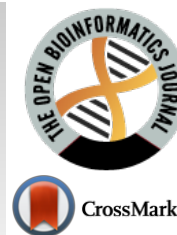




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SYSTEMATIC REVIEW

Mobile Applications for the Promotion and Support of Healthy Nutrition and Physical Activity Habits: A Systematic Review, Extraction of Features and Taxonomy Proposal

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Abstract:

Background:

Mobile applications can be used for the monitoring of lifestyles and physical activity. It can be installed in commodity mobile devices, which are currently used by different types of people in their daily activities worldwide.

Objective:

This paper reviews and categorizes the mobile applications related to diet, nutrition, health, physical activity and education, showing the analysis of 73 mobile applications available on Google Play Store with the extraction of the different features.

Methods:

The mobile applications were analyzed in relation to each proposed category and their features, starting with the definition of the search keywords used in the Google Play Store. Each mobile application was installed on a smartphone, and validated whether it was researched in scientific studies. Finally, all mobile applications and features were categorized.

Results:

These mobile applications were clustered into four groups, including diet and nutrition, health, physical activity and education. The features of mobile applications were also categorized into six groups, including diet, anthropometric parameters, social, physical activity, medical parameters and vital parameters. The most available features of the mobile applications are weight, height, age, gender, goals, calories needed calculation, diet diary, food database with calories, calories burned and calorie intake.

Conclusion:

With this review, it was concluded that most mobile applications available in the market are related to diet, and they are important for different types of people. A promising idea for future work is to evaluate the acceptance by young people of such mobile applications.

Keywords: Nutrition, Physical activity, Mobile applications, Health, Systematic review, Diet, Google Play Store.

Article History

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1. INTRODUCTION

The use of technology in mobility can assist the population in performing daily activities [1] and it can be separated in two

large groups [2], including mobile devices, e.g., smartphone, laptop, tablet computing, smartwatch and others, and technology without mobility, e.g., desktop computer. This paper is focused on the use of smartphones, which have

different operating systems (e.g., Android, iOS, Windows Phone and others), of which the most widely used is Android [3]. It is an open-source platform, whose mobile applications are distributed with the Google Play Store [4]. Anyone with the knowledge to develop a mobile application for this operating system can publish it on the Google Play Store, which has policies in place that are frequently updated [5].

Mobile applications are software components that support daily activities [1], from nutrition improvement to promoting physical activity habits. Currently, the use of mobile applications for weight control and a healthy diet is increasing [6]. The development of this type of mobile applications is included in the Mobile Health subject [7] and Ambient Assisted Living systems [8 - 10].

This paper reviews the mobile applications available on Google Play Store related to diet, nutrition, health and physical activity, analyses their features, and proposes a taxonomy of such mobile applications.

The main goal of this work was to study the functionalities of the mobile applications existing in the market.

The scope of this review consists of the analysis of the mobile applications available on Google Play Store with a user rating higher or equal to 4.0, more than 15000 downloads, the last update between 2017 and 2019 and availability in the English language.

As a result of this review, 73 mobile applications were exhaustively analyzed and categorized as “diet and nutrition” (52%), “education” (11%), “health” (25%) and “physical activity” (12%). Some of the mobile applications analyzed are *Lifesum: Food Diary, Meal Planner & Diet Tracker*, *Health and Nutrition Guide*, *Lose It! - Calorie Counter* and *My Diet Coach - Weight Loss Motivation & Tracker*. Their features were extracted and categorized as “diet”, “anthropometric parameters”, “social”, “physical activity”, “medical parameters” and “vital parameters”. The most relevant features extracted include diet diary, exercise diary, diet plan, physical activity monitoring, medication intake diary etc.

The remainder of this article is structured as follows. The methodology is presented in Section 2, detailing the research questions, inclusion and exclusion criteria, search strategy and the extracted features for the systematic review. Afterward, Section 3 presents the results, and then it discusses them in Section 4. Finally, Section 5 presents the conclusion of this study.

2. METHODOLOGY

2.1. Research Questions

The research questions for this review are organized as follows: (RQ1) What are the mobile applications for physical activity, diet, nutrition and health purposes? (RQ2) Are mobile

applications for this purpose validated in scientific studies? (RQ3) What are the essential features for this type for mobile applications? (RQ4) How can the elements of these mobile applications be classified?

2.2. Inclusion Criteria

Mobile applications related to physical activity and nutrition were included in this review if they fulfilled the following criteria: (1) the mobile applications have nutrition, health and/or physical activity component; (2) the download and registration are free, because it simplifies user testing; (3) the number of downloads is a minimum of 15000, meaning that the application has user traction; (4) the assessment by users is at least 4.0 stars, because it shows that the mobile application took into account the expectations of the users; (5) the mobile applications were updated between 2017 and 2019; (6) the mobile applications were available in English; (7) the mobile applications were present on Google Play Store.

2.3. Exclusion Criteria

Mobile applications related to physical activity and nutrition were excluded from this review if they met any of the following criteria: (1) the mobile applications were removed from the store during the analysis; (2) the mobile applications were intended for pregnant women or women in the postpartum period; (3) the mobile applications were designed for the health of pets; (4) the mobile applications were used for entertainment and/or games; (5) the mobile applications were used hypnosis as a means of weight loss; (6) the mobile applications were only connected to other applications; (7) the registration in the mobile applications was not possible; (8) the mobile applications had no functionality beyond the timekeeping; (9) the mobile applications were destined to the population with thyroid pathology; (10) the mobile applications were intended to the community with hepatic pathology; (11) the mobile applications were fasting programs; and (12) the mobile applications were not available on Google Play Store.

2.4. Search Strategy

To obtain mobile applications, the following combination of keywords was used: “nutrition”, “diet”, “calories”, “health”, “exercise” and “weight”. They were searched according to inclusion and exclusion criteria. These were analyzed to identify the characteristics of each and their suitability in promoting healthy lifestyle habits.

2.5. Extraction of Study Characteristics

The following information was extracted from the mobile applications (Table 1): description, number of users, number of downloads at the date of analysis, author, use of sensors, availability in scientific studies, year of last update and goal. This analysis was performed in the Google Play Store, wherein a total of 250 mobile applications obtained in the research, only 73 mobile applications matched the focus of this paper. The availability in scientific studies considers whether these mobile applications are present in previous research studies available in the literature.

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Table 1. List of mobile applications analyzed.

Name	Description	User Rating (Number of Reviews) ^{b)}	Number of Downloads ^{b)}	Author	Use of Sensors	Available in Scientific Studies	Year	Goal
Lifesum: Food Diary, Meal Planner & Diet Tracker [11] ^{a)}	Diet, physical activity and anthropometric parameters control	4.3 (201,800)	10,000,000	Lifesum	No	Yes	2019	Health
Calorie Counter-MyFitnessPal [12] ^{a)}	Diet and physical activity control	4.5 (2,145,510)	50,000,000	MyFitnessPal, Inc	Yes	Yes	2019	Health
Health and Nutrition Guide [13]	Education on health, nutrition and physical activity, with calorie calculation	4.3 (7,706)	500,000	Naveeninfotech	No	Yes	2018	Education
Samsung Health [14]	Diet, physical activity, glucose, vital signs, sleep and anthropometric parameters control, education and training plan	4.4 (794,449)	100,000,000	Samsung Electronics Co., Ltd.	Yes	Yes	2019	Health
Nutrition facts [15]	Food database with calories	4.2 (927)	100,000	Alexey Korobov	No	No	2019	Diet and Nutrition
YAZIO Calorie Counter, Nutrition Diary & Diet Plan [16] ^{a)}	Diet and physical activity control	4.5 (211,198)	10,000,000	YAZIO	Yes	Yes	2019	Health
My Diet Diary Calorie Counter [17]	Diet and physical activity control	4.0 (18,573)	1,000,000	StayWell	Yes	Yes	2019	Health
Calories in food [18]	Food database with calories	4.6 (37,614)	1,000,000	Alexey Korobov	No	No	2018	Diet and Nutrition
Calorie, Carb & Fat Counter [19]	Diet and anthropometric parameters control, food plan and challenge	4.5 (40,516)	1,000,000	Virtuagym	No	Yes	2019	Diet and Nutrition
1200 Calorie Weight Loss Diet(2018) [20]	Anthropometric parameters control and food plan	4.5 (180)	100,000	Diet Pundits	No	No	2018	Diet and nutrition
Lose It! - Calorie Counter [21] ^{a)}	Diet, physical activity and anthropometric parameters control	4.5 (84,116)	10,000,000	FitNow, Inc.	No	Yes	2019	Diet and nutrition
My Diet Coach - Weight Loss Motivation & Tracker [22] ^{a)}	Physical activity control, education and challenges	4.6 (145,333)	10,000,000	InspiredApps (A.L) LTD	No	No	2018	Physical activity
Calorie Counter – MyNetDiary [23] ^{a)}	Diet, physical activity and anthropometric parameters control	4.6 (32,617)	1,000,000	MyNetDiary.com	No	Yes	2019	Health
Macros - Calculate your Diet [24]	Diet and anthropometric parameters control	4.4 (4,087)	1,000,000	JosmanTek	No	No	2019	Diet and nutrition
Diary of Nutrition [25]	Diet control	4.5 (1,821)	100,000	Ediger	No	No	2019	Diet and nutrition
Calories Counter & Diet Plans By MevoFit [26]	Diet, physical activity and anthropometric parameters control and recipes	4.0 (1,792)	100,000	Mevolife Inc.	Yes	No	2019	Health
Pedometer, Step Counter & Weight Loss Tracker App [27] ^{a)}	Physical activity and challenges	4.7 (647,041)	10,000,000	Pacer Health	Yes	Yes	2019	Physical activity
8fit - Workouts & Meal Planner [28] ^{a)}	Physical activity and anthropometric parameters control, training plan	4.5 (133,507)	10,000,000	8fit	No	No	2019	Physical activity

