainees to interact with each other and create a community of people supporting each other.
- **Recognition:** The trainees individually or in a group get public recognition on their awards, progress and contributions.

Individual persuasion strategies have been evaluated in several studies (e.g., [8, 27]). For instance, Rodriguez et al. [27] designed a mobile app for the elderly that persuade them to walk. The system incorporates *reminders*, *notifications, self-monitoring* and a "coin metaphor" as *rewards* for the users. The system rewards the trainee's walking activity with "virtual coins" and their social interaction with "virtual diamonds". Findings after an intervention with older adults reveals that all of them found *self-monitoring* and the reward metaphor motivating to exercise regularly. However, some participants argued that they would have preferred other types of metaphors than "virtual coin" for instance. In fact, researchers (e.g. [28]) emphasis that the heterogeneity in the older population require persuasive strategies, and in particular individual persuasion strategies, to be tailored according to older adults abilities, interests and taste.

However, beyond personalization and usability issues, several studies report on higher level of interest in social persuasion strategies and report that in particular older adults prefer apps that leverage their social activities [28,29]. Silveira et al. [8] experimented the effectiveness of individual and social persuasion strategies in two groups of individual trainees and social trainees. The result of the study reveals that the long-term adherence was higher in the social group. Moreover, the follow up of the research and further experimentations with individual and social trainees discovered a raise in exercising duration for the social training group.

Despite the evidence in the literature, individual persuasion strategies are more extensively adopted than social strategies, especially with trackers (98% individual, 46% social) and training apps (63% individual, 25% social). A summary of design considerations and current practices is shown in Figure 5.



Design considerations

- Individual persuasion strategies, such as self-monitoring, are effective in persuading the trainee's to adhere to the training plan.
- The use of *social* persuasion strategies can increase adherence of older adults to home-based training programs.
- Designing persuasive strategies for older adults requires tailoring and personalization of the strategy, as older adults are heterogeneous and have different taste and abilities.

Design in practice

- Except for games (90%), social strategies are just a fraction (25% training apps, 45% tracker apps) of individual persuasion strategies.
- Self-monitoring is the most popular individual persuasion strategy (86%), followed by rewards (43%) and reinforcement (31%).
- Comparison, cooperation and competition (53%) are the social strategies more popular, followed by social support (14 %)

Figure 5 - Persuasion in fitness applications

Findings and Opportunities

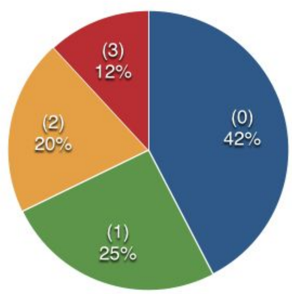
This investigation has shown that home fitness landscape is sprouting with ideas and applications which offers a variety of interaction modes, coaching methods and, measuring techniques. Current solutions provide very good support for the general population, especially for those that do not require expert coaching. However, there are very few applications that explicitly target older adults and are designed for the average interaction skills and physical abilities of the average adult in their late life. This is the case despite the ample evidence of the positive effect of sustained training on mental and physical health and in turn, the benefit that better health has, in terms of reduced expenditure by government and families [1].

Thus, sensible groups such as older adults find more limited support in current solutions. This is evidenced in Figure 6 and the description below, where we summarized the result of inspecting current applications against the various design considerations motivated in this paper.

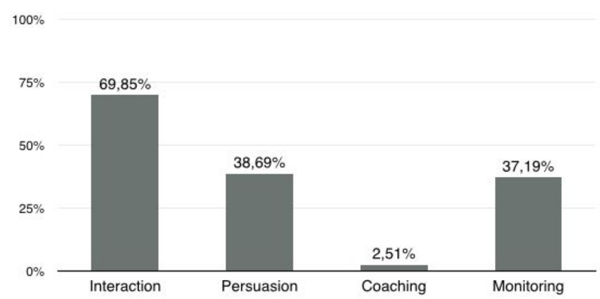
The principal lessons learned are specific ingredients that stimulate higher level of engagement and of adherence to training programs:

- The provision for social persuasion mechanisms in addition to individual persuasions.
- The presence of a human coach (as opposed to virtual or no coaches).
- The adoption of sensors that enable automated detection of activity (as opposed to manual data entry), but only as long as the sensors are accurate and do not generate lack of trust in the user as to the reliability of the measures.
- The provision of a multi-modal interaction with the user.

