



Nikolaou, C.K., and Lean, M.E.J. (2017) Mobile applications for obesity and weight management: current market characteristics. *International Journal of Obesity*, 41(1), pp. 200-202.

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Deposited on: 20 February 2017

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3 **Mobile applications ('apps') for obesity**  
4 **and weight management: current market**  
5 **characteristics**  
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25 **Short Report Word count:** Abstract= 200 Main text= 1,444  
26

27 **Key Words:** apps, mHealth, weight-management, weight-gain prevention

28 **Conflict of interest:** The authors declare there is no conflict of interest.

29 **Funding:** No funding  
30

31 **Abstract (word limit= 199: word count=200)**

32

33 mHealth is the fastest-developing eHealth sector, with over 100,000 health-apps currently  
34 available. Overweight/obesity is a problem of wide public concern which is potentially  
35 treatable/preventable through mHealth. This study describes the current weight-  
36 management app-market.

37

38 Five app-stores (Apple, Google, Amazon, Windows, Blackberry) in UK, US, Russia, Japan,  
39 Germany, Italy, France, China, Australia, and Canada were searched for key words: 'weight',  
40 'calorie', 'weight-loss', 'slimming', 'diet', 'dietitian' and 'overweight' in January/February 2016  
41 using App-Annie (San Francisco, CA, USA) software. The ten most downloaded apps in the  
42 lifetime of an app were recorded. Developers' lists and the app descriptions were searched  
43 to identify any professional input with key words 'professional', 'dietitian', and 'nutritionist'.  
44

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45 A total of 28,905 relevant apps were identified; Apple-iTunes=8,559(4,634, 54% paid),  
46 Google-Play=1,762 (597, 33.9% paid), Amazonapp=13,569 (4,821, 35.5% paid), Windows=  
47 2,419 (819, 17% paid), Blackberry= 2,596 (940, 36% paid). The 28,905 identified apps focused  
48 mainly on physical activity (34%), diet (31%), and recording/monitoring of exercise, calorie-  
49 intake and body-weight (23%). Only 17 apps(0.05%) were developed with identifiable  
50 professional input.

51

52 Apps on weight-management are widely available and very popular but currently lack  
53 professional content-expertise. Encouraging app-development based on evidence-based  
54 online approaches would assure content quality, allowing health-care professionals to  
55 recommend their use.

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## 57 **Background (Short Report word limit=1,547: word count= 1,500)**

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59 Mobile-Health (mHealth), a subcategory of eHealth, covering interventions and practice  
60 involving 'apps' and mobile devices is a new and fast-growing field. Blackberry introduced the  
61 first mobile device with computing features in 2002, followed by Apple in 2007 and Google in  
62 2008<sup>1</sup>. In 2010, 'tablet' computers whose portability, and large screens expanded the mobile  
63 market further, were introduced by Apple and Google<sup>1,2</sup>. Subsequent smartphones and  
64 tablets with advanced features and capabilities, coupled with falling prices, increased the  
65 ownership of these devices rapidly<sup>3</sup>. Unique subscriber-penetration currently stands at 79%  
66 and 45% of the entire population in the developed and developing worlds, respectively<sup>4</sup>.

67

68 'Apps' are software programs developed to run on mobile devices to accomplish a specific  
69 purpose<sup>5</sup>. There are more than 100,000 mHealth-apps available<sup>6</sup> for downloading free or at  
70 a nominal value from five stores; Apple-iTunes for iOS operating systems, Google-Play for  
71 Android operating system, Amazonapp for Fire and Android operating systems, Windows and  
72 Blackberry for their eponymous operating systems<sup>7</sup>.