Name	Description	User Rating (Number of Reviews) ^{b)}	Number of Downloads ^{b)}	Author	Use of Sensors	Available in Scientific Studies	Year	Goal
Effective Weight Loss Guide [29]	Diet, physical activity and anthropometric parameters control, training and diet plan and health, nutrition and physical activity education	4.3 (18,268)	1,000,000	Naveeninfotech	No	Yes	2019	Diet and nutrition
Lose Weight In 30 Days [30]	Anthropometric parameters control, training and diet plan	4.6 (82,346)	5,000,000	Veev Apps	No	No	2019	Diet and nutrition
Carb Manager - Keto & Low Carb Diet Tracker [31] ^{a)}	Diet and anthropometric parameters control and physical activity diary	4.5 (34,307)	1,000,000	Wombat Apps LLC	No	Yes	2019	Diet and nutrition
Diet 2019 - lose weight and stay healthy [32]	Diet plan	4.2 (4,946)	500,000	Mobiem	No	No	2018	Diet and nutrition
Lose Weight in 30 Days [33]	Diet and training program and calories burned	4.7 (377,016)	50,000,000	Simple Design Ltd.	No	No	2019	Diet and nutrition
Health & Fitness Tracker with Calorie Counter [34] ^{a)}	Diet, physical activity, sleep, vital signs and anthropometric parameters control. Recreational component and health education	4.2 (1,659)	1,000,000	DROID INFINITY	Yes	No	2019	Health
Vegetables For Health [35]	Nutrition education	4.5 (278)	50,000	Extended Web AppTech	No	No	2018	Education
Monitor Your Weight [36]	Anthropometric parameters control	4.6 (152,402)	5,000,000	Husain Al-Bustan	No	Yes	2019	Health
Weight Loss & BMI Calculator [37]	BMI control	4.6 (59,496)	5,000,000	aktiWir GmbH	No	No	2019	Health
Best Boiled Egg Diet Plan [38]	Diet plan based on eggs	4.1 (358)	500,000	Cylonblast Mobile Apps	No	No	2019	Diet and Nutrition
Boiled Egg Diet [39]	Diet plan based on eggs and recipes	4.4 (98)	100,000	Angelworks	No	No	2019	Diet and Nutrition
Healthy Weight Loss Recipes [40]	Recipes	4.1 (224)	100,000	Insplicity	No	No	2019	Diet and nutrition
Calorie Counter by Fat Secret [41]	Diet, sleep and physical activity control	4.7 (286,354)	10,000,000	FatSecret	No	Yes	2019	Health
How To Gain Weight Fast [42]	Health and nutrition education, diet plan and recipes for gain weight	4.0 (132)	50,000	The Almighty Dollar	No	No	2019	Diet and nutrition
Daily Health Tips [43]	Health and nutrition education and glucometer information	4.5 (453)	50,000	Karthik App Solutions	No	No	2019	Education
Natural Weight Loss in 30 Days [44]	Anthropometric parameters control, nutrition and physical activity education, diet diary and training plan	4.3 (907)	100,000	Shantha Technologies	No	No	2019	Physical activity
Weight Loss Recipes [45]	Recipes	4.3 (1,854)	500,000	Fitness Circle	No	No	2019	Diet and nutrition
Detox diet plan: Lose fat fast in 7 days [46]	Nutrition, health and physical activity education and diet plan for weight loss based on detox diet and 1200 calories diet	4.4 (1,569)	100,000	Patrikat Softech	No	No	2019	Diet and nutrition

Name	Description	User Rating (Number of Reviews) ^{b)}	Number of Downloads ^{b)}	Author	Use of Sensors	Available in Scientific Studies	Year	Goal
Weight Loss Smoothies [47]	Nutrition, health and physical activity education, anthropometric parameters control, diet plan and recipes	4.4 (800)	100,000	LenPol	No	No	2018	Diet and nutrition
Indian weight loss GM Diet [48]	Diet plan	4.5 (12,267)	500,000	MadGun	No	No	2019	Diet and nutrition
Simple Diet Diary [49]	Diet control	4.6 (330)	100,000	Martin Stone	No	No	2019	Diet and nutrition
Fruits For Health [50]	Nutrition education	4.3 (369)	50,000	Extended Web AppTech	No	No	2018	Education
Weight Loss Recipes [51]	Recipes	4.8 (2,585)	500,000	DIL	No	No	2019	Diet and nutrition
Keto diet app [52]	Recipes	4.5 (1,713)	100,000	AKSAL APPS	No	No	2018	Diet and Nutrition
Calorie counter Life Balance [53]	Diet, physical activity and anthropometric parameters control	4.6 (10,013)	1,000,000	Stefan Diener Software-Entwicklung	No	Yes	2019	Health
MyKeto - Low Carb Keto Diet Tracker & Calculator [54]	Nutrition education, food database with calories and recipes	4.2 (1,711)	100,000	Prestige Worldwide Apps, Inc	No	No	2019	Diet and Nutrition
The Secret of Weight [55]	Diet control and recipes	4.2 (16,102)	1,000,000	Le Secret du Poids SAS	No	No	2019	Diet and nutrition
Weight Loss - 10 kg/10 days, Fitness App [56]	Anthropometric parameters control and recipes	4.2 (3,852)	1,000,000	Life Changer Apps	No	No	2019	Diet and nutrition
7-Day Weight Loss Plan [57]	Diet plan and recipes	4.2 (218)	100,000	AAASoft	No	No	2018	Diet and nutrition
30 Day Workout: Fast Home Weight Loss & Diet Plans [58]	Physical activity control, training plan and recipes	4.6 (18,699)	1,000,000	Feel The Burn Apps	Yes	No	2019	Diet and nutrition
FizzUp - Online Fitness & Nutrition Coaching [59] ^{a)}	Training plan	4.3 (26,663)	1,000,000	Fysiki	No	No	2019	Physical activity
FitMenCook - Healthy Recipes [60]	Recipes	4.7 (3,059)	1,000,000	Nibble Apps	No	No	2019	Diet and Nutrition
Dukan Diet – official app [61] ^{a)}	Anthropometric parameters and well-being control, recipes and diet plan based on dukan diet	4.0 (6,111)	1,000,000	Owly Labs	No	No	2019	Diet and Nutrition
90-Day Diet & Break [62]	Anthropometric parameters control and diet plan	4.7 (1,458)	100,000	SMDDev Solutions Ltd	No	No	2018	Diet and nutrition
How To Gain Weight Fast Tips [63]	Health, nutrition and physical activity education for gain weight	4.2 (179)	100,000	Health & Fitness Guide	No	No	2018	Education
Diet and Weight Loss [64] ^{a)}	Diet, physical activity, sleep and anthropometric parameters control and diet plan	4.5 (81,912)	1,000,000	Dieta	No	No	2019	Diet and nutrition
Ada - Your Health Guide [65]	Vital signs and medication control and medical diagnostics associate	4.7 (230,259)	5,000,000	Ada Health	No	No	2019	Health
Weight Loss 7 Day Diet Plan [66]	Diet plan	4.0 (362)	100,000	VR Development	No	No	2019	Diet and nutrition
Food Diary [67]	Diet and physical activity control	4.2 (16,568)	1,000,000	My Daily Bits LLC	No	No	2019	Diet and nutrition

Name	Description	User Rating (Number of Reviews) ^{b)}	Number of Downloads ^{b)}	Author	Use of Sensors	Available in Scientific Studies	Year	Goal
Herbs For Health [68]	Nutrition education	4.5 (468)	100,000	Extended Web AppTech	No	No	2019	Education
FOODMAP Helper - Diet Companion [69]	Food maps	4.5 (999)	50,000	Appstronaut Studios	No	No	2019	Diet and Nutrition
iTrackBites: Smart Weight Loss [70] ^{a)}	Diet control and physical activity register	4.3 (5,317)	100,000	Sunshine Health Studios	No	No	2019	Diet and nutrition
Lose Weight In 21 Days - Home Fitness Workouts [71]	training plans with points	4.7 (29,376)	1,000,000	Fit apps	No	Yes	2019	Health
Glycemic Index & Load: low-carb diet & fiber [72]	Nutritional education	4.3 (9,275)	500,000	cream.software	No	No	2019	Education
1500+ Health Tips [73]	Health and physical activity education and recipes	4.0 (296)	50,000	Smart Droidies	No	Yes	2017	Education
Step Counter - Pedometer Free & Calorie Counter [74]	Physical activity control	4.6 (257,085)	10,000,000	Leap Fitness Group	Yes	No	2019	Physical activity
WeightWar - Weight Loss [75]	Anthropometric parameters control and diet register	4.6 (22,911)	1,000,000	Cleveni Inc.	No	No	2019	Diet and nutrition
Yoga for weight loss - lose weight program at home [76]	Anthropometric parameters control and yoga training plan	4.7 (9,910)	1,000,000	mEL Studio	No	No	2019	Physical activity
Diet and Health - Lose Weight [77] ^{a)}	Diet and physical activity register	4.4 (113,646)	5,000,000	tech.fit	No	No	2019	Diet and nutrition
Fitso - GPS Track & Running App [78]	Diet, physical activity and anthropometric parameters control	4.3 (6,377)	100,000	Fitso	No	No	2019	Health
JEFIT Workout Tracker, Weight Lifting, Gym Log App [79] ^{a)}	Anthropometric parameters control and training plan	4.4 (6,649)	5,000,000	Jefit Inc.	No	No	2019	Physical activity
MyPlate Calorie Tracker [80] ^{a)}	Diet, physical activity and anthropometric parameters control	4.6 (34,328)	1,000,000	LIVESTRONG	No	Yes	2019	Health
Weight loss tracker [81]	Anthropometric parameters control	4.4 (4,744)	100,000	Perfectly Simple	No	No	2018	Health
Weight [82]	Anthropometric parameters control	4.4 (1,221)	100,000	Escogitare	No	No	2019	Health
7 Minute Workout - Weight Loss [83] ^{a)}	Training plan and calories consumer	4.8 (56,793)	1,000,000	Lumowell - Ego360	No	Yes	2018	Physical activity

a) it was not possible to evaluate this application due to the need for subscription; b) these values only reflect data from the Google Play Store.