From existing research it is however still unclear which UI representation and metaphors works better in terms of stimulating adherence, making this a topic of further research.



Coverage of ideal settings in the 4 design aspects according to the literature
(N) = compliance with N design recommendations (max 4)



Compliance of apps per design aspect

Observations

- There are no apps that comply with the design considerations from the literature in the 4 design aspects we review in this paper.
- The most limiting aspects are the very few solutions that provide expert feedback during training.

Summary of Gaps

Interaction. The suitability of fitness application is in part influenced by the platform. Mobile and game consoles provide the *input* and *output* mechanisms that can facilitate interaction. Indeed, we have seen a higher adoption of **bidirectional** and **multimodal** interfaces in those platforms. However, how the applications use these ingredients to implement usable interfaces is still a topic for further research.

Sensing. Automatic detection of activities are preferable for older adults, especially when it comes to objective measures. Still, **self-reporting** is widely used as a method for data collection, despite potential effects in adoption and precision of readings. On the other hand, integration of **sensors** in fitness applications is still limited, with the exception of applications in game consoles that offer motion tracking capabilities during training.

Coaching. Training programs supervised by an expert human coach are preferable for older adults. However, most of the applications on the outlined markets rely on **hybrid** solutions (technology + self coaching), focusing mainly on exercise prescription, while only 3% of the analysed training applications provide **expert human coach** support.

Persuasion. The few studies on persuasion strategies to boost adherence, especially in older adults, show strong evidence on the benefits of using persuasion strategies, and especially **social strategies**. However, very few of the training application exploit these features, other than allowing users to reflect on their activities. In general, we see this as a clear opportunity for applications that exploit these aspects.

Figure 6 - Summary of compliance of fitness apps with design considerations

References

1. Norman, Emily, et al. "An exercise and education program improves well-being of new mothers: a randomized controlled trial." Physical Therapy 90.3 (2010).
2. Müller, A. M., & Khoo, S. (2014). Non-face-to-face physical activity interventions in older adults: a systematic review. *Int J Behav Nutr Phys Act*, *11*(1), 35.
3. Chase, J. A. D. (2013). Physical activity interventions among older adults: a literature review. *Research and theory for nursing practice*, *27*(1), 53-80.
4. Aalbers, T., Baars, M. A. E., & Rikkert, M. O. (2011). Characteristics of effective Internet-mediated interventions to change lifestyle in people aged 50 and older: a systematic review. *Ageing research reviews*, *10*(4), 487-497.
5. Wójcicki, Thomas R., et al. "Maintenance effects of a DVD-delivered exercise intervention on physical function in older adults." The Journals of Gerontology Series A: Biological Sciences and Medical Sciences (2014).
6. Murata, Atsuo, and Hirokazu Iwase. "Usability of touch-panel interfaces for older adults." Human Factors: The Journal of the Human Factors and Ergonomics Society 47.4 (2005).
7. Fisk, Arthur D., et al. *Designing for older adults: Principles and creative human factors approaches*. CRC press, 2009.
8. Silveira, Patrícia, et al. "Tablet-based strength-balance training to motivate and improve adherence to exercise in independently living older people: a phase II preclinical exploratory trial." Journal of medical Internet research 15.8 (2013).
9. Pham, Tan Phat, and Yin-Leng Theng. "Game controllers for older adults: experimental study on gameplay experiences and preferences." Proceedings of the International Conference on the Foundations of Digital Games. ACM, 2012.
10. Emery, V. Kathlene, et al. "Toward achieving universal usability for older adults through multimodal feedback." ACM SIGCAPH Computers and the Physically Handicapped. ACM, 2003.
11. Warren, Janet M., et al. "Assessment of physical activity–a review of methodologies with reference to epidemiological research: a report of the exercise physiology section of the European Association of Cardiovascular Prevention and Rehabilitation." European Journal of Cardiovascular Prevention & Rehabilitation 17.2 (2010).
12. Sallis, James F., and Brian E. Saelens. "Assessment of physical activity by self-report: status, limitations, and future directions." Research quarterly for exercise and sport (2000).
13. Ahtinen, Aino, et al. "User experiences of mobile wellness applications in health promotion: User study of Wellness Diary, Mobile Coach and SelfRelax."Pervasive Computing Technologies for Healthcare, 2009.

