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elearning approaches to prevent weight-gain in young adults: a randomised controlled study

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2

What is already known about this subject?
- Young adulthood is a period of rapid weight-gain, leading to obesity for many
- Effective obesity prevention, specifically for young adults, is not currently routinely available or provided

What does your study add?
- Two potentially transferable on-line programmes, based on different theoretical models, to prevent weight-gain overtly or covertly, were both associated with prevention of the usual weight-gain observed in young adults

1   **Abstract**   (word count=200, word limit=200)

2   **Objective:** Preventing obesity among young-adults should be a preferred public health

3   approach given the limited efficacy of treatment interventions. This study examined

4   whether weight-gain can be prevented by on-line approaches using two different

5   behavioural models, one overtly directed at obesity and the other covertly.

6   **Methods:** A three-group-parallel randomised controlled intervention was conducted in

7   2012-2013 (trial registration number: UMIN000014529); 20,975 young-adults were

8   allocated *a priori* to one control and two 'treatment' groups.

9   Two treatment groups were offered on-line courses over 19 weeks on 1) personal weight-

10   control ('Not-The-Ice-Cream-Van', 'NTICV'), 2) political, environmental and social issues

11   around food ('Goddess Demetra', 'GD'). Control-group received no-contact. The primary

12   outcome was weight-change over 40-weeks.

13   **Results:** Within-group 40-week weight-changes were different between groups ($p<0.001$):

14   Control (n=2,134): +2.0kg(95%CI 1.5, 2.3kg); NTICV (n=1,810): -1.0kg(95%CI -1.3, -0.5); and

15   GD (n=2,057): -1.35kg(95%CI -1.4, - 0.7).   Relative risks for weight-gain vs control:

16   NTICV=0.13kg (95% CI=0.10, 0.15) $p<0.0001$; GD=0.07kg(95% CI=0.05, 0.10) $p<0.0001$.

17   **Conclusion:** Both interventions were associated with prevention of the weight-gain

18   observed among control subjects. This low-cost intervention could be widely transferable as

19   one tool against the obesity epidemic. Outside the RCT setting it could be enhanced using

20   supporting advertising and social media.

21

4

22   **Introduction**

23

24   Obesity is a major public health concern but its treatment has been of limited efficacy[1].

25   Obesity prevention appears a preferable public health approach, but few reliable and

26   effective, sustainable, solutions have been developed to date. Weight-gain, potentially

27   leading to obesity, is most rapid in the transitional period spanning adolescence and young

28   adulthood[2,3], and especially noted in those attending higher education[4,5,6]. Maintaining a

29   healthy lifestyle throughout young adulthood has been shown to be an effective way of

30   reducing the risk for chronic disease such as cardiovascular disease[7]. In theory, preventing

31   this weight-gain should be relatively easy to achieve since the average weight-gain observed

32   requires only an extra 50-100 kcal/day above estimated energy requirements. In reality,

33   factors affecting human behaviour and weight equilibrium can vary extensively[8,9] and

34   relapse into previous behaviours has been the rule[10]. The use of behavioural models for the

35   prevention of weight-gain is under-researched.

36

37   US and UK public health policy encourages lifestyle changes to improve population health

38   and outcomes by drawing attention to personal responsibility and empowerment[11,12].

39   Young-adults are establishing lifestyle habits independently, often for the first time[13]. Since

40   young-adults are going to form future workforce and be the parents of the future,

41   empowering them to resist unwanted weight-gain by establishing healthy lifestyles will lead

42   to multiple benefits both at personal and societal level. However, young-adults are often

43   resistant to advice and 'hard-to-reach' for health promotion. Young adulthood is a relatively

44   overlooked lifecycle period for intervention, but concern about body weight is often high.

45

46   Advances in the technology and increased use of internet provide a low-cost platform for

47   delivering and disseminating health messages. A new and evolving area in the promotion of

48   lifestyle changes is elearning ie the use of interactive electronic media to facilitate teaching

49   and learning. Given the high percentage of internet users, internet interventions are

50   underutilized. Over 80% of young people have smart-phones now, even in deprived

51   communities, and 89.6% and 84.2% of the citizens have access to the Internet in the UK and

52   US, respectively[14].

53

54   The present study examined the effectiveness of elearning approaches for preventing

55   weight-gain and encouraging healthier lifestyles among young-adults in higher education

56   based on two different behavioural models.

57

58   **Methods**

59   The trial was approved by the College of Medicine, Veterinary, and Life Sciences ethical

60   committee and registered in the Clinical Trials Register of Japan, registration number:

61   UMIN000014529). A separate study measuring and validating weights and heights in the

62   same subject-base was approved by the NHS Glasgow and Clyde Ethics Committee.

63

64   **Participants and setting**

65   Eligible participants for this study were young-adults registered for undergraduate studies at

66   a large multidisciplinary university, in a country with a very high prevalence of obesity,

67   approaching 30% of all adults[15].

68

69   **Design**

70   A three-group parallel randomized controlled trial design was employed for the

71   intervention, with an observational design for outcome data collection.