3. RESULTS

This review, as illustrated in Fig. (1), identified 250 applications, of which 25 applications have already been removed from the store. The remaining 225 applications were evaluated in terms of area, target audience, price, date of update, user assessment and downloads resulting in the exclusion of 131 applications. The analysis of the 94 applications resulted in the elimination of 21 applications that not meet the defined criteria. The remaining 73 applications were included in the qualitative synthesis.

(Table 1) shows the description, the number of users, the user's evaluation, the number of downloads, the author, the use of sensors, its inclusion in scientific studies, the year of the last

update and its goal. From the point of view of user's evaluation, there are 6 mobile applications with 4.0 stars (8%), 2 mobile applications with 4.1 stars (3%), 9 mobile applications with 4.2 stars (12%), 10 mobile applications with 4.3 stars (14%), 9 mobile applications with 4.4 stars (12%), 15 mobile applications with 4.5 stars (21%) 12 mobile applications with 4.6 stars (16%), 8 mobile applications with 4.7 stars (11%), and 2 mobile applications with 4.8 stars (3%). In regards to the number of downloads, there are 6 applications with at least 50,000 downloads (8%), 21 that with at least 100,000 downloads (29%), 500,000 with at least 7 downloads (10%), 22 with at least 1,000,000 downloads (30%), 6 with at least 5,000,000 downloads (8%), 8 with at least 10,000,000 downloads (11%), 2 with at least 50,000,000 (3%) and 1 with

at least 500,000,000 (1%). The sensors available in the mobile devices are used in 9 mobile applications (12%), and, in the remaining 64 mobile applications (88%), the physical activity is not directly monitored. Furthermore, only 19 mobile applications (26%) have already been presented in scientific studies available on Google Scholar. The major part of the applications was updated in 2019, *i.e.*, 58 mobile applications (79%), 14 mobile applications were updated in 2018 (19%), and the remaining 1 mobile application was updated in 2017 (1%). Regarding the goals of the mobile applications, “Diet and nutrition” predominate with 38 mobile applications (52%), and “Health” has 18 mobile applications (25%), “Education” has 8 mobile applications (11%), “Physical activity” has 9 mobile applications (12%).

3.1. Mobile Applications not Scientifically Validated

From the mobile applications categorized as “Diet and Nutrition”, *Nutrition facts* [15] and *Calories in food* [18] are only a food databased with calories. *Macros-Calculate your Diet* [24] allows the registration of the age, physical activity level, gender, goals, height, weight, Body Mass Index (BMI) and fat mass calculation. In the diet area, a food database with calories, diet diary, measurement of the calories, macronutrients and fluid intake and calculation of fluid, macronutrients and calories needed has been featured, having different ways to calculate the basal metabolic rate, allowing the users to switch between them [24].

3.1.1. Diary of Nutrition

[25] has a screen to the registration of the age, physical activity level, gender, weight, height and goals, with graphics display. In the diet area, there is the food database with calories and diet diary register with the calculation of the calories, macronutrients and fluid intake and needed fluids, macronutrients and calories [25].

Lose weight in 30 days [30] allows the registration of age, gender, weight and height, with a graphics display. In the diet area, it records food preferences and suggests a diet plan and a shopping list. In the physical activity section, a training plan is suggested [32].

3.1.2. Diet 2019-lose weight and stay healthy

[32] suggests a diet plan for weight loss. *Lose Weight in 30 Days* [33] allows the registration of weight and height, calculates the BMI and displays a chart. In the diet area, it allows the recording of food preferences, with the suggestion of a diet plan and shopping a list [33]. In the physical activity area, there is a suggested training plan and an indication of the energy expenditure [33].

3.1.3. Best Boiled Egg Diet Plan

[38] suggests a diet plan based on eggs, with nutrition education. *Boiled Egg Diet* [39] suggests a diet plan based on eggs, with recipes and a shopping list. *Healthy Weight Loss Recipes* [40] suggests recipes for weight loss. *How to Gain Weight Fast* [42] has the goal of the gain weight, indicating the food plan and recipes, with education about health and nutrition.

3.1.4. Weight Loss Recipes

[45] has the goal of weight loss, suggesting the recipes and shopping list. *Detox diet plan: Lose fat fast in 7 days* [46] features a detox diet, registration of the gender, height and weight with BMI calculation, suggesting a diet plan and education about nutrition, health and physical activity. *Weight Loss Smoothies* [47] has a screen for the registration of age, gender, height and weight. It also calculates the BMI, fat mass, waist-height relation, suggesting a diet plan, recipes and education about health, nutrition and physical activity. *Indian weight loss GM Diet* [48] is aimed at weight loss, with the suggestion of diet plan and control of fluid intakes. *Simple Diet Diary* [49] allows the registration of a diet diary with an indication of the calories and macronutrient intake with a graphics display.

3.1.5. Keto Diet App

[52] suggests recipes. *MyKeto – Low Carb Keto Diet Tracker & Calculator* [54] allows the registration of age, physical activity level, gender, weight, height and goals. In the diet section, there is a food database with calories, suggestion recipes and calculate the calories and macronutrients needed. It includes an educational component of health and nutrition [52].

3.1.6. The Secret of Weight

[55] allows the registration of gender, weight and height with graphics display. In the diet area, food database with calories, diet diary, with calorie intake and recipes is featured. *Weight Loss – 10 kg /10 days, Fitness App* [56] has the goal of the weight loss, with the registration of age, gender, height, weight and BMI and fat mass calculation. In the diet area, there is a suggestion of the diet plan with registration food preferences [56].

3.1.7. 7-Day Weight Loss Plan

[57] has the goal of weight loss, suggesting a diet plan and recipes. *30 Day Workout: Fast Home Weight Loss & Diet Plans* [58] has the intention of weight loss with the registration of goals. In the diet area, there is a suggested diet plan and recipes [58]. In the physical activity area, there is a physical activity monitoring with the measurement of the energy expenditure and suggestion of the training plan [58]. *Weight Loss Recipes* [51] has the goal of weight loss with the advice of the recipes and shopping list. *FitMenCook- Healthy Recipes* [60] suggests recipes and a shopping list.

3.1.8. 90-Day Diet & Break

[62] allows the registration of weight, height and waist size, suggesting a diet plan. *Diet and Weight Loss* [64] has the goal of the weight loss with the registration of age, gender, height, weight and goals with BMI calculation. In the diet section, it contains a food database with calories, diet diary, fluid intake, indicated calorie intake, and fluid and calories estimation [64]. It suggests a diet plan and recipes [64]. In the physical activity section, daily exercise with calories burned is registered [64]. In the well-being area, sleep control and reminders are available [64].

3.1.9. Dukan Diet – Official App

[61] allows the registration of age, gender, overweight tendency, pregnancy number and goals. In the sector diet, it will enable the filing of the daily diet with the suggestion of a diet plan and recipes [61]. The registration of mood and emotions with the possibility of reminders is also available [61]. In anthropometric values, the record of weight and height with ideal weight calculation, waist size, breast and hip is also available [61]. *Weight Loss 7 Day Diet Plan* [66] presents a diet plan for weight loss.

3.1.10. Food Diary

[67] allows the registration of the age, physical activity level, gender, weight, height and goals and with graphics display and reminders. It presents a food database with calories, a daily diet with the counting of calories and macronutrient intake and the calculation of the calories needed [67]. In the physical activity section, a counter of daily exercise and calories burned is presented [67]. *FOODMAP Helper-Diet Companion* [69] shows the information about the food intake.

3.1.11. iTackBites: Smart Weight Loss

[70] allows the registration of age, physical activity level, gender, weight, height and goals. In the diet component, it will enable the filing of a daily diet with the indication of calories and macronutrients intake. In the physical activity component, it presents the exercising frequency [70].

3.1.12. WeightWar-Weight Loss

[75] has the goal of the weight loss, allowing the registration of age, gender, weight and height, and the calculation of the BMI. It tracks the diet diary and presents the fluid intake and the calculation of basal metabolic rate [75].

3.1.13. 1200 Calorie Weight Loss Diet(2018)

[20] enables the recording of weight and height and calculation of the BMI. It also suggests a diet plan [20].

3.1.14. Diet and Health - Lose Weight

[77] has the goal of weight loss, allowing the registration of age, gender, weight, height and goals. It includes a module of ideal weight calculation and reminders [77]. In the diet area, it has a food database with calories, allowing the registration of a daily diet and fluid intake [77]. In the physical activity section, it will enable the registration of regular exercise and the possibility of sharing information with another application [77].

Following the mobile applications categorized as “Physical Activity”, *My Diet Coach-Weight Loss Motivation & Tracker* [22] allows the registration of age, physical activity level, gender, height, weight and goals with BMI calculation. In the diet area, it provides the calculation of fluid intake control and calories needed [22]. In the physical activity area, it presents an exercise diary, with the measurement of energy expenditure and challenges [22]. This mobile application also includes a module related to health and nutrition education, reminders and gamification [22].

3.1.15. 8fit-Workouts & Meal Planner

[28] allows the registration of age, physical activity level, gender, weight, height and goals. In the diet area, it enables the record of food preferences and the calculation of calories needed [28]. It also suggests the training plan and daily exercise and measures energy expenditure and allows them to share information with other mobile applications [28].

3.1.16. Natural Weight Loss in 30 Days

[44] has the goal of weight loss, allowing the registration of weight and health parameters with BMI calculation. It will enable the registration of daily diet with control of fluid intake [44]. It presents a module with training plan suggestions and education about nutrition and physical activity [44].

3.1.17. FizzUp-Online Fitness & Nutrition Coaching

[59] allows the registration of age, physical activity level, gender, goals and material. It also suggests a training plan and recipes [59].

3.1.18. Step Counter-Pedometer Free & Calories Counter

[74] allows the registration of gender, weight, height, goals and reminders. It includes the physical activity monitoring and measurement of the energy expenditure [74].

