



# A Review on Individual Assessment of Strength Training Using Smartphone Applications

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**Abstract.** This paper presents a state of the art review of popular strength training applications. The literature review and heuristic evaluation presented in this paper show that there is a large selection of strength training applications on the Android Market, which is not build on behavioural change theories. Furthermore, these provide very limited variety and use of sensory feedback. Additionally, only few applications deliver extended and detailed instructional information, meaning that the user needs prior strength training knowledge to achieve full usage. Nevertheless, it is believed that these applications could have great potential to fill a hole in the fitness and health market, and provide users with more affordable and available strength training support.

**Keywords:** Fitness · Health · Human-computer interaction  
Mobile applications · Skill assessment · Strength training

## 1 Introduction

Exercising regularly is a key factor for maintaining personal health and physical well-being. The Danish board of health recommends that the average person should perform approximately 30 min of moderate physical activity per day to insure personal health [1]. However, to maintain motivation and encourage people to perform physical activity, such as strength training, is difficult, since it requires a general knowledge on exercise selection and execution, in order to improve personal weak areas and avoid injuries [2–4]. Therefore, it is important to find new effective ways of providing people with the right information regarding fitness and health.

Maintaining an exercise regime and getting effective over an extended period, requires a significant level of discipline and motivation. Here, it has been proven highly effective having access to a personal trainer, both on adherence and motivation [3, 5]. The continuous monitoring of exercise execution, individualized advice and corrections, and motivational feedback, are just some of the roles undertaken by a personal trainer, which can lead to successful results [3, 5]. However, having a personal trainer can be costly and intrusive, depending on the extent of the inquired service [3]. Studies have shown that fitness and health technology have the potential to improve physical health, and increase healthcare awareness with the use of fewer resources [5–8].

Mobile phone or smartphones are rapidly becoming more essential and widespread part of modern life. These smartphones are embedded with powerful sensors, such as

accelerometer, digital compass, gyroscope, GPS, microphone and cameras, all of which allows for great utility and possibilities [9]. These technological advancements have allowed health applications to utilise these sensor information for health and fitness feedback, such as heart rate monitors, step counter, exercise trackers, etc. [5]. However, many of these applications and technologies have deficiencies and limits, because they are not based on behavioural theories and guidelines from the medical and health industry [6, 7].

In the field of rehabilitation and strength training, studies have shown that the use of biofeedback technology can significantly improve the health and mobility of people suffering from brain injury, cerebral palsy and stroke [10–12]. However, very few commercial applications have directly been made for the purpose of strength training.

This paper performs a state of the art review of current commercial applications and scientific studies on strength training support, inspired by a previous study [5], and provide recommendation for future applications. This is done by firstly investigating what criteria is needed for a strength training application to be considered successful, then reviewing how similar applications are used within the scientific field to improve fitness and health (Sect. 2). Next, we review the current top 10 strength training applications on the android market, and make a heuristic evaluation of the current applications on the market (Sect. 3), along with future design recommendations for the development of a successful strength training application (Sect. 4). Finally concluding remarks are given (Sect. 5).

## 2 Literature Review

As stated in the organisation of this paper, the literature review first investigate what criteria is needed for a strength training application to be considered successful (Sect. 2.1), then reviewing how similar applications are used within the scientific field to improve fitness and health (Sect. 2.2).

### 2.1 Criteria of Success for Strength Training

In order to define the criteria of success for a strength training application, it is needed to have an understanding of what makes a successful strength training regime. However, since strength training is a large area of sports medicine and biology, which spans over both biomechanical and physiological areas, and is larger than can be addressed in this review, this paper will solely provide a basis for understanding the general aspects of strength training, which can provide a basis for the criteria of success.

**What is Strength Training?** The human body consists of a frame (the skeleton) and expanding and contracting tissue called muscles. It is through the function and positioning of these muscles that the human body becomes mobile. During strength training the muscles becomes stronger and more effective. Strength training is defined as the process of breaking and rebuilding muscle tissue. This process implies inflicting a form of stress on the body, both physically and mentally. The body's reaction to this form of stress is to adapt by reshaping and rebuilding muscle tissue, which can withstand this

impact [13, 14]. The chemical environment of the muscle changes during strength training, by the process of energy stores depletion and lactic acid accumulation, which gives the feeling of fatigue. This, alongside the breakdown of muscle tissue, is what signals the body to improve from its current state [14]. Unexpectedly, the process of self-repair and improvement happens, not during the execution of strength training, but in the resting period that follows [13].