72

73   University email addresses and registration numbers were provided by registry to

74   researchers, and used for *a priori* randomisation to 'treatment' or control groups, using

75   statistical software (SPSS 19, Chicago). A table was created based on a unique 6-digit

76   number for each of the 20,975 eligible participants. All were randomised, with 6,991

77   participants in group 1 (Treatment-1), 6,992 participants in group 2 (control group), and

78   6,992 participants in group 3 (Treatment-2), respectively (Figure 1). This large number

79   ensured power to detect or exclude a small effect size and allowed for a potentially high

80   non-response rate. In order to avoid inter-group contamination, and to retain a 'realistic'

81   design, so that results might be directly applicable to other real-life settings, publicity about

82   the interventions was avoided. Intervention groups were told that as part of university-wide

83   services some new non-matriculated courses were being trialled for some students, and

84   that participation was voluntary but not that allocation of the courses was random. There

85   was no academic advantage to participation, and no disadvantage from declining. The act

86   of following the link to the courses and subscribing to them implied consent. Participants

87   had no obligation to continue logging in the courses or participate in any activities. This

88   'covert' approach was approved by the ethical committee as no potential harm to

89   participants was identified. No financial or academic incentives were offered for

90   participation, and there was no pressure to participate from 'reminder' invitations.

91

92   Weight-changes over the academic year (a 40-week period) in the population randomised to

93   the RCT were collected through a questionnaire designed to explore lifestyle changes in

94   young-adults. This was administered on-line to all students, separately and unconnected

95   from the intervention, in order to reduce risk of biasing recruitment or responses for self-

96   reported body-weight and height. An information sheet was incorporated into the

97   questionnaire and completing the questionnaire implied consent to that study. Participants

98   were free to withdraw from the study at any time and incomplete questionnaires were not

99   stored. A commercial survey method was used to collect responses (SurveyMonkey,

100   California, https://www.surveymonkey.com/mp/aboutus/).

101

102   Recognising the potential for bias in self-reported data, the self-reported weight and height

103   data were validated against two different sets of measured data. One validation was

104   conducted against data measured independently at the General Practitioner (GP) surgery

105   located within the university campus. At the time of registration with the GP at the start of

106   the academic year, all students are required to provide basic health information and have

107   their weight and height measured by nursing staff using stadiometer and set of scales. The

108   self-reported weights and heights from study participants were matched with their data

109   collected from GP records and compared using statistical methods.

110

111   A second subsample of study participants was visited at their place of residence at the stat

112   of the academic year. Their weights and heights were measured using Portable Stadiometer

113   and a set of electronic scales (SECA), and those data were matched with their self-reported

114   data.

115

116   **Power Calculation and Masking**

117   Sample size was estimated using data from a study[16] conducted in similar subjects, aged 20

118   (SD 3.6) which showed a mean 9-month weight-gain without intervention of 1.8kg, with SD

119   2.6. The power calculation (IBM-SPSS SamplePower) indicated that there would be 85%

120   power to detect a difference in weight change of 1.8kg between intervention and control

121   groups with a minimum of 290 evaluable participants in each group. Researchers were

122   blinded to the group identity until after analysis.

123

124   **Intervention**

125   **Materials, Delivery and Timings**

126   Materials for the two intervention groups were developed based on the behavioural models

127   described in the section below and tailored to the specific age group and time of the year

128 when the programmes were delivered (**Table 1**). A group of three people with expertise in

129 nutrition and public health were involved in the content development of resources. A

130 member of the team who also had expertise in web designing managed the learning

131 platform (uploading the developed materials, storage and access) and further tailored the

132 graphics for the materials. The time required to design and finalise the materials was about

133 140 hours per person spread over 20 weeks. Materials for the intervention were delivered

134 in weekly instalments using the learning platform 'Moodle' which records each participant's

135 'log-in' times, dates and the on-line resources accessed and time spent on each. These data

136 allowed an independent assessment of the use of the materials developed for the

137 interventions. Emailing lists were created for each group, and every week an email was sent,

138 informing participants of the topic for the week, with a password reminder for accessing the

139 new materials that had been uploaded. Materials were posted weekly for 19 weeks with

140 the exception of Christmas and Easter holidays, and remained accessible thereafter.

141 Mailboxes were created for each group to allow communication between participants and

142 feedback to the administrator if necessary.

143

144

145 **Behavioural models**

146 Use of an appropriate behavioural theory to design interventions is associated with larger

147 effect sizes, according to a recent review and meta-analysis[17]. For the present study two

148 contrasting simple theoretical models were used.

149 *Treatment 1 'NOT THE ICE CREAM VAN' (NTICV).* This treatment followed the 'rational

150 model'[18], based on the assumption that people, when provided with information, will make

151 the best choice for themselves with a view to maximising utility. While information

152 exchange has been rather unsuccessful among obese subjects in weight-loss strategies[19],

153 this rational model may fit better with weight-gain prevention. Thus the NTICV programme

154 was directed towards non-obese people and addressed unwanted weight-gain and obesity

155 overtly. The title referred to 'ice cream vans' (vendor trucks), which tour around

156 neighbourhoods daily, as an obesogenic 'vector' which is very familiar to young-adults in UK:

157   this detail can be adapted to suit other cultural situations.

158

159   *Treatment 2 'Goddess Demetra' (GD).* This treatment was based on the 'stealth' model[20]

160   directed at behaviours that are motivating in themselves, the desired outcome being a 'side-

161   effect' of the intervention. This programme (named after the Greek goddess responsible for

162   earth and sustainable food) aimed to prevent obesity covertly, by raising discussion around

163   social and political movements which are associated with more, or less, healthful diets and

164   lifestyles.