3.1.19. Yoga for weight loss - lose weight program at home

[76] promotes weight loss through the practice of yoga. It allows the registration of age, gender, weight, height, waist, breast and hip measurements [76]. It also suggests a yoga training plan with calories burned and reminders [76].

3.1.20. JEFIT Workout Tracker, Weight Lifting, Gym Log App

[79] allows the registration of age, gender and anthropometric values, including weight, height, fat mass, waist, neck, breast, forearm, arm, shoulders, leg, hip, thigh and goals. It allows the registration of reminders [79]. In the physical activity area, it suggests a training plan with the filing of a training plan [79].

Following the mobile applications categorized as “Health”, *Calories Counter & Diet Plans By MevoFit* [26] controls the anthropometric parameters, waist, breast, arm, forearm, thigh, shoulders and leg. In the diet area, it includes a food database with calories, a diet diary with calories and count of macronutrient intake, the calculation of calories needed and the suggestion of the diet plan, recipes and shopping list [26]. In the physical activity area, it includes an exercise diary, physical activity monitoring with the pedometer and the measurement of the energy expenditure [26].

3.1.21. Health & Fitness Tracker with Calorie Counter

[34] allows the registration of age, physical activity level, gender and goals. The diet area includes a food database with calories, a diet diary, the calculation of calories spent, macronutrients and fluid intake, and the calculation of calories needed, basal metabolic rate and weight index. In the physical activity area, it includes a physical activity monitoring with the

measurement of the energy expenditure, daily exercise and challenges [34]. In anthropometrics parameters, it allows the registration of weight, height, waist and hip, calculating the BMI, fat mass, lean body mass and ideal weight [34]. Furthermore, it includes the measurement of heart rate and the registration and targeting of heart rate calculation and sleep control [34]. There is also an educational component of health, challenges and reminders, including the possibility of having a weight-loss coach with connection to other mobile applications [34].

3.1.22. *Weight Loss & BMI Calculator*

[37] allows the BMI control with the registration of age, gender, weight and height for the calculation of the BMI. *Ada-Your Health Guide* [65] enables the record of age, gender, weight, height, diabetic, smoker, allergies, current pregnancy and high blood pressure. It includes a medication diary and a health questionnaire for indicated pathologies [65]. It also includes an educational component for health [65]. *Weight loss tracker* [81] has goals for weight loss, allowing the registration of age, gender, weight, height and goals, calculating the BMI and creation of reminders.

3.1.23. *Fitso-GPS Track & Running App*

[78] allows the registration of age, physical activity level, gender, weight, height, waist and goals. It includes the calculation and reminders for BMI and fat mass [78]. In the diet section, it shows a food database with calories and the estimate of a diet diary, fluid intake, calories and macronutrients intake and calories needed [78]. In the physical activity section, it also includes the registration of daily exercise, suggesting a training plan with videos and challenges and allowing the physical activity monitoring with other mobile applications [78]. *Weight* [82] enables the registration of age, physical activity level, gender, height, weight, blood pressure, waist, hip and goals. It allows the calculation of BMI and basal metabolic rate [82].

Following the mobile applications categorized as "Education", *Vegetables for Health* [35], *Herbs For Health* [68], and *Fruits for Health* [50] are used for educational nutrition.

3.1.24. *Daily Health Tips*

[43] is related to education about health and nutrition with information about glucose. *How To Gain Weight Fast Tips* [63] is relevant to teaching about health, nutrition and physical activity. *Glycemic Index & Load: low-carb diet & fiber* [72] is related to the education about nutrition, including a food database with glycemic index with the registration of weight, height and goals.

3.2. *Mobile Applications Scientifically Validated*

Following the mobile applications categorized as "Health", *Lifesum: Food Diary, Meal Planner & Diet Tracker* [11] allow the registration of age, physical activity level and gender. In the diet section, it presents a food database with calories, allowing the record of diet diary with calories, fluid intake, food preferences and food questionnaire, calculating the calories

counter needed. In the physical activity section, it shows a log of physical activity, and calories burned, allowing to share the information with other mobile applications related to physical activity monitoring [11]. In the health section, it enables the control of anthropometric values, health parameters, including weight, height, and others, and waist size, allowing the calculation of body mass index [11]. It also permits the registration of allergies and goals. In the studies [84 - 86], the features of this mobile application are only presented. However, in the study [87], significant analysis of the mobile application is performed, showing the advantages and disadvantages of the mobile application. Its benefits remind the user about drinking water, providing feedback to improve the quality of eating, selecting diets for healthy living, and summarizing nutrition and exercise habits. However, this mobile application has disadvantages, including the fact that it is not focused on daily exercise, the data should be inserted manually, and it is slightly difficult to use [87]. The authors present a correlation with body fat [88].

3.2.1. *Calorie Counter- MyFitnessPal*

[12] allows the registration of age, physical activity level and gender. In the diet area, it presents a food database with calories and authorizes the filing of a diet diary, the control of calories and macronutrient intake and the calculation of fluid intake and calories needed. In the physical activity area, it allows the monitoring of physical activity with other mobile applications and devices, calculating the calories burned and allowing the registration of an activity diary [12]. Finally, this mobile application allows the control of the weight and the height with the record of goals [12]. The studies [85], [89], and [90] referred to the features of the mobile application, but they lacked the validation of the mobile applications. Moreover, the studies [89], [91], and [92] referred that it is one of the most used mobile applications. In a study [93], the social component of this mobile application was revealed. In a study [94], the authors presented the gamification components of this application. Furthermore, the reviews [95] and [96] referred that the development of this mobile application did not involve medical professionals. The study [97] reported that the significant benefit of this mobile application is the promotion of a therapeutic lifestyle change in patients with diabetes because it includes a food database and the integration with other mobile applications and devices. In a study [98], the authors said that it has excellent advantageous and diabetes-friendly features, including an extensive food database and integration with other mobile applications and devices. In a study [99], the authors referred that this mobile application is reliable for monitoring of energy and macronutrients, but it lacks tracking of micronutrients. Finally, the study [100] concludes the mobile application is reliable for counting the number of calories, but the results returned by the mobile application related to the control of the weight are difficult to understand and are uninteresting.

3.2.2. *YAZIO Calorie Counter, Nutrition Diary & Diet Plan*

[16] allows the registration of age, gender, physical activity level, height, weight and goals. In the diet area, it includes a food database with calories, the registration of the diet diary

and the calculation of calories and macronutrient intake [16]. In the physical activity section, it includes the monitoring of the physical activity, the sharing of information with other mobile applications, the control of the calories burned and the registration of activity diary and goals [16]. The studies [85], [98], [101 - 103] only referred to some features of the mobile application.

3.2.3. My Diet Diary Calorie Counter

[17] allows the registration of age, physical activity level, gender, height, weight and goals. In the diet section, it enables the registration of diet diary with the calculation of calories and fluid intake and calories needed. In the physical activity section, it allows the monitoring of calorie burn control [17]. In studies [104 - 106], the evaluation of the features of the mobile application is presented.

3.2.4. Calorie Counter – MyNetDiary

[23] allows the registration of age, physical activity level, gender and goals. In the diet section, it presents a food database

with calories, allowing the registration of diet diary and the control of calories, macronutrients and fluid intake, and the calculation of fluid and calories needed as well as the basal metabolic rate [23]. In the physical activity section, it allows the registration of an activity diary and the measurement of calories burned [23]. In the part of the anthropometric values, it will enable the registration of weight, waist, neck and thigh, and the calculation of body mass index and ideal weight [23]. This mobile application is presented in several scientific studies [107 - 108], but the validation is only offered for the paid version, relating that only 60% of the individuals consider this mobile application better than others.

3.2.5. Monitor Your Weight

[36] allows the control of anthropometric values with the registration of age, physical activity level, gender, goals, height, weight, waist, neck, breast, forearm, arm, shoulders, leg, hip, thigh and body structure. It also allows the calculation of body mass index, body fat, ideal weight with the calculation of calories needed [36]. It is presented in the studies [106, 109] with reference to its features.

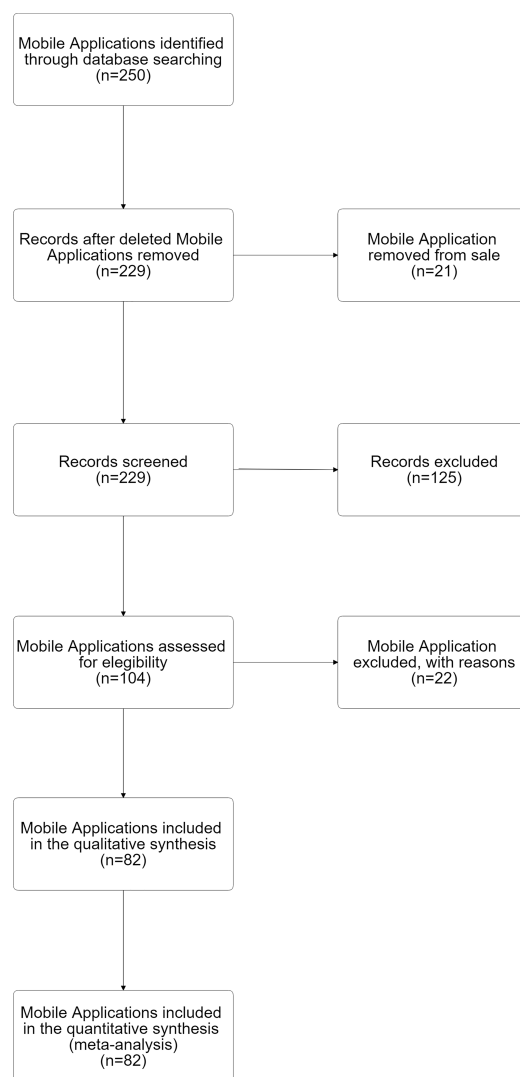


Fig. (1). Mobile Applications analysis.