**What Make a Successful Training Regime?** A successful strength training regime is dependent on many variables, such as *intensity*, *volume*, *frequency*, *periodization* and *exercise selection*.

When designing a strength training program, *intensity* is one of the crucial variables to maximize strength. It refers to the load or poundage used during an exercise. *Intensity* is described as the percentage of the one rep maximum load (1RM) lifted [15]. The body's reaction to a high training intensity is to adapt by increasing neural activation; increased peak in electromyographic activity in the muscle, which relates to an increased rate of force development [13–15].

Training *volume* is defined as the total volume performed over a given exercise, and is calculated by the repetitions  $\times$  sets  $\times$  weight used. As well as *intensity*, *volume* is an important factor when trying to gain strength, since one has to increase volume over time in order to increase muscle fibre activation and size [13, 15]. Also related to *volume* is the *frequency*, since the total volume over a week is determined by the number of times one hit certain muscle parts during a week. The *frequency* is therefore defined as the number of time one workout a particular muscle. Here it is recommended that one workout each muscle part at least twice a week [13, 15].

The concepts of *periodization* builds on the principle that the training year is often divided into different periods of training, with different focus for each period, to achieve improvement. Within each sport, there are large individual differences, as some athletes are planning a relatively short duration (days/weeks) to achieve a peak once or twice a year, while other athletes in a long season are expected to peak every weekend. Strength training athletes often use the principle of training with high volume and low intensity in the individual exercises, when there is a long time to form the peak, and gradually increase the intensity and maintain or gradually reduce the amount as the peak approaches. Strength training is heavily dependent on other training activities (technique, endurance, etc.) during the week [13, 15].

Lastly, in an effective strength training program several exercises for each muscle/muscle group are used, such that the benefit of small differences in the activation, affect the muscle slightly differently. The order of the exercises within a training program can be varied. However, it is recommended that firstly one train the large muscle groups, so that they are not fatigue by the peripheral muscle groups, thereby determining whether one can lift heavy loads [13, 15].

Taking this information into consideration, it can be assumed that any successful strength training application allows for individual control of these factors. It must provide the user with the ability to, firstly, select exercises based on the needs, and track one's intensity, volume and frequency. To this end, it must provide a means of periodization for the user, since this is a fairly complex task, which requires extensive knowledge. Lastly, it must provide a basis for tracking one's performance over time.

## 2.2 Related Work

With the intention of providing future application developers with recommendations based on the review of other studies and applications, it is necessary to look into what have currently been done within the community and what do the current applications utilise. In this section, related work, studies and similar application are reviewed.

**Automatic Assessment of Physical Activity.** Conventional methods for measuring and improving exercise execution involve physiotherapists or personal trainers, who observe and correct the person performing the exercise. This method has proven highly effective and motivating for the user [3, 4]. However, this method has significant deficiencies in cost, accuracy, opportunity, coverage, and adherence. A physiotherapist or a personal trainer typically splits their attention among several patients at different locations, which means that the patients or clients have to be self-sufficient at some level. Self-reporting is often used in order to ensure that the patients or clients execute the exercises themselves; however, this is often inaccurate due to forgetfulness or un- and intentional misreporting, or lack of knowledge on how to correctly perform the exercises [16].

Researches have investigated how to improve self-reporting, by using wearable sensors to recognise, classify and report activities done. Most studies have proven the effectiveness of wearable sensors on activity recognition [2, 17–19]. However, the majority of this research has been done in controlled environments and with the focus on rehabilitation, and in most cases solely GPS and/or accelerometers have been used [6, 8, 16–18, 20].

In regards to the realisation outside the scientific field and towards the commercial market, there are many applications created for the purpose of improving training and health. Since smartphones are both highly available and have several sensors that can be used, many application developers have created a vast number of fitness and health applications with functionality, such as information distribution, exercise library, training logging and tracking tool [5–7, 20]. The state of the art applications mostly use accelerometer and GPS, and in some cases heart rate monitors and calorie counters are also used [5–7, 20]. However, reviews of these applications have shown that they are not based on behavioural change theories or guidelines, and lack biofeedback [6, 21].