73

74 Between 1980-2013 the global prevalence of overweight (BMI>25kg/m<sup>2</sup>) increased from 29%  
75 to 37% in men and from 30% to 38% in women<sup>8</sup>. Obesity prevalences (BMI>30kg/m<sup>2</sup>) now  
76 approach or exceed 30% in US, UK, the Gulf States, Australia, and Canada<sup>8</sup>. In UK, obesity  
77 prevalence now reaches about 40% by age 65<sup>9</sup> and national physical activity  
78 recommendations are met by 69.5% of adults<sup>10</sup>. The need for effective anti-obesity  
79 interventions that will reach large population-sectors at low-cost is increasingly critical. A  
80 recent systematic review concluded that self-directed interventions can promote weight-  
81 loss<sup>11</sup>. Mobile-apps on weight-management could provide low-cost, self-directed  
82 mechanisms to reach the 80% of young, obesity-prone, populations who own tablets or  
83 smartphones<sup>12</sup>. Healthcare professionals and public health services could suggest and re-  
84 inforce the movement towards prescription of more evidence-based apps. This study  
85 quantifies and describes the current weight-management provision in the largest app-  
86 markets worldwide.

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## 89 **Methods**

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91 An electronic search was conducted to identify apps relevant to weight-management in the  
92 five main app-stores, covering all devices and operating systems currently on the market:  
93 Apple-iTunes, Google-Play, Amazonapp, Windows, and Blackberry. The app-stores in the  
94 leading ten app-markets worldwide (UK, US, Russia, Japan, Germany, Italy, France, China,  
95 Australia, and Canada) were searched using key-words: 'weight', 'calorie', 'weight-loss',  
96 'slimming', 'diet', 'dietitian' and 'overweight'. App-Annie (San Francisco, CA, USA) software  
97 was used for Apple-iTunes and Google-Play stores, and the provided search engines for  
98 Windows, Amazonapp, and Blackberry stores. The software automatically converts English  
99 into the appropriate language for searching.

100

101 Developers' lists and descriptions of all apps identified as relevant to weight-management  
102 were searched with key-words: 'professional', 'dietitian' and 'nutritionist' in order to identify  
103 professional input for development, and evidence of development for professional bodies,  
104 universities or governmental Health Agencies. ANOVA on SPSS-23 was used to examine  
105 differences between countries and online shops.

106

107 The five free, and five paid, most downloaded apps from 'Lifestyle/Health' and 'Fitness'  
108 categories of the five app-stores for the same countries (total 500 apps) were identified for  
109 more complete description, using App-Annie (San Francisco, CA, USA) software.

110

## 111 **Results**

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113 A total of 28,905 unique apps relevant to weight-management were identified; Apple-  
114 iTunes=8,559 (4,634, 54% paid), Google-Play=1,762 (597, 33.9% paid), Amazonapp=13,569  
115 (4,821, 35.5% paid), Windows=2,419 (819, 17% paid), Blackberry=2,596 (940, 36% paid)  
116 (Table 1). They accounted for over two billion downloads over the apps' lifetimes. However,  
117 over half of all those downloads were generated by just 15 apps, 12 on physical activity and  
118 three on monitoring of calorie intake, physical activity, body weight, and sleeping patterns.  
119 Of these eleven apps were directly associated with a wearable device.

120

121 The 28,905 identified apps focused mainly on physical activity (34%), on diet (31%), and on  
122 recording and monitoring of exercise, calorie intake and body-weight (23%) (Figure 1).  
123 'Weight loss' or 'slimming' was specifically mentioned by 22,587 (78%) of apps relevant to  
124 weight-management. There were 53 apps aimed at prevention of diabetes, cancer or chronic-  
125 disease that included weight maintenance in their content. However, none of the 28,905  
126 apps mentioned specifically the words 'obesity-prevention' or 'prevent weight-gain'.

127

128 There were few differences between countries in the total numbers of apps available. In all  
129 countries, Amazon app store contained significantly more weight-management apps  
130 ( $p < 0.001$ ) and Apple iTunes had a largest proportion of paid apps ( $p < 0.001$ ).