3.2.6. *Calorie counter Life Balance*

[53] allows the registration of age, gender, weight, height and goals with the calculation of the body mass index. In the diet section, this application as a food database with calories, also allowing the registration of a diet diary, calories and macronutrients, as well as the calculation of calories, needed [53]. This mobile application also enables the record of an exercise diary and indicates calories burned [53]. It is presented in a study [85] without any validation procedure, referring only to the features available.

3.2.7. *MyPlate Calorie Tracker*

[80] allows the registration of age, physical activity level, gender, height, weight, goals and reminders. In the diet section, it presents a food database with calories, and it allows the registration of diet diary and fluid intake with the indication of calories and macronutrient intake and the calculation of calories needed [80]. In the physical activity section, it allows the registration of an exercise diary, indicating the calories burned and enabling the monitoring of physical activity with other mobile applications [80]. In a study [91], the authors referred that only 2% of the participants in the study used this mobile application. The study [110] only incorporated some features of the mobile application. Finally, this mobile application was used in a case study without reference to its conclusion [111].

3.2.8. *Samsung Health*

[14] presents a food database with calories, allowing the registration of diet diary and the control of calories, macronutrient, caffeine and fluid intake, the education of the user, and the calculation of the calories needed. In the physical activity section, it includes the monitoring and control of the calories burned with a training plan suggestion [14]. In the health section, it allows the registration of pulse, blood pressure, glycemic, fat mass, weight, goals, sleep control and medication diary (insulin) [14]. In the studies [112 - 115], the authors only referred to the features of this mobile application. In a study [116], the authors revealed a limitation for the detection of outdoor activities. In a study [117], this mobile application was used for the heart rate measurement, comparing its performance with other mobile applications, showing, when compared with a smart shirt, an average difference of around 1.28% and a standard deviation of 0.83%, and, when compared with hexoskin's app, an average of 31.24% and a standard deviation of 12.07%. On the other hand, some authors [118] compared the mobile application installed in two different smartphones, concluding that the validity of the mobile application depends on the model of the smartphone, its body location and the types of physical activities performed, showing, while running, a Root Mean Squared Error (RMSE) between 2.5 and 5.6 with the smartphone on the hand and RMSE between 3.6 and 4.9 with the smartphone on the arm. On the other hand, while walking, the study reveals an RMSE of 5.4 and an RMSE of 3.7, showing unacceptable results for different positions of the smartphone.

3.2.9. *Calorie Counter by FatSecret*

[41] allows the registration of age, physical activity level, gender, height, weight and goals. In the diet section, it presents a food database with calories, allowing the registration of the diet diary with the possibility of submission of a photograph of the food, the indication of calories and macronutrient intake, the calculation of calories needed and the availability of recipes [41]. In the physical activity section, it allows the registration of a physical activity diary with the indication of calories burned and the monitoring of physical activity with other mobile applications [41]. Additionally, the mobile application includes a section to sleep control and reminders about the different functionalities of the mobile application. In the studies [85], [119 - 121], the authors only referred to the features of this mobile application. Moreover, a study [122] reveals the existence of significant differences between the calorie intake and the calorie measures in the diet diary. In another study [123], it was reported that the results of the calorie counting may be incorrect because it is not based in real practice. With the same conclusion, the authors [124], revealed that the values of calorie intake were 14% greater than the actual costs. The authors [125], [126] compared this mobile application with the Bite Counter, presenting that this mobile application increases the number of weight loss with the increased physical activity.

Following the mobile applications categorized as "Education", *Health and Nutrition Guide* [13] allows the registration of age, physical activity level, height and weight. In the diet area, it presents a food database with calories and allows the calculation of calories and macronutrients needed [13]. It has mainly an educational component in health, nutrition and physical activity with the suggestion of home medications [13]. This mobile application has been presented in a study [127 - 129], but the authors only described its features.

3.2.10. *1500+ Health Tips*

[73] has an educational component about health and physical activity, allowing the registration of recipes and home medication. This mobile application has been presented in a study [130], but it lacks scientific validation.

Following the mobile applications categorized as "Diet and nutrition", *Calorie, Carb & Fat Counter* [19] allows the registration of age, physical activity level, weight, height and goals. In the diet section, it will enable the filing of a diet diary, presents a food database with calories, helps in the control of calorie and macronutrient intake, calculates the calories needed, suggests a diet plan and presents challenges [19]. This mobile application has been reported in a study [85] with the presentation of its features.

3.2.11. *Lose It! - Calorie Counter*

[21] allows the registration of age, gender, weight, height and goals. In the diet section, it presents a food database with calories, enables the filing of a diet diary, helps in the control of calories and macronutrient intake, and allows the calculation of calories needed [21]. In the physical activity section, it will enable the registration of an activity diary and controls the

calories burned [21]. This mobile application is only presented in the studies [131 - 133], but there are no details given.

3.2.12. Carb Manager - Keto & Low Carb Diet Tracker

[31] allows the registration of age, physical activity level, gender, weight and height. In the diet section, it presents a food database with calories and allows the registration of diet diary with the indication of calories, macronutrient and fluid intake [31]. In the physical activity section, it will enable the listing of the physical log [31]. In a study [98] it has been referred that this mobile application is relevant for the tracking of patients with diabetes, but they found some issues.

Following the mobile applications categorized as “Physical activity”, Pedometer, Step Counter & *Weight Loss Tracker App* [27] allows the registration of age, physical activity level, gender, weight, height and goals, and the calculation of the body mass index. In the main page, it allows the monitoring of physical activity with the control of calories burned, challenges and gamification. In a study [134], the authors only described the features of this mobile application. In a study [135], it was reported to use for data acquisition.

3.2.13. Lose Weight In 21 Days - Home Fitness Workouts

[71] allows the creation of goals for weight loss, with the suggestion of training plan, gamification and reminders. This

mobile application has been presented in research [136], describing some features.

3.2.14. 7 Minute Workout - Weight Loss

[83], allows the registration of age, physical activity level, gender, weight and height. It allows the calculation of calories needed and basal metabolic rate. Furthermore , it suggests a training plan with videos. This mobile application is not validated, but it is presented in an investigation [137].

4. OTHER RESULTS

Based on the results presented in (Table 2), each mobile application has several features, where the number of functionalities defined for each mobile application varies between 1 and 27. Based on the number of features included, 16% of the mobile applications analyzed include only 1 feature, 11% of the mobile applications embed 2 features, 8% of the mobile applications examined include 6 or 11 features, 7% of the mobile applications explained present 3 or 9 features, and 5% of the mobile applications analyzed include 7 or 15 features. Moreover , 4% of the mobile applications examined include 12 or 19 features, and 3% of the mobile applications analyzed include 4, 8, 10, 13, 16 or 18 features. Finally, 1% of the mobile applications analyzed include 5, 14, 20, 21 or 27 features.

Table 2. Distribution by the number of features included.

# Features	Mobile Applications
1	[15], [18], [35], [40], [43], [50], [52], [63], [66], [68], [69]
2	[38], [42], [45], [48], [51], [57], [60], [73]
3	[20], [39], [49], [62], [71]
4	[37], [72]
5	[46]
6	[13], [44], [55], [59], [74], [81]
7	[30], [33], [58], [75]
8	[56], [83]
9	[27], [47], [54], [70], [76]
10	[31], [82]
11	[19], [21], [28], [29], [65], [77]
12	[17], [25], [53]
13	[22], [67]
14	[16]
15	[12], [24], [61], [80]
16	[41], [79]
18	[11], [64]
19	[14], [26], [36]
20	[23]
21	[78]
27	[34]

In (Table 3) to 9, the features were distributed by the different mobile applications analyzed, where 64% of the mobile applications allow the registration of the weight and/or height, 53% allows the age and the gender, 44% allows the registration of goals, 36% allows the registration of diet diary, 34% presents a food database with calories and the calculation

of the calories needed, 33% presents a physical activity level, 30% measures the calories intake and burned, 29% allows the calculation of the BMI and has educational purposes, 26% allows the registration of the diet plan and registration of recipes, 25% allows the measurement of macronutrient intake and and exercise diary, 23% allows the registration of the fluid

intake, 22% allows the definitions the reminders, 18% allows the definition of the training plan, 15% allows the registration of the waist size, 12% allows measurement of the body fat, 11% allows the monitoring of the physical activity, 10% allows the registration of the shopping list, and the monitoring of physical activity with other mobile applications, 8% allows the registration of challenges, the calculation of the ideal weight and the basal metabolic rate, the registration of the hip size, 7% allows the registration of the food preferences and the breast size, 5% allows the measurement of the fluid needed, the monitoring of the sleep and the registration of the thigh size, 4% allows the registration of the size of neck, forearm, arm, shoulders and leg, 3% uses other devices, allows the registration blood pressure, medication diary, pulse, diabetic and/or allergies and shows videos to the user, and, finally, 1% allows the registration of caffeine intake, glycemic, smoker, mood and emotions, lean body mass, overweight tendency, pregnancy number, health questionnaire, pregnancy and body structure, the calculation of weight index and waist/height relation, the visualization of a food database with glycemic index and the diagnosis, presents questionnaires to the user and the possibility to gain points.

In total, the 82 mobile applications analyzed have different features classified into two groups, where one group contained the functions related to vital, anthropometric, medical and social parameters and another group that includes the purposes related to diet and physical activity data. Firstly, Table 3 contains the features distributed in the first group, where the most available features are the registration of age, gender, weight, height, reminders and goals, as well as the calculation of body mass index (BMI) and physical activity level, and the availability of an educational component. Finally, Table 4 contains the features distributed in the second group, where the most available features are the measurement of the calories, macronutrient and fluid intake, and calories needed, the registration of diet and exercise diaries, diet and training plans, and exercise diary, and the availability of food database with calories and recipes.

Globally, Fig. (2) shows the distribution of the features by the 82 mobile applications analyzed. The features available in

more than 20 mobile applications are the registration of weight, height, gender, age, diet diary, diet plan and goals, the measurement of calories needed, calories burned, physical activity level, body mass index (BMI) and calorie intake, and the availability of food database with calories and educational components.