Several studies have looked into creating embodied virtual trainer applications, which use all of the above mentioned features to improve health, execution and adherence [5, 16]. These studies found that the use of mobile devices and virtual trainers has big potential; however, the applications should integrate behavioural change theories into the design, and sensors should be implemented to improve the effectiveness. There are several different behavioural change theories which could be implemented [22]. The common factor for all, are that they are focusing on using response-efficacy. However, in several studies it is noted that the use of self-efficacy can provide a stronger base for change in human health behaviour [22, 23]. The notion of behavioural change theories in the design should encourage change within the user towards health behaviour and facilitate a long-term success [22, 23]. Additionally, the feedback shown on the mobile device needs to be presented in a useful manner to ensure correct usage [16, 24, 25].

### 3 Comparison of Smartphone Applications for Strength Training

In this section, the design space of current popular strength training smartphone applications is evaluated in a comparative review. For this purpose, applications from the Health and Fitness category on the Android Market are reviewed. In order to review most satisfying and the highest quality applications available at the time, the 10 most popular applications based on the user rating (stars) from the most popular list on the Android Market were considered (see Table 1).

**Table 1.** Overview of the 10 most popular smartphone applications for strength training based on the user rating (stars) from the most popular list on the Android Market.

Category	Name	Developer	Downloads	Stars
Workout planner	5 × 5	Stronglifts	500.000–1.000.000	4.9
Workout planner	30 days fitness challenge	Leap fitness group	5.000.000–10.000.000	4.8
Training journal	Fitnotes	James Gay	1.000.000–5.000.000	4.5
Workout planner	Gym workout tracker & trainer	Fitness 22	500.000–1.000.000	4.5
Training journal	Fit journals	Sultan Seidalin	50.000–100.000	4.5
Exercise archive	My fitness – strength training	Andrey Tsaregorodtsev	10.000–50.000	4.5
Exercise archive	Female fitness – bikini body	VGFIT LLC	500.000–1.000.000	4.4
Training journal	WorkIt Gym log workout tracker	WorkIt	50.000–100.000	4.4
Training journal	Strength training planner	Szabolcs Erdelyi	100–500	4.1
Workout planner	Wodster			

#### 3.1 Heuristic Evaluation

A two-step analysis of the selected applications is carried out using a heuristic evaluation, in order to assess the functionality and features of the applications (inspired by [5]). To discover and structure the different types of applications on the market, the first step is a classification of each individual application based on the core functionality into a number of descriptive categories. In the second step, each application is used during several strength training sessions over the course of three weeks, in order to assess the features and usability.

Four heuristics were used to assess the most important aspects of strength training applications, which are explained below, based on the literature reviewed.

The application *usability* and *effectiveness* for strength training are evaluated based on interaction features (control, appropriate output and ease of use) and customizability, i.e., if the users can modify the application to their specific needs. Additionally, it is assessed whether the application allows for proper tracking of strength training features mentioned in the literature review, such as intensity, volume, frequency, periodization and exercise selection.

The *Instructional features* of the application are examined, i.e., how well the instructions of the exercises are presented on the smartphone. This included the clarity and level of instructions, sufficient level of detail, etc., providing the user with sufficient knowledge about the given exercise.

Next, the *sensor data usage* is evaluated. In other words, to what extent the application utilises the smartphone sensor capabilities, acquired information (e.g., GPS, accelerometer data, etc.) and external sensor output.

Lastly, the applications ability to *motivate* is examined. Hereunder, how well the application is suited for generating adherence and long-term motivation based on variety in the training experience and proper statistical feedback on training progress to maintain extrinsic motivation.

### 3.2 Results and Discussion

The classifications process identified three categories of strength training applications: *training journal*, *workout planner* and *exercise archive*.

*Training journals* are classified as applications, whose core feature is to work as a diary and calendar for the exercises done. Here the users can plot in their training program, exercises, set, repetitions and weight, and the application keeps track of the progress through the use of statistics. However, the applications do not propose a program regime or have in depth descriptions of each exercise.

*Workout planners* are applications which have pre-programmed workout regime that the users can choose between based on their needs and desire. The applications include pre-programmed weight, repetitions, sets and progress based on the 1RM value of the user.