131

132 The most downloaded free and paid apps in 'Lifestyle/Health' and 'Fitness' categories listed  
133 by the five app-stores in ten countries are shown in supplementary Table 1. In every country,  
134 and in every store, at least one app directed towards weight-management was among the  
135 top ten apps. In US, UK, Canada, Germany, and Russia all top ten apps were for weight-  
136 management. The actual numbers of downloads of these apps was not provided by all app  
137 stores.

138

139 Searching the developers' list and descriptions of the retrieved apps, only 17 (0.05% of  
140 28,905) indicated that they were developed with the input from a professional, or for  
141 professional bodies, universities or governmental health agencies. Five of these were  
142 designed for use by health-care professionals, rather than directly by the public.

143

144 Among the top ten apps in 'Lifestyle/Health' and 'Fitness' categories in the ten countries (500  
145 apps in total), only three apps (0.6%) were identified as having been developed by  
146 professional bodies.

147

## 148 **Discussion**

149 Interest and activity in mHealth is high. The total number of available mHealth apps is  
150 growing rapidly, including an increase of 284% in the number of available mHealth apps since  
151 2013<sup>13</sup>.

152

153 Over a quarter of approximately 100,000 mHealth apps are directed to some degree towards  
154 weight-management. While weight-management apps are widely available in all stores and  
155 in the largest app markets, use-patterns appear restricted. Consumers appear only to choose  
156 amongst a small number of the most downloaded apps: only 15 of almost 30,000 apps  
157 directed towards weight-management accounted for over half of all downloads. The US  
158 Institution of Medical Information recently reported similarly that nearly half of all mHealth  
159 apps downloads were for just 36 apps with the relatively low retention rates being at least  
160 10% higher if the app has been advised by a healthcare professional<sup>13</sup>. Retention rate was  
161 also 30% higher for prescribed fitness apps and 30-day retention rate was reports as 47% for  
162 health and fitness apps in 2012<sup>14</sup>.

163

164 Our results suggest that very few weight-management apps (0.05%) were developed by  
165 official or professional sources, so quality might be of concern. Even those apps that were  
166 developed with professional input are not backed up by clinical studies on the effectiveness  
167 and validation of apps on health outcomes. Only three studies, to date, tested the  
168 effectiveness of commercially available apps on health outcomes with Direito's being the  
169 latest. He tested two commercially-available apps, aiming at increasing the physical activity  
170 of young people in New Zealand vs control over two months<sup>15</sup>. In this very small study, 51  
171 participants were randomized but neither app significantly increased physical activity.

172

173 Few studies have assessed the quality of apps for controlling body-weight. Azar and  
174 colleagues assessed 23 weight-loss apps for inclusion of behavioral theories using two  
175 instruments: one on a traditional behavioural theory and the other on Fogg behavioural  
176 model. All assessed apps received low scores with both tools<sup>16</sup>. Pagoto and colleagues  
177 assessed 30 weight-loss apps and found that they included only 19% of 20 pre-defined  
178 behavioral strategies derived from an evidence-based weight-loss program<sup>17</sup>. Chen assessed  
179 weight-loss apps in Australia. Most of the 28 selected apps for quality assessment provided  
180 estimated energy requirements (86%) and used a food database to calculate energy intake  
181 (75%)<sup>18</sup>. Direito and colleagues assessed 40 apps from the New Zealand online stores: they  
182 included an average of 8.1 (range 2-18) behavioural-change techniques<sup>19</sup>.

183

184 In view of the increased interest and activity in the mHealth sector, both the Food and Drug  
185 Administration (FDA) in US<sup>20</sup> and the European Commission (EC)<sup>21</sup> have published guidelines  
186 on mHealth apps. However, neither guideline provides any standards for the quality of app  
187 content. FDA merely intends to exercise enforcement discretion for lifestyle apps, while EC  
188 focuses on the legal framework for the sales of lifestyle and wellbeing apps.