Finally, the mobile applications available on the Google Play Store are rated by the users. (Table 5) synthesizes the relation between the number of reviews and the current user rating verified on 5th October 2019. Regarding the mobile applications rated with 4.0, 50% of them were rated by less than 1,000 users, 33% were rated by between 1,000 and 10,000 users, and 17% were rated by between 10,000 and 100,000 users. All mobile applications rated with 4.1 were rated by less than 1,000 users. Regarding the mobile applications rated with 4.2, 33% of them were rated by less than 1,000 users, 44% were rated by between 1,000 and 10,000 users, and 22% were rated by between 10,000 and 100,000 users. Of the mobile applications rated with 4.3, 20% were rated by less than 1,000 users, 50% were rated by between 1,000 and 10,000 users, 20% were rated by between 10,000 and 100,000 users, and 10% were rated by between 100,000 and 500,000 users. Concerning the mobile applications rated with 4.4, 22% of them were rated by less than 1,000 users, 56% were rated by between 1,000 and 10,000 users, 11% were rated by between 100,000 and 500,000 users, and 11% were rated by between 500,000 and 1,000,000 users. Of the mobile applications rated with 4.5, 33% were rated by less than 1,000 users, 13% were rated by between 1,000 and 10,000 users, 33% were rated by between 10,000 and 100,000 users, 13% were rated by between 100,000 and 500,000 users, and 7% were rated by more than 1,000,000 users. Of the mobile applications rated with 4.6, 8% were rated by less than 1,000 users, 67% were rated by between 10,000 and 100,000 users, and 25% were rated by between 100,000 and 500,000 users. Of the mobile applications rated with 4.7, 38% were rated by between 1,000 and 10,000 users, 13% were rated by between 10,000 and 100,000 users, 38% were rated by between 100,000 and 500,000 users, and 13% were rated by between 500,000 and 1,000,000 users. Of the mobile applications rated with 4.8, 50% were rated by between 1,000 and 10,000 users, and 50% were rated by between 10,000 and 100,000 users.

Table 3. Mobile applications with features related to vital, anthropometric, medical and social parameters.

Features	Mobile applications
Age	[11], [12], [13], [16], [17], [19], [21], [22], [23], [24], [25], [27], [28], [29], [30], [31], [34], [36], [37], [41], [47], [53], [54], [56], [59], [61], [64], [65], [67], [70], [75], [76], [77], [78], [79], [80], [81], [82], [83]
Gender	[11], [12], [16], [17], [21], [22], [23], [24], [25], [27], [28], [30], [31], [34], [36], [37], [41], [46], [47], [53], [54], [55], [56], [59], [61], [64], [65], [67], [70], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83]
Weight/Height	[11], [12], [13], [14], [16], [17], [19], [20], [21], [22], [23], [24], [25], [27], [28], [29], [30], [31], [33], [34], [36], [37], [41], [44], [46], [47], [53], [54], [55], [56], [61], [62], [64], [65], [67], [70], [72], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83]
BMI	[11], [20], [22], [23], [24], [27], [29], [33], [34], [36], [37], [44], [46], [47], [53], [56], [64], [75], [78], [81], [82]
Body fat	[14], [24], [29], [34], [36], [47], [56], [79], [78]
Body lean	[34]
Waist-height relation	[47]
Ideal weight calculation	[23], [29], [34], [36], [61], [77]
Waist	[11], [23], [26], [34], [36], [61], [62], [76], [78], [79], [82]
Neck	[23], [36], [79]

(Table 3) contd....

Features	Mobile applications
Breast	[26], [36], [61], [76], [79],
Forearm	[26], [36], [79]
Arm	[26], [36], [79]
Shoulders	[26], [36], [79]
Leg	[26], [36], [79]
Hip	[34], [36], [61], [76], [79], [82]
Thigh	[23], [26], [36], [79]
Body structure	[36]
Physical activity level	[11], [12], [13], [16], [17], [19], [22], [23], [24], [25], [27], [28], [31], [34], [36], [41], [54], [59], [67], [70], [78], [80], [82], [83]
Mood and emotions	[61]
Sleep	[14], [34], [41], [64]
Education	[13], [14], [22], [29], [34], [35], [38], [42], [43], [44], [46], [47], [50], [54], [63], [64], [65], [68], [69], [72], [73]
Reminders	[22], [34], [41], [56], [58], [61], [64], [67], [71], [74], [76], [77], [78], [79], [80], [81]
Smoker	[65]
Goals	[11], [12], [14], [16], [17], [19], [21], [22], [23], [24], [25], [27], [28], [34], [36], [41], [53], [54], [58], [59], [61], [64], [67], [70], [72], [74], [77], [78], [79], [80], [81], [82]
Points	[71]
Blood pressure	[14], [82]
Pulse	[14], [34]
Medication diary	[14], [65]
Glycemic	[14]
Diabetic	[17], [65]
Allergies	[11], [65]
Health questionnaire	[65]
Diagnostic	[65]
Pregnancy	[65]
Registration of overweight tendency	[61]
Registration of pregnancy number	[61]

Table 4. Mobile applications with features related to diet and physical activity data.

Features	Mobile applications
Food database with calories	[11], [12], [13], [14], [15], [16], [18], [19], [21], [23], [24], [25], [26], [29], [31], [34], [41], [53], [54], [55], [64], [67], [77], [78], [80]
Food database with a glycemic index	[72]
Calories intake	[11], [12], [14], [16], [17], [19], [21], [23], [24], [25], [26], [31], [34], [41], [49], [53], [55], [64], [67], [70], [78], [80]
Macronutrients intake	[12], [14], [16], [19], [21], [23], [24], [25], [26], [31], [34], [41], [49], [53], [67], [70], [78], [80]
Fluid intake	[11], [12], [14], [17], [22], [23], [24], [25], [31], [34], [44], [48], [64], [75], [77], [78], [80]
Fluid needed calculation	[23], [24], [25], [64]
Diet diary	[11], [12], [14], [16], [17], [19], [21], [23], [24], [25], [26], [31], [34], [41], [44], [49], [53], [55], [61], [64], [67], [70], [75], [77], [78], [80]
Caffeine intake	[14]
Calories needed calculation	[11], [12], [13], [14], [16], [17], [19], [21], [22], [23], [24], [25], [26], [28], [29], [34], [36], [41], [53], [54], [64], [67], [78], [80], [83]
Basal metabolic rate	[23], [24], [34], [75], [82], [83]
Weight index calculation	[34]
Food preferences	[11], [28], [30], [33], [56]
Diet plan	[19], [20], [26], [29], [30], [138], [33], [38], [39], [46], [47], [48], [56], [57], [58], [61], [62], [64], [66],
Recipes	[26], [39], [40], [41], [42], [45], [47], [51], [52], [54], [55], [57], [58], [59], [60], [61], [64], [65], [73]
Shopping list	[26], [30], [33], [39], [45], [51], [60],
Questionnaire	[11]

(Table 4) contd.....

Features	Mobile applications
Calories burned	[11], [12], [14], [16], [17], [21], [22], [23], [26], [27], [28], [33], [34], [41], [53], [58], [64], [67], [74], [76], [78], [80]
Physical activity monitoring	[12], [14], [17], [26], [27], [34], [58], [74]
Exercise diary	[11], [12], [16], [21], [22], [23], [26], [28], [31], [34], [41], [53], [64], [67], [70], [77], [78], [80]
Challenges	[16], [19], [22], [27], [34], [78]
Videos	[78], [83]
Training plan	[14], [28], [29], [30], [33], [44], [58], [59], [71], [76], [78], [79], [83]
Devices	[12], [26]
Physical activity monitoring with another mobile applications	[11], [16], [28], [41], [77], [78], [80]