165

166   **Statistical Analysis**

167   Analyses were conducted using an intention-to-treat (ITT) approach to enhance

168   methodological study quality[21] as recommended by the CONSORT group for improving the

169   quality of reporting the results from parallel group randomised trials[22]. It aims to protect

170   against threats to validity from attrition or incomplete responses[23] by analysing all data

171   based on each participant's assigned group. For participants who did not provide follow-up

172   data, the mean weight-change of responders in the group was assumed. Analyses of

173   variance (ANOVAs) were conducted at baseline and follow-up to assess for any significant

174   differences among the three groups (two interventions, one control). Independent t-tests

175   were also conducted to test for differences between groups. Pearson correlation was used

176   to examine the strength of relationships between self-reported and measured

177   anthropometric data and Bland-Altman plots were used to assess the degree of agreement

178   for the same.

179

180   **Results**

181   During the study, 1,412 'active participants' (23% of randomised subjects) logged-in at least

182   once to the NTICV programme and 625 (11% of randomised subjects) to GD. Those subjects

183   randomised to intervention groups who subscribed to the groups and accessed the Moodle

184   sites are defined as 'active' participants. Those who received the weekly emails but did not

185   subscribe, and were not actively seeking to be removed from the mailing lists, are defined as

186   'non-active' participants. Twelve subjects asked to be removed from the NTICV mailing list,

187   and three from GD.

188

189   **Weight-changes**

190   Baseline body-weight was provided by 5,903 participants and follow-up body-weight by

191   4,879 (follow-up rate 83%) (**Table 2**). Participants who provided follow-up data did not differ

192   significantly from those who did not, by age, weight, height, or BMI. All weight-change data

193   were found to be approximately normally distributed, using the Smirnov-Kolmogorov test.

194   Mean overall weight-change over the 40-week study-period for all participants (n=5,903)

195   was -0.35 (95% CI -0.6, 0.3) kg. Mean overall weight-change within groups was: control

196   group (n=2,134): +2.0kg (95%CI +1.5, +2.3); NTICV group (n=1,810): -1.0kg (95%CI -1.3, -0.5);

197   and GD group (n=2,057): -1.4kg (95%CI -1.4, - 0.7) (**Table 3, Figure 2**). Weight-changes

198   within groups remained significant (all p<0.001) when analysed separately for men and

199   women.

200

201   Significant weight-loss was seen in both intervention groups for 'active' participants (those

202   who logged in to the group at least once): NTICV (n=1,317) -1.2kg (95%CI -1.6, -0.6) p=0.001,

203   and GD (n=592) -1.5kg (95%CI -1.7, -0.9) p=<0.001. The changes were statistically significant

204   for both men and women when analysed separately. Among 'non-active' participants (who

205   were receiving the weekly emails but never logged into the programmes), there were no

206   significant weight-changes over the 40-week study period: NTICV (n=413): -0.1kg (95%CI -

207   0.3, 0.2), p=0.743, GD (n=1,165): -0.2kg (95%CI -0.5, 0.4) p=0.675.

208   Odds ratios for weight-loss, compared to the control group, were; NTICV=27 (95% CI 21.7-

209   33.6) p<0.0001, GD=43.8 (95% CI 31.0- 62.0) p<0.0001.

210   Relative risks for weight-gain, vs control, were: NTICV=0.13kg (95% CI=0.10, 0.15) p<0.0001;

211   GD=0.07kg (95% CI=0.05, 0.10) p<0.0001.

212

213   **Validation of weights and heights**

214   Measured data were available for 1,448 participants (1,283 from GP data, 165 measured by

215   principal researcher). Pearson correlations between these measures was very high, r=0.998,

216   r=0.999 respectively, with a mean under-report of 0.5kg for weight.

217

218   **Log-in activity and weight-changes**

219   The use of the Moodle platform/week of both interventions fell by approximately 50% for

220   the NTICV and by a third for the GD, during the intervention (**Figure 3**).

221   *Rational Model-NTICV:* Over the study period, 1,412 young-adults (mean age 18.4 SD3.1,

222   68% women) who subscribed as active participants made 10,470 log-ins to the home-page,

223   with 5,410 viewings of weekly-materials. Of these, 305 participants logged in only once, 638

224   participants 2-5 times, 220 participants 6-10 times and 248 participants ≥11 times, up to an

225   individual maximum of 106 log-ins. The average number of log-ins per active participant

226   was 7.2 (SD4.1) up to an individual maximum of 106 log-ins. Mean log-in time per

227   participant was 14.0(7.7) minutes.   There was an inverse correlation (-0.217, p=0.01)

228   between the number of log-ins and weight-change for the NTICV group.

229   *Stealth Model-GD:* 625 young-adults (mean age 21.4SD2.9, 48% women) subscribed to the

230   group, making 5,863 log-ins with 1,233 viewings of weekly-materials.   Of these, 169

231   participants logged in only once, 343 participants 2-5 times, 65 participants 6-10 times and

232   47participants ≥11, up to an individual maximum of 50 log-ins. The average number of log-

233   ins per active participant were 5.4 (SD 3.4), with an individual maximum of 50. Mean log-in

234   time/participant was 17.0(SD 9.1) minutes. There was no significant correlation between

235   log-in frequency and weight-change for the GD group.

236

237   Analysed by weight-change category, both intervention groups showed fewer log-ins among

238   weight-gainers, and more among weight-losers (p=0.034) (**Figure 4**). Analysed separately by

239   gender, log-in frequency was higher among women losing weight, but not men.