14. Fausset, Cara Bailey, et al. "Older Adults' Use of and Attitudes toward Activity Monitoring Technologies." Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 2013.
15. Tudor-Locke, Catrine, et al. "Evaluation of quality of commercial pedometers."Canadian Journal of Public Health/Revue Canadienne de Sante'e Publique(2006).
16. Tripette, Julien, et al. "Home-based active video games to promote weight loss during the postpartum period." Med Sci Sports Exerc 46.3 (2014).
17. American College of Sports Medicine. (2013). *ACSM's guidelines for exercise testing and prescription*. Lippincott Williams & Wilkins.
18. IJsselsteijn, W., de Kort, Y., Bonants, R., Westerink, J., & de Jager, M. (2004). Virtual Cycling: Effects of immersion and a virtual coach on motivation and presence in a home fitness application. In Proceedings Virtual Reality Design and Evaluation Workshop (pp. 22–23). Retrieved from http://www.ijsselsteijn.nl/papers/vrworkshop2004.pdf
19. Ofli, F., Kurillo, G., Obdrzalek, S., Bajcsy, R., Jimison, H., & Pavel, M. (2015). Design and Evaluation of an Interactive Exercise Coaching System for Older Adults: Lessons Learned. *IEEE Journal of Biomedical and Health Informatics*, *PP*(99), 1. doi:10.1109/JBHI.2015.2391671
20. Fjeldsoe, Brianna S., et al. "MobileMums: a randomized controlled trial of an SMS-based physical activity intervention."Annals of Behavioral Medicine 39.2 (2010).
21. Chi-Wai, Ron Kwok, et al. "Can mobile virtual fitness apps replace human fitness trainer?." Information Science and Service Science (NISS), 2011 5th International Conference on New Trends in. Vol. 1. IEEE, 2011.
22. Thórisson, K., & Jonsdottir, G. Towards a Reactive Virtual Trainer. Intelligent Virtual Agents, 5208, (2008).
23. Steffen, D., Bleser, G., Weber, M., Stricker, D., Fradet, L., & Marin, F. (2011). A Personalized Exercise Trainer for Elderly. Proceedings of the 5th International ICST Conference on Pervasive Computing Technologies for Healthcare, 24–31. doi:10.4108/icst.pervasivehealth.2011.245937
24. Watson, Alice, et al. "An internet-based virtual coach to promote physical activity adherence in overweight adults: randomized controlled trial." Journal of medical Internet research 14.1 (2012): e1.
25. Hanneton, Sylvain, and Anaïs Varenne. "Coaching the Wii." Haptic Audio visual Environments and Games, 2009.
26. Fogg, B. J. Persuasive Technology: Using Computers to Change What We Think and Do. Amsterdam: Morgan Kaufmann Publishers, 2003.
27. Rodriguez, M. D., Roa, J. R., Moran, a L., & Nava-Munoz, S. (2012). Persuasive strategies for motivating elders to exercise. Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2012 6th International Conference on, 219–223. doi:10.4108/icst.pervasivehealth.2012.248774
28. Ijsselsteijn, W., Nap, H. H., de Kort, Y., & Poels, K. (2007). Digital game design for elderly users. Proceedings of the 2007 Conference on Future Play - Future Play '07, 17. doi:10.1145/1328202.1328206
29. Brox, Ellen, et al. "Exergames for elderly: Social exergames to persuade seniors to increase physical activity." PervasiveHealth 2011.