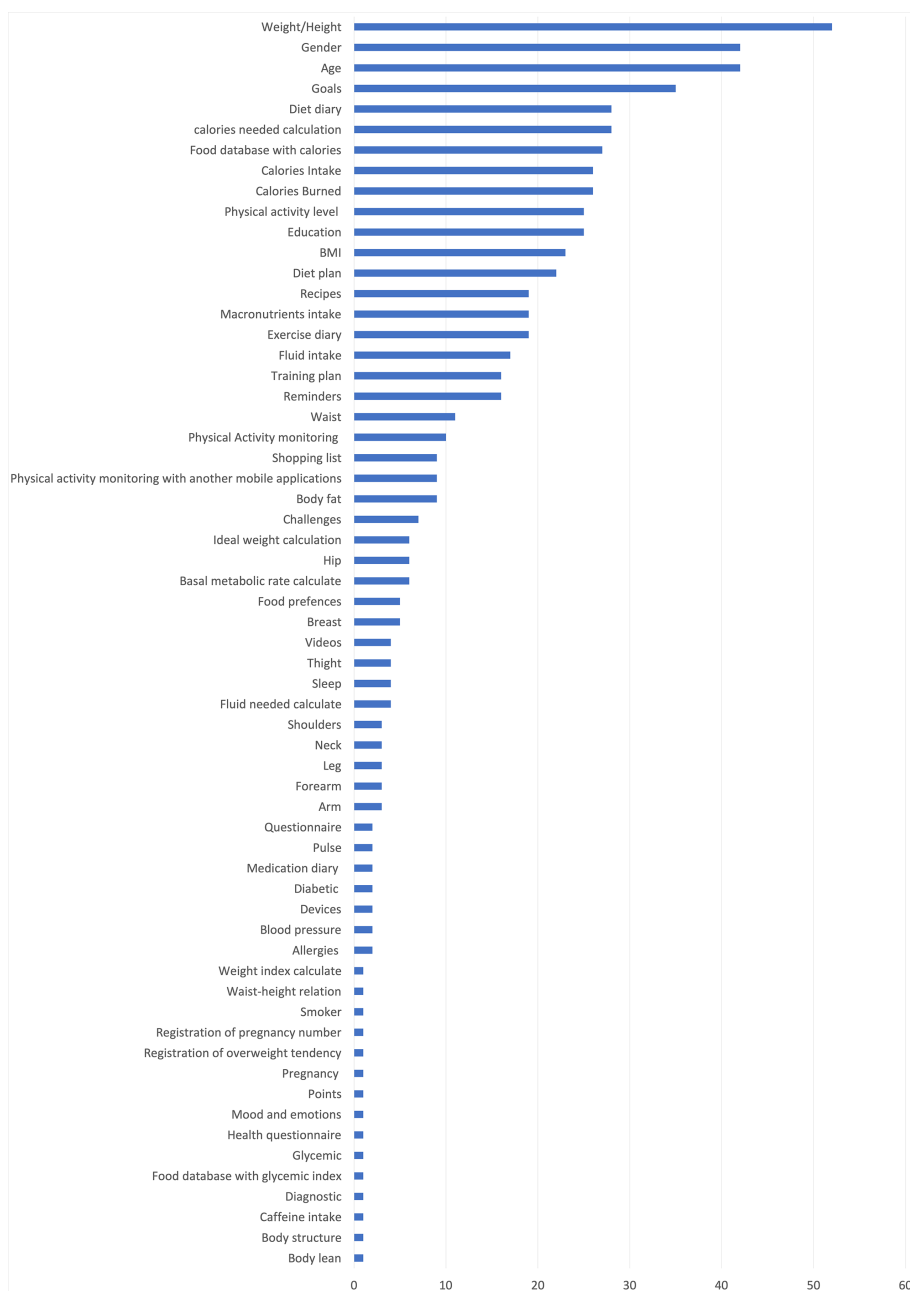


Fig. (2). Distribution of the features by the mobile applications.

5. DISCUSSION

Regarding (Table 6), the synthesis of other reviews available in the literature that matches our analysis is presented, verifying that the maximum number of analyzed mobile applications is 80 and the major part of them is related to health and fitness.

Based on the literature, there are other reviews about the same subject, but they are less detailed and with a smaller set of mobile applications than our review. In summary, this review analyzed 73 mobile applications related to nutrition, physical activity and health, which is a similar number of mobile applications analyzed in a study [109], but some of them were already removed from the Google Play Store. In (Table 5), eight literature reviews with a similar methodology of this paper have been summarized, verifying that the highest number of mobile applications examined is 80, but some of them were already removed from the online application stores. As presented in Fig. (3), the mobile applications that are the most analyzed are *Calorie Counter- MyFitnessPal*, which was explained in all literature reviews, and *Calorie Counter by FatSecret* and *Lose It! - Calorie Counter*, which was analyzed in 5 literature reviews. Regarding the literature reviews

analyzed, a review [98] examined the most number of mobile applications discussed in our report, in a total of 9. Secondly, Franco *et al.* [86] analyzed seven mobile applications available in our study. On the other hand, our review examined 80% of the mobile applications explained by the authors [88], 54% of the mobile applications analyzed by the authors of a study [86] and 21% of the mobile applications examined by the authors of another research [98]. In addition, 20% of the mobile applications analyzed in a study [139], 14% of the mobile applications explained in an investigation [124], 13% of the mobile applications analyzed by the authors of another study [121], 10% of the mobile applications examined by the authors of an analysis [104] and 5% of the mobile applications analyzed by the authors in a study [109].

The number of mobile applications analyzed in a report [109] is similar to the number of mobile applications explained in our review, examining 80 mobile applications, but only four of the mobile applications analyzed by the authors are the same as in this review. The main reason was related to the subject of the research, where the authors [109] studied the mobile applications more focused on health, where our review is more concentrated in nutrition and physical activity.

Table 5. Distribution of the rating of mobile applications.

Number of reviews	User Rating								
	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8
< 1,000	[42], [66], [73]	[38], [40]	[15], [57], [63]	[44], [50]	[39], [47]	[20], [35], [43], [68], [69]	[49]	-	-
1,000 – 10,000	[26], [61]	-	[32], [34], [54], [56]	[13], [45], [70], [72], [78]	[24], [46], [79], [81], [82]	[25], [52]	-	[60], [62], [76]	[51]
10,000 – 100,000	[17]	-	[55], [67]	[29], [59]	-	[19], [21], [31], [48], [64]	[18], [23], [30], [37], [53], [58], [75], [80]	[71]	[83]
100,000 – 500,000	-	-	-	[11]	[77]	[16], [28]	[22], [36], [74]	[33], [41], [65]	-
500,000 – 1,000,000	-	-	-	-	[14]	-	-	[27]	-
> 1,000,000	-	-	-	-	-	[12]	-	-	-

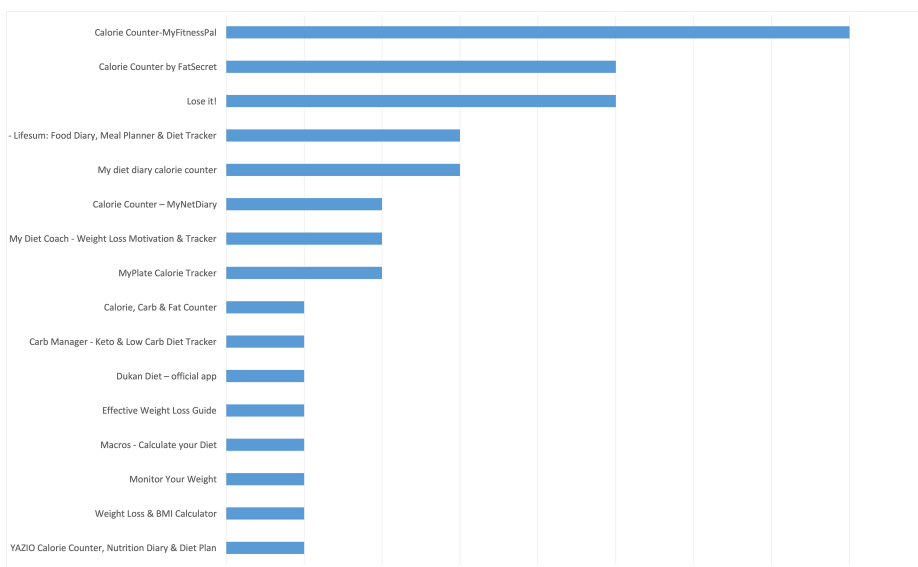


Fig. (3). Ranking of the mobile application presented in studies.

In a study [104], the authors analyzed 40 mobile applications, but our review only explained 10% of them, because they examined only the most popular mobile applications in the Mobile Health subject. On the other hand, the study [121] presented the analysis of 30 mobile applications, and they analyzed 13% of the mobile applications examined in our review because they explained the mobile applications for Android and iOS operating systems. About the Android operating system, the study [121] only analyzed the mobile applications available in the top 100 of the Google Play Store.

Following the user rating of the mobile applications analyzed, the mobile applications only reviewed by less than 1,000 users (i.e., 25% of the mobile applications analyzed) are the less relevant, where the user rating is not very relevant. The mobile applications analyzed by more than 1,000 users corresponds to the major part (i.e., 75% of the mobile applications analyzed) of the mobile applications analyzed. Thus, 30% of the mobile applications are analyzed by between 1,000 and 10,000 users, 20% of the mobile applications are analyzed by between 10,000 and 100,000 users, 10% of the mobile applications are analyzed by between 100,000 and 500,000 users, and only 5% of the mobile applications are analyzed by more than 500,000 users. Considering that the rating of the mobile applications reviewed by a number of users higher than 1,000 users is relevant, 54 of the mobile applications analyzed (75%) may be evaluated by the user rating.

Following the results, a taxonomy for the mobile applications analyzed in this study has been proposed, which, as presented in Fig. (4), is composed of four categories, namely "Education", "Diet and nutrition", "Physical activity" and "Health".

Following the results of other reviews and the analyses of different mobile applications, two taxonomies have been proposed, one of them is related to the goals of the mobile applications (Fig. 4) and other associated with the categorization of the functionalities of these mobile applications

analyzed (Fig. 5).

Based on the features available in the different mobile applications analyzed, it can be classified into four groups, including "Education", "Diet and nutrition", "Physical activity" and "Health". The mobile applications included in the "Education" category consists of the mobile applications related to the teaching of some concepts related to the information available in the literature or shared by different people. Another important category is related to "Diet and nutrition", where these mobile applications are mainly related to healthy nutrition habits. Next, the "Physical activity" category is related to different mobile applications related to the measurement of the different parameters related to physical activity. Finally, the "Health" category includes the mobile applications related to all concepts focused on this paper, such as diet, nutrition, physical activity and medical concepts.

Following the mobile applications analyzed in other reviews, nine mobile applications are categorized in "Health", six mobile applications are classified in "Diet and Nutrition", and one mobile application is categorized in "Health". However, our review found more mobile applications in "Diet and Nutrition", but the other studies in the literature have more applications related to "Health" available in our review.

In Fig. (5), a taxonomy related to the functionalities found in the mobile applications examined has been proposed, composed by "Diet", "Anthropometric parameters", "Social", "Physical activity", "Medical parameters" and "Vital parameters". The categories with more functionalities are "Anthropometric parameters" and "Diet".

Also, Table 7 presents the categorization of the mobile applications analyzed in this review by the functionalities of their features, where it is verified that the category with more mobile applications is "Diet" with 60 mobile applications (82%). Next, the category "Social" has 53 mobile applications (73%), and the class "Anthropometric parameters" have 49 mobile applications (67%). The mobile applications include several features, and they can be included in more than one category.

Table 6. Summary of the studies that present other literature reviews.

Study	Year of Publication	Number of Mobile Applications Analyzed	Number of Mobile Applications Also Examined in this Study	Mobiles Applications in Common	Search Criteria	Purpose of the Study
Franco et al. [86]	2016	13	7	[12], [41], [22], [21], [17], [29], [19]	Calories; Diet; Diet tracker; Dietician; Dietitian; Eating; Fit; Fitness; Food; Food diary; Food tracker; Health; Lose weight; Nutrition; Nutritionist; Weight; Weight loss; Weight management; Weight watcher; Weight watcher calculator	Analysis of mobile applications related to nutrition purposes

(Table 6) contd.....