*Exercise archives* are applications which provide the user with a large, detailed, browsable library of exercises that can be selected for one's training program. The applications have either a visual/written or video explanation of each exercise with key points on executions and performance.

The results of the second step of the heuristic evaluation deliver key insights into the strengths and limitations of the most popular strength training applications.

Firstly, even though the Android Market has a large selection of strength training applications, these provide very limited variety. As shown by the former classification, there are only three primary classes within the Health and Fitness category on the Android Market. To this end, when examining the different applications and categories many deficits are revealed.

The *training journal* applications lack the motivational aspect, since they provide limited progress feedback. Most of these applications present feedback in a statistical

format, which requires detailed knowledge on how to use this information. As a result, they are not well suited for beginners; however, they offer great usability through the use of customisation of exercises and the information presented to an intermediate user with sufficient strength training knowledge.

The *workout planners* are very rigid and only allow for small individualization. Furthermore, even though these applications offer a large collection of workouts, they provide only limited advice and information on which workouts are best suited to one's level of experience.

The main deficit of the *exercise archive* applications is that the exercise collections are very limited in comparison to what can be found on the web. Furthermore, they lack details on how to execute the exercises correctly, and to what extent the exercises are useful.

Overall the applications provide limited to no suggestions and corrections, in order to maintain adherence and motivation. Additionally, the applications require physical interaction, meaning that the users have to divert their attention from training to log their performance, in order to get precise tracking of exercises. Additionally, even though most smartphones have a large variety of sensors available [9], the majority of applications use very limited sensory feedback.

## 4 Guidelines and Recommendations

When taking into account the information that has been presented in the literature review and the findings of the heuristic evaluation, this review deduce some general guidelines and recommendations for future strength training applications. These guidelines and recommendations are summarised in four core points: *foundation*, *usability*, *instructional information*, and *adherence and motivation*.

As stated in the criteria of success, a strength training application should build its *foundation* on providing the user with sufficient knowledge on how to structure the *intensity*, *volume*, *frequency*, *periodization* and *exercise selection* [13–15]. This can be done by providing examples based on different needs, which again can be tailored to each individual.

Furthermore, to improve the current *usability* of the applications, the way the information is presented to the user should be simplistic and easy to understand to avoid confusion and frustration [5, 16, 24–27]. Furthermore, current applications use very limited sensory feedback; despite several studies indicating that the use of the advanced sensor possibilities of modern day smartphones can be used for activity recognition and thereby limiting unnecessary interaction during workouts [5, 6, 8, 9, 16, 20, 24].

Regarding *instructional information*, the current applications have many deficits, which could easily be corrected by using existing exercise libraries such as Exorlive [28]. To this end, the possibility to expand these libraries through user customization, based on user experience and training level, could provide a larger and more detailed exercise register.

As mentioned, the conventional methods for improving *adherence and motivation*, and improving exercise execution involve physiotherapists or personal trainers who

observe and correct the person performing the exercise [3, 4]. Similar studies have shown that most health and fitness applications are not based on behavioural change theories, meaning that they lack the ability to insure lifestyle changes, which is a key part of a successful strength training regime [3, 4, 13–15, 21]. Some important behavioural change theories are: goal setting, reward system, social support, and behavioural feedback [21].

Lastly, behavioural change theories are well grounded medical and scientific foundations; hence, implementing these into the design could potentially improve the overall effectiveness of the applications. Here it is advised to ensure the of use self-efficacy, through providing goals, structure and confidence in the user's progression [22]. Additionally, it should be considered whether future strength training applications should implement assessment theories from the field of sports science, where the use of external sensors such as electromyography is vital for the analysis of movement and rehabilitation [29–32].

## 5 Conclusion

The main goal of this paper was to perform a state of the art review with the purpose of providing the next generation of strength training applications with design recommendations and guidelines based on literature and a heuristic evaluation of the current top ranked strength training applications. The results of this review show that there is a large selection of strength training applications, which to some degree are built upon theories behind strength training. However, these applications provide very limited variety and use of sensory feedback. Additionally, only few delivers extended and detailed instructional information, meaning that the user needs prior strength training knowledge to achieve full usage. Nevertheless, based on the literature reviewed, it is believed that with the implementation of behavioural change theories [21] and assessment theories from the fields of sports science [29–32], these applications have great potential for the fitness and health market, and can provide the users with more affordable and available strength training support.

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