240

241   **Discussion**

242   This study evaluated a web-based intervention to prevent weight-gain in young-adults. Two

243   different behavioural models were examined, both of which were associated with avoidance

244   of the increase in body weight usually seen among young-adults in the UK and US, with

245   similar effect sizes. Without intervention, the weight-gain in the control group was similar to

246   that observed in previous studies among young-adults in the UK[16,24]. A 'rational theory'

247   intervention used a culture-specific model appropriate to young-adults in the UK, with the

248   'ice-cream van' as a familiar and eye-catching focus as a weight-gain vector, through which

249   to deliver an overt individually-relevant weight-control programme. A second 'stealth

250   model' aimed to generate interest in food production and marketing and related

251   environmental and political issues, which contribute to overconsumption and weight-gain at

252   a population level. Both interventions were associated with prevention of weight-gain for

253   substantial proportions of young adult who engaged with the programmes, and could be

254   adapted to be delivered using other culture-specific 'hooks' in other countries and for

255   different population sectors.

256

257   Three previous studies[25,26,27] of programmes against weight-gain have been conducted in

258   higher-education settings, all small. Hivert[25] et al randomised 115 students to control, or

259   an intervention group which received seminars on obesity, weight, physical activity, diet,

260   fortnightly for two months and then monthly until 24 months. The control group gained

261   0.7(SD 0.6)kg while the intervention group lost 0.7(SD 0.4)kg (p=0.04). The other studies

262   were all negative. Gow[26] et al tested an online seminar on diet, delivered weekly in a 6-week

263   4-arm randomised trial. Those who received the seminar lost weight but only if combined

264   with self-weighing using scales provided in the gym. Dennis[27] et al assessed two on-line

265   courses based on social cognitive theory, supplemented by face-to-face lessons delivered by

266   an instructor. One of the groups received additional instructions on self-regulation. There

267   was no control group. Thirty nine students who completed the 14-week study gained

268   weight, with no difference between the courses. Other studies, such as that of Lytle et al

269   have incorporated weight loss advice for overweight subjects[28], which sets them apart from

270   our aim to focus entirely on weight-gain prevention in the whole population. A major

271   weakness of all the existing studies was that participants were informed of the study aims,

272   which is likely to have attracted more committed individuals, willing to report weight-

273   change. As well as being much larger, our study was therefore unusual in its more 'realistic'

274   design, randomising all eligible young-adults, and also in collecting weights and heights in a

275   completely separate study, independently from the intervention programmes. We used

276   self-reported data, as the only feasible method to collect information from a large free-living

277   population, but validated them against weights and heights collected independently, openly

278   in one sub-sample and in another covertly from routine measurements made at a health

279   centre.

280

281   For most individuals, preventing weight-gain requires only small shifts in average energy

282   intake or expenditure (50-100kcal/day), a great deal less than that needed for clinically

283   important weight-loss, around 600kcal/day[29]. Our results suggest that engaging on-line with

284   young-adults can help them make such a change in energy balance, sustainably to prevent

285   weight-gain over an academic year. There was benefit not only for those who actively

286   participated in the intervention groups and actually lost weight, but also among 'non-active'

287   participants who merely received the weekly emails (without further engagement) as

288   reminders or 'nudges' towards controlling energy intake/expenditure, and avoided weight-

289   gain. It was not possible to study our subjects beyond 40 weeks, over the subsequent

290   summer vacation. Interestingly, there is evidence that young-adults may gain less weight

291   over the summer, but they do not lose the weight gained over the rest of the year[30].

292

293   None of the existing studies of on-line interventions have reported data on resource usage

294   or links between resource use and weight-changes, from which to judge 'dose-effect'

295   relationships. In our study activity fell approximately by a third in both interventions. This is

296   in agreement with data from online studies aiming at weight loss[31]. Our study found that

297   those who logged into both interventions the most times, lost less weight or had a greater

298   tendency to gain weight. This may reflect greater concern among those with more marked

299   weight problems, but could indicate links between screen-time and other behaviours, such

300   as snacking or sleeping times. Further studies will be needed to define the best 'dose' for

301   this type of intervention and for specific populations.

302

303   There were differences between the patterns of uptake of out two programmes. The

304   'rational' model, directed overtly towards preventing weight-gain, was more popular than

305   the 'stealth' model (response rate 23% vs 11%), and most attractive to young women (68%

306   of participants). The 'stealth' model, interestingly, was more popular among older male

307   students (**supplementary Table 1**). A 'stealth' model of this type has only ever previously

308   been reported in one very small study, with 104 student participants[32]. This quasi-

309   experimental, non-RCT study examined two face-to-face courses, to which students were

310   offered a choice, one focussed on obesity and health (more popular, with 79 participants),

311   the other on health and society (29 participants). Those who chose the course on society

312   and health had the greatest improvement in their eating habits, assessed by food-

313   frequency, but subjects' weights were not recorded.

314

315   There are inevitably limitations inherent in research of this kind: several have already been

316   discussed, and our results may not all able to be extrapolated to other settings, even after

317   appropriate redesign of the models. The present study was conducted in only one centre,

318   albeit large and broadly representative of similar higher education settings, and among an

319   educated, but not elite, population sector. The intention-to-treat analysis used in this study

320   may overestimate the effect size of the intervention and there are other more conservative

321   methods that could have been used[33]. Reassuringly, though, even when our data was

322　analysed as per protocol, results remained significant. All studies of public health

323　interventions have limitations in relation to predicted reach, impact and sustainability. This

324　study was large in terms of the eligible participant-base, and targeted young-adults, a hard-

325　to-reach and relatively under-researched, even neglected, group at a life-stage associated

326　with rapid weight-gain[16]. Designing effective interventions specific to young-adults is

327　challenging, with many competing elements aiming to attract their attention. Elearning has

328　several advantages compared to traditional approaches, especially for young-adults, such

329　as ease of tailoring to individual circumstances; translating complex information through

330　video, graphics and audio systems; and cost savings on face-to-face interventions. It is

331　unlikely that any single on-line programme would suit the needs and interests of all young-

332　adults, and our two interventions appealed to different segments. Clearly there is interest

333　both in weight-control and in the environmental issues around food among young people.

334　Outside the confines of a randomised trial, there would be no reason to offer only one

335　programme, and greater engagement could be encouraged with supporting local advertising

336　and use of social media. A common theme from qualitative evaluation of the program was

337　that students did not actively engage as did not pay attention to the email due to the

338　volume of emails they receive. This is something to be addressed by supporting advertising

339　if the intervention is introduced routinely outside the RCT setting.

340

341　Effective interventions to prevent weight-gain among young-adults, even with very modest

342　effect sizes, would have massive public health value if they are sustainable and reach

343　substantial sections of the at-risk population. The low cost and simplicity of on-line

344　interventions makes sustainability more likely since access to the internet and social media

345　is uniformed across all socio-economic status, in the young. Programmes should be adapted

346　to the targeted population's needs, otherwise health inequalities will increase. University

347　students used to represent a highly educated elite sector, but that is no longer the case in

348　obesity prone European and North American countries: half of all young-adults now attend

349　universities in the UK[34].   Inevitably, self-selection defines response rates and the

350　characteristics of non-responders may be different. For NTICV, the response rate of 23%

351　probably represents a substantial proportion of those who were currently fighting

352   overweight, or perceived that they were at risk of weight-gain. Similarly, it is possible that

353   those who elected to participate actively with the GD 'stealth' intervention could also

354   represent a section of young-adults with unusual attitudes or physical characteristics. It was

355   important therefore to see that baseline weights and BMIs in the control group were very

356   similar to those in the two intervention groups, and that the active and non-active

357   participants had similar BMIs.

358

359   To conclude, two online interventions, based on 'rational' and 'stealth' behavioural models,

360   both proved successful in preventing the expected weight-gain observed in young-adults. An

361   online platform provides a simple and low-cost way to reach large segments of a targeted

362   population for weight-gain prevention. The programmes developed could easily be

363   replicated and adapted for a wider young adult population, and in other settings. Adding

364   promotion through social media could enhance uptake and effectiveness when outside the

365   RCT setting.

366

372   **Conflicts of interest**

373   The authors declare no conflicts of interest.
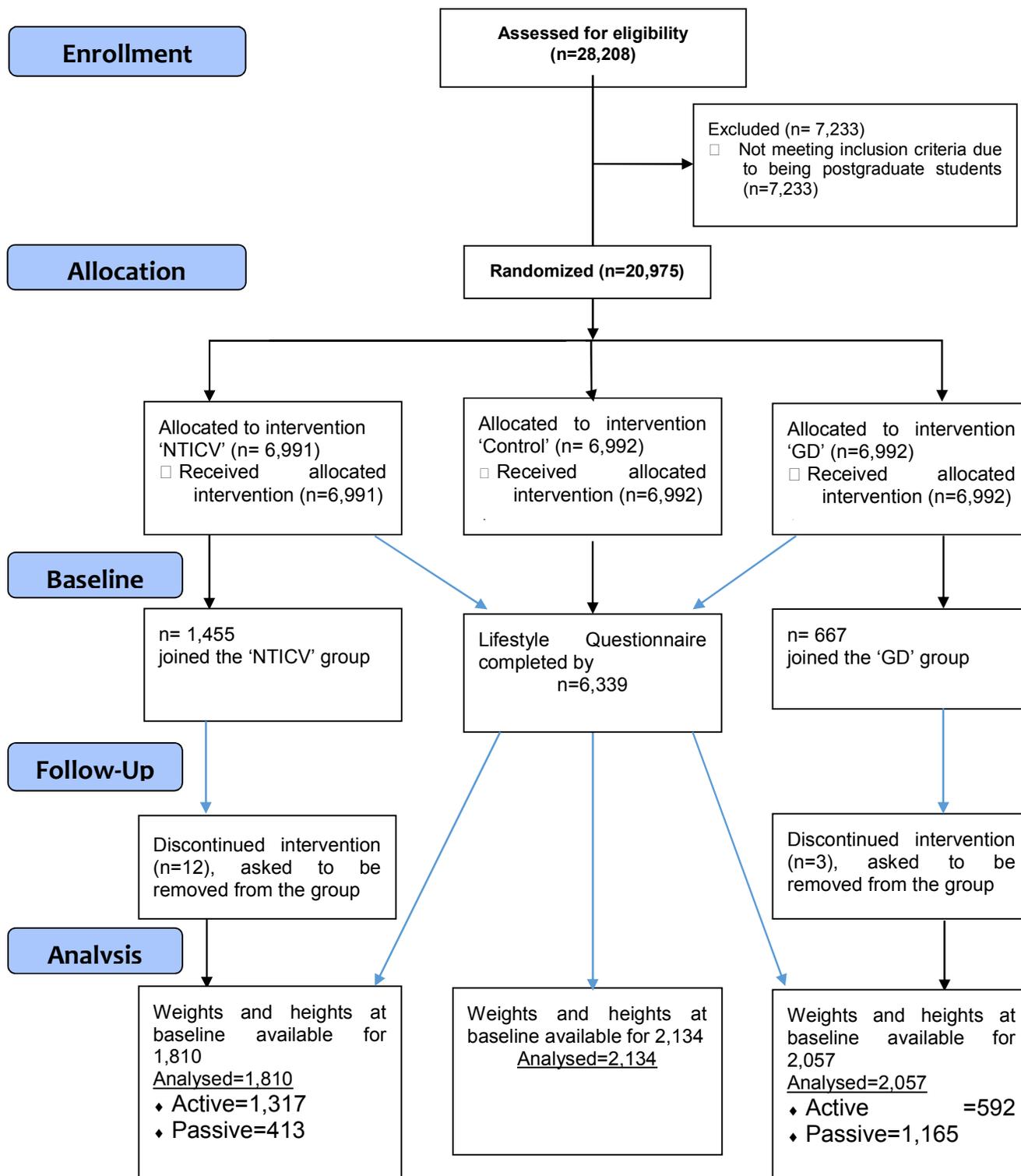
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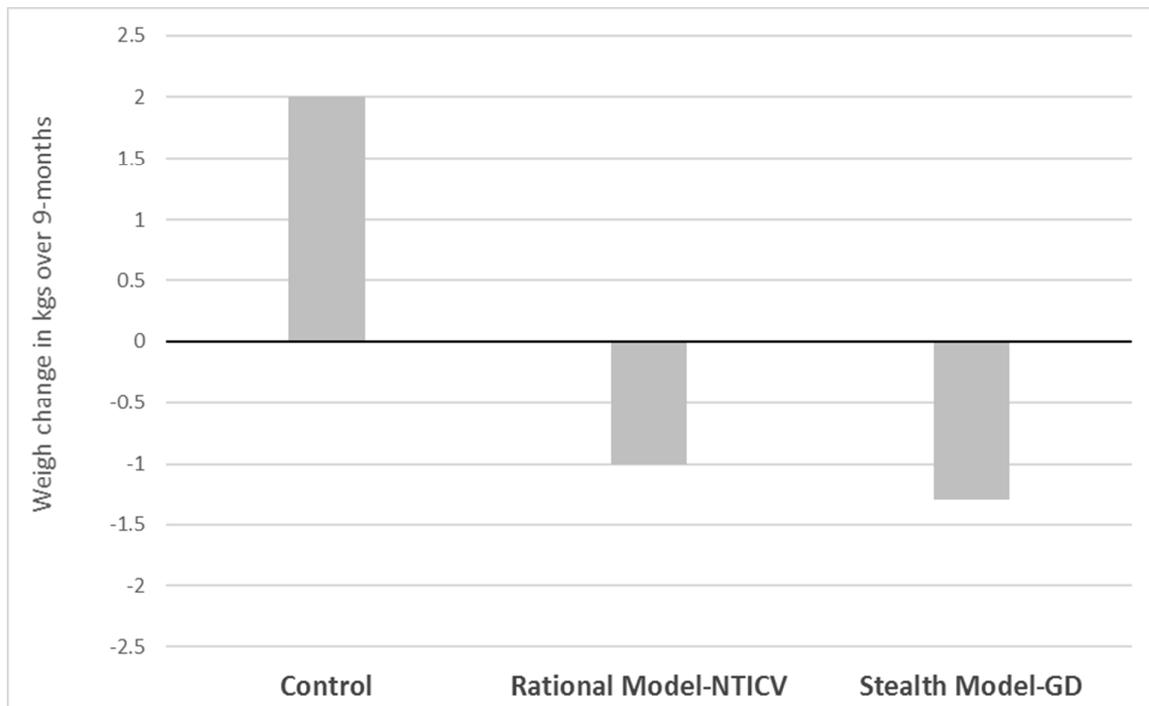438   23. Spilker B. Guide to clinical trials. Raven, New York Stead LF.1991.

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Figure 1: Study Flowchart

Enrollment	Assessed for eligibility (n=28,208)	

Excluded (n= 7,233)
  Not meeting inclusion criteria due to being postgraduate students (n=7,233)

Allocation — Randomized (n=20,975)

Allocated to intervention 'NTICV' (n= 6,991)
  Received allocated intervention (n=6,991)

Allocated to intervention 'Control' (n= 6,992)
  Received allocated intervention (n=6,992)

Allocated to intervention 'GD' (n=6,992)
  Received allocated intervention (n=6,992)

Baseline

n= 1,455 joined the 'NTICV' group

Lifestyle Questionnaire completed by n=6,339

n= 667 joined the 'GD' group

Follow-Up

Discontinued intervention (n=12), asked to be removed from the group

Discontinued intervention (n=3), asked to be removed from the group

Analysis

Weights and heights at baseline available for 1,810
Analysed=1,810
♦ Active=1,317
♦ Passive=413

Weights and heights at baseline available for 2,134
Analysed=2,134

Weights and heights at baseline available for 2,057
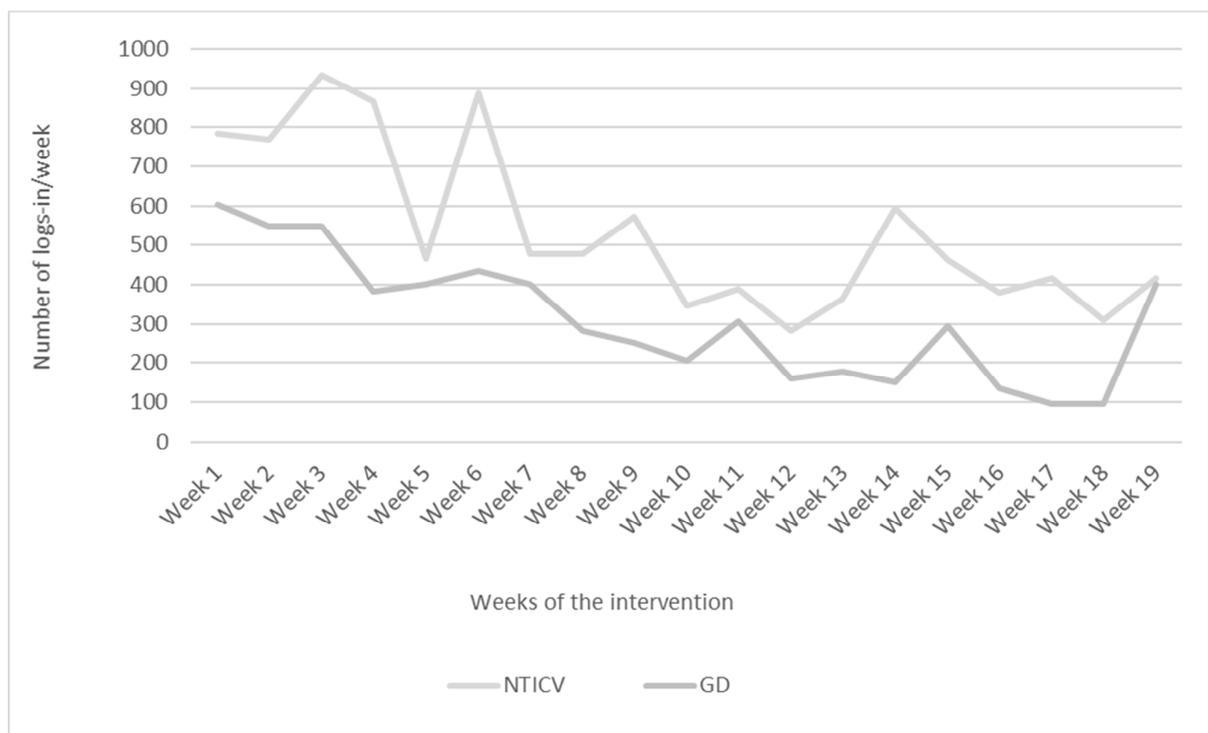Analysed=2,057
♦ Active   =592
♦ Passive=1,165
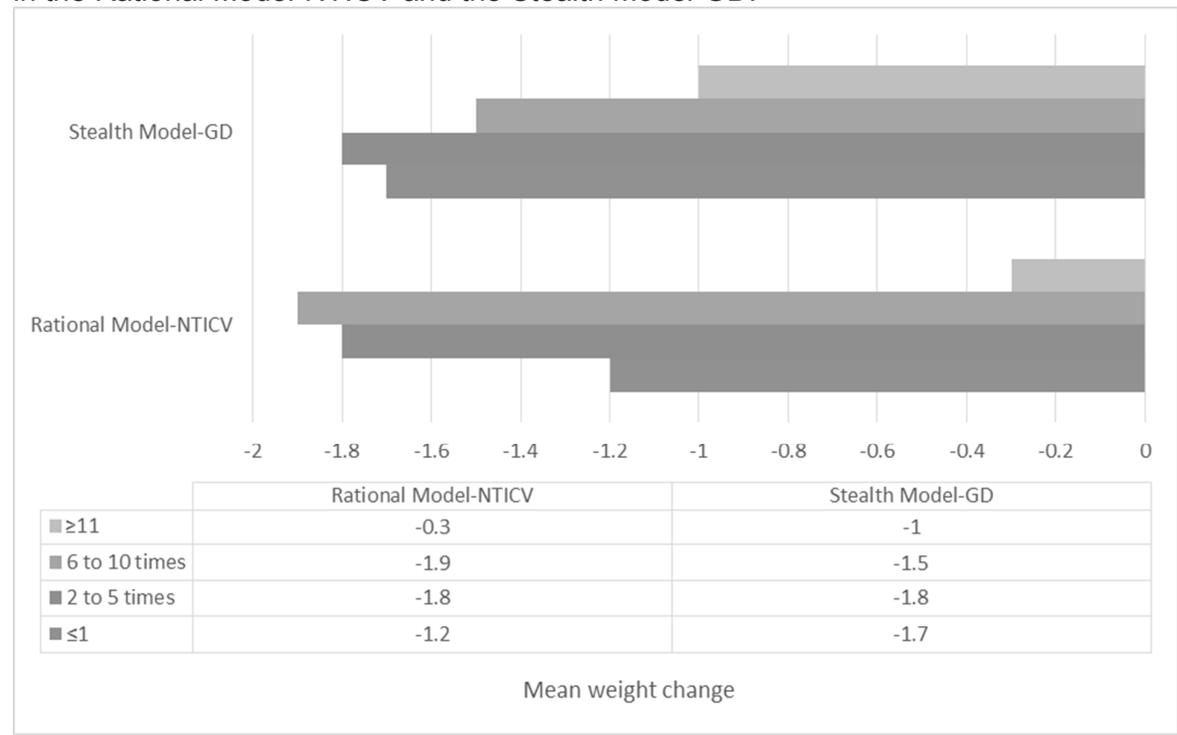
*NTICV=Not The Ice Cream Van, GD=Goddess Demeter

Figure 2: Weight-changes reported in a 9-month study period among participants in the; control group, Rationale Model-NTICV (overtly targeting weight control), and Stealth Model-GD (covertly targeting diet and lifestyles).

Figure 3: Weekly activity in logs for the duration of the study for the two interventions

Figure 4: Logs in quartiles and mean weight change per quartile for the participants in the Rational Model-NTICV and the Stealth Model-GD.

	Rational Model-NTICV	Stealth Model-GD
■ ≥11	-0.3	-1
■ 6 to 10 times	-1.9	-1.5
■ 2 to 5 times	-1.8	-1.8
■ ≤1	-1.2	-1.7

Mean weight change

Table 1: Weekly topics of the two interventions, NTICV (the group based on the rational model) and GD (the group based on the 'stealth' model)

Week	NTICV	GD
1	Weight, BMI, & waist circumference	Carbon footprint
2	Calories/energy & food myths	Cultivation
3	Calories/energy & alcohol	Sustainable Meat
4	Cupboard & cooking essentials	Sustainable Fish
5	Sugary & energy drinks	Food miles
6	Eating during exams	Fresh vs Frozen
7	Eating during Christmas	Christmas Marketing
8	New Year's Resolution	New Year's Resolutions
9	Snacking	Vending machines & snacks
10	Salt	Salt
11	Fat	Fat-Free products
12	Popular Diets	Marketing of diets
13	Ready Meals	Ready meals
14	Marketing	Supermarkets
15	Physical Activity	Food and Drink companies
16	Fast Food	Fast vs Slow food
17	Food Labels	Genetically modified products
18	Negative Calories	The power of marketing
19	Summary	Summary

Table 2: Participants characteristics, at baseline, by treatment group

| Characteristic	All	Control	Treatment 1 NTICV (Rational Model)	Treatment 2 GD (Stealth Model)
n	5,903	2,134	1,810	2,057
Gender (% Female)	60	62	63	55
Age (years)	19.8 (3.1)	19.6 (3.2)	18.8 (3.1)	21.1 (3.0)
Weight (kg)	66.0 (13.4)	64.9 (12.6)	65.4 (13.1)	67.9 (14.6)
Height (m)	1.71 (0.1)	1.7 (0.1)	1.7(0.1)	1.72 (0.1)
BMI (kg/m^2)	22.3 (4.6)	22.2 (4.4)	22.3 (4.6)	22.6 (4.9)

All data mean and standard deviation (SD)

Table 3: Participant characteristics at baseline and follow up, and weight-changes in the 9-month study period, by treatment group (Intention to treat analysis)

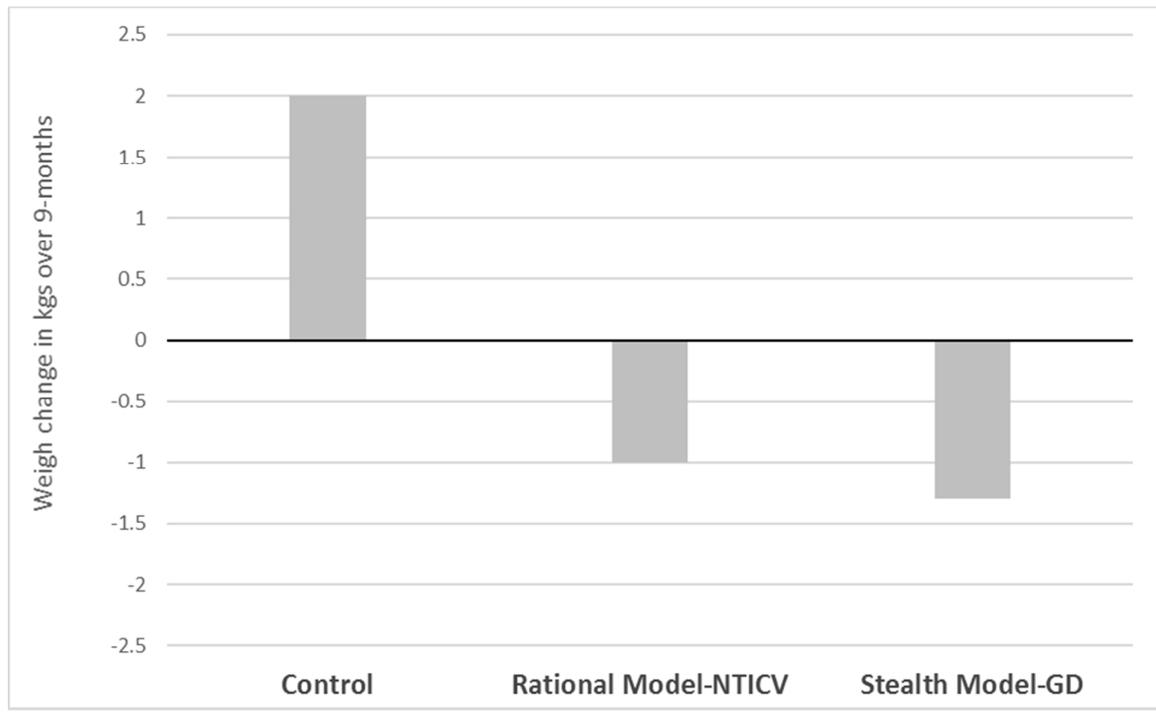