Study	Year of Publication	Number of Mobile Applications Analysed	Number of Mobile Applications Also Examined in this Study	Mobiles Applications in Common	Search Criteria	Purpose of the Study
Darby <i>et al.</i> [98]	2016	42	9	[31], [41], [11], [21], [24], [22], [12], [23], [16]	Diet; Eating; Food; Food diary; Health; Nutrition; Nutrition diary; Nutrition tracking	Analysis of nutritional tracking applications that should be the first recommendations to diabetes patients
Chen <i>et al.</i> [124]	2015	28	4	[80], [12], [17], [41]	Health and fitness	Evaluation of the quality of most popular dietary weight-loss mobile applications
Azar <i>et al.</i> [139]	2013	10	2	[21], [12]	Health and Fitness	Evaluation of the diet/nutrition and anthropometric tracking mobile applications
Pagoto <i>et al.</i> [121]	2013	30	4	[23], [12], [41], [21]	Health and fitness	Analysis of weight-loss mobile applications
Griffiths <i>et al.</i> [88]	2018	5	4	[12], [21], [80], [11]	Health and fitness Nutrition	Assessment of the accuracy of nutrient intake calculations performed by mobile applications
Mea <i>et al.</i> [109]	2015	80	4	[61], [37], [12], [36]	Medical Health and Fitness	Classification of mobile applications and medical devices
Azfar <i>et al.</i> [104]	2015	40	4	[12], [41], [17], [11]	mHealth	Propose a forensic taxonomy for mobile applications

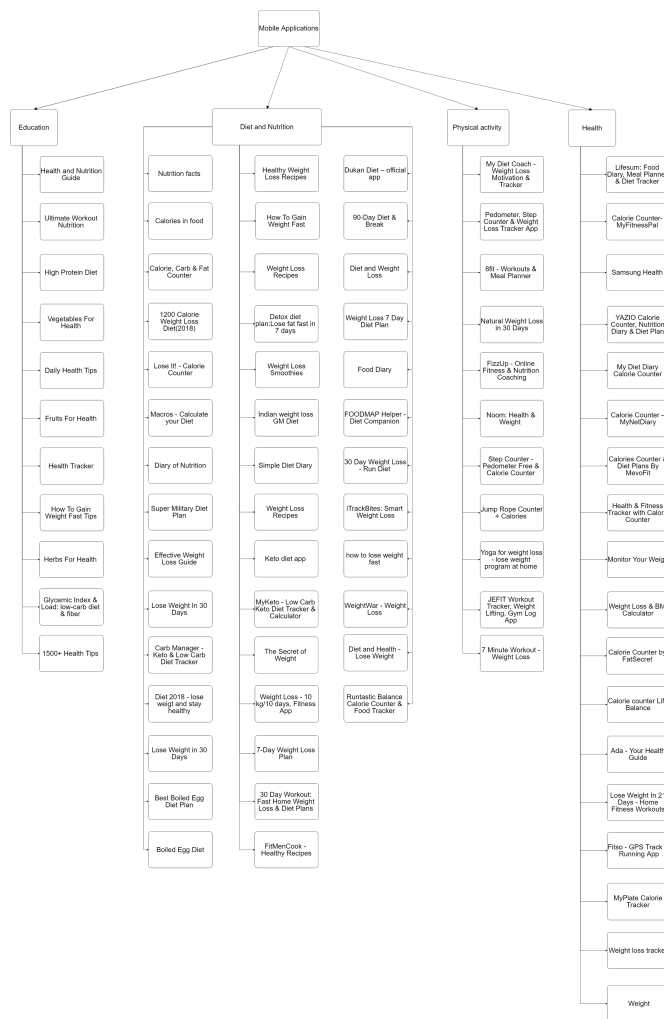


Fig. (4). Taxonomy for the mobile applications analyzed in this study.

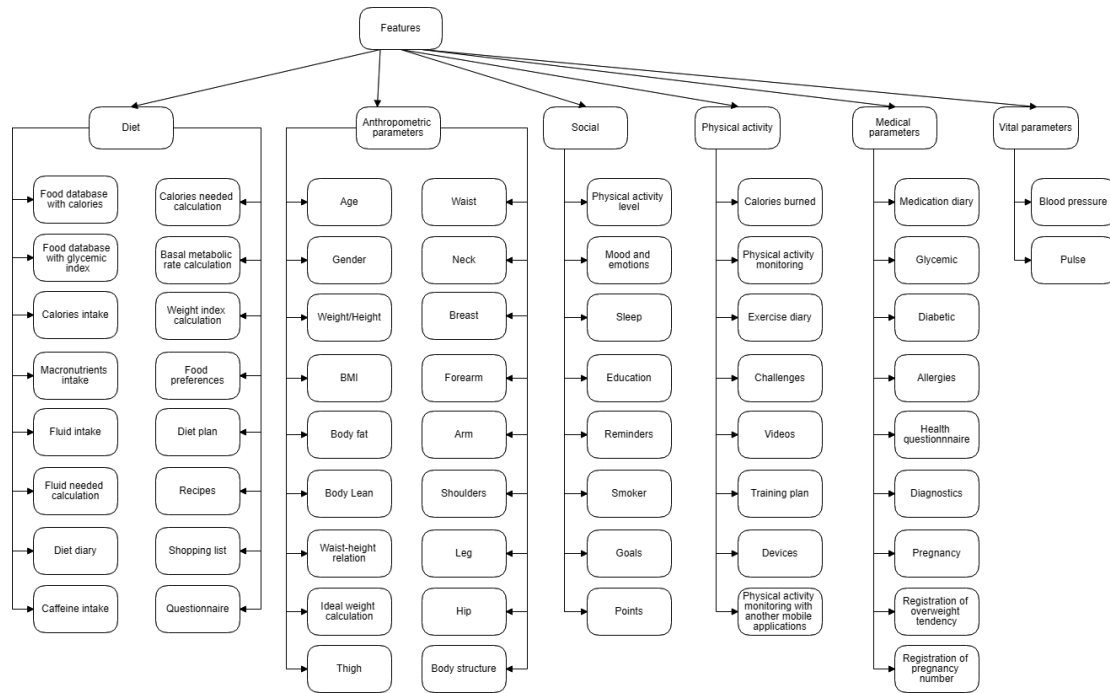


Fig. (5). Taxonomy for the features of the mobile applications analyzed in this study.

Table 7. Distribution of mobile applications by categories of features.

Categories	Mobile Applications
Diet	[11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21] [22], [23], [24], [25], [26], [28], , [29], [30], [31], [138], [33], [34], [36], [38], [39], [40], [41], [42], [44], [45], [46], [47], [48], [49], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [64], [66], [67], [70], [72], [73], [75], [77], [78], [80], [82], [83]
Anthropometric parameters	[11], [12], [13], [14], [16], [17], [19], [20], [21] [22], [23], [24], [25], [26], [27], [28], [29], [30], [31], [33], [34], [36], [37], [41], [46], [47], [53], [54], [55], [56], [59], [61], [62], [64], [65], [67], [70], [72], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83]
Social	[11], [12], [13], [14], [16], [17], [19], [21] [22], [23], [24], [25], [27], [28], [29], [31], [34], [35], [36], [38], [41], [42], [43], [44], [46], [47], [50], [53], [54], [56], [58], [59], [61], [63], [64], [65], [67], [68], [69], [70], [71], [72], [73], [74], [76], [77], [78], [79], [80], [81], [82], [83]
Physical activity	[11], [12], [14], [16], [17], [19], [21] [22], [23], [26], [27], [28], [29], [30], [31], [33], [34], [41], [44], [53], [58], [59], [64], [67], [70], [71], [74], [76], [77], [78], [79], [80], [83]
Medical parameters	[11], [14], [17], [61], [65], [82]
Vital parameters	[14], [34]

CONCLUSION

This review identified and described the mobile applications related to health, nutrition and physical activity. Eighty-two mobile applications were analyzed, and the main findings are as follows :

- (RQ1) There are several mobile applications related to physical activity, diet, nutrition and health purposes, resulting in the analysis of 73 mobile applications available on the Google Play Store. The mobile applications analyzed are mainly related to diet and nutrition, including *Lose it! – Calorie Counter*, *Calorie, Carb & Fat Counter* [21], *1200 Calorie Weight Loss Diet(2018)* [20], *Macros - Calculate your Diet* [24], *MyKeto - Low Carb Keto Diet Tracker & Calculator* [54], and *iTrackBites: Smart Weight Loss* [70].
- (RQ2) There are only 19 mobile applications referenced in scientific studies, where experimental validation is rarely verified. In the major part of the studies, the mobile applications are only referred, but it lacks the analysis and validation of them.
- (RQ3) The essential features available in the mobile applications analyzed are Weight/height, Age, Gender, Goals, Calculation of Calories needed, Diet diary, Food database with calories, calories burned, calorie intake and others.
- (RQ4) The features available in the mobile applications analyzed can be classified into six groups, such as diet, anthropometric parameters, social, physical activity, medical parameters and vital parameters. Additionally, mobile applications analyzed can be grouped into four categories, such as education, diet and nutrition, physical exercise, and health.

Furthermore, this review highlights the mobile applications related to “nutrition”, “diet”, “calories”, “health”, “exercise” and “weight”, where the download and registration are free, the user rating and the number of downloads are high. The mobile applications with the focus to pregnancy, children and pets are excluded, as well as games, and mobile applications for hypnosis for weight loss or a specific pathology are also excluded. Finally, only the mobile applications available in English were included.

Of the analyzed mobile applications, 52% are related to “Diet and nutrition”, 25% are related to “Health”, 11% are related to “Education”, and 12% are related to “Physical activity”.

This study was performed to investigate the functionalities of the mobile applications available on the Google Play Store for nutrition and physical activity. As future work, it is required to develop and analyze a mobile application for teenagers to promote healthy lifestyles.

CONSENT FOR PUBLICATION

Not applicable.

STANDARD OF REPORTING

PRISMA Guideline and methodology were followed.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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