189

190 An online study of this kind is inevitably limited by the quality of information presented by  
191 the source material. Search terms may not identify all terminologies that may be used. It is  
192 possible that more apps did involve some professional or official input, but if so that  
193 information is not evident to potential users (public or professional). Healthcare industry and  
194 public organizations across the world have accelerated mHealth dialogues, to include more  
195 innovations including mobile/wireless technologies. However, to generate better health, and  
196 specifically better self-directed weight-control for obesity-prevention, there is need to  
197 incorporate more evidence-based methods into mHealth apps and reinforce movements like  
198 iPrescribeapps where apps are developed by medical experts for specific medical  
199 conditions<sup>22</sup>, especially since retention rates of health and fitness apps are so much better  
200 when those are prescribed instead of being self-selected. Researchers with evidence for  
201 effective online weight-loss or weight-gain prevention programmes in RCT settings could be  
202 encouraged to transfer their resources into an app form with greater reach. A new 'Apps For  
203 Patients' category, restricted to those with professional, evidence-based content, would be  
204 valuable, with subcategories for lifestyle-diseases, identifiable as for prevention or treatment.

205

206 In conclusion, mHealth offers potential to deliver improved, personalized, care while reducing  
207 healthcare-costs. For lifestyle-diseases and weight-management there are already many  
208 available apps but lack of professional, evidence-based content raises concerns about efficacy  
209 and patient/consumer safety. Encouraging app-development from tested and validated  
210 online-studies would offer confidence to both patients and healthcare-professionals.

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215 Supplementary information is available at IJO's website

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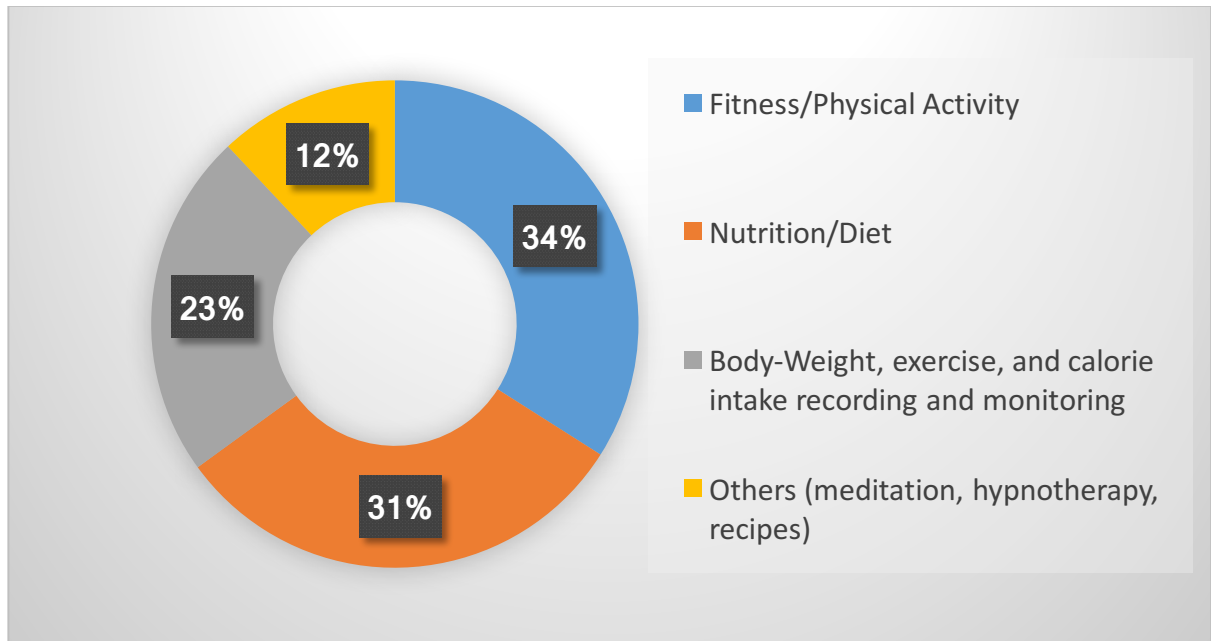
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Figure 1: Main content of apps identified through the search in all five online app-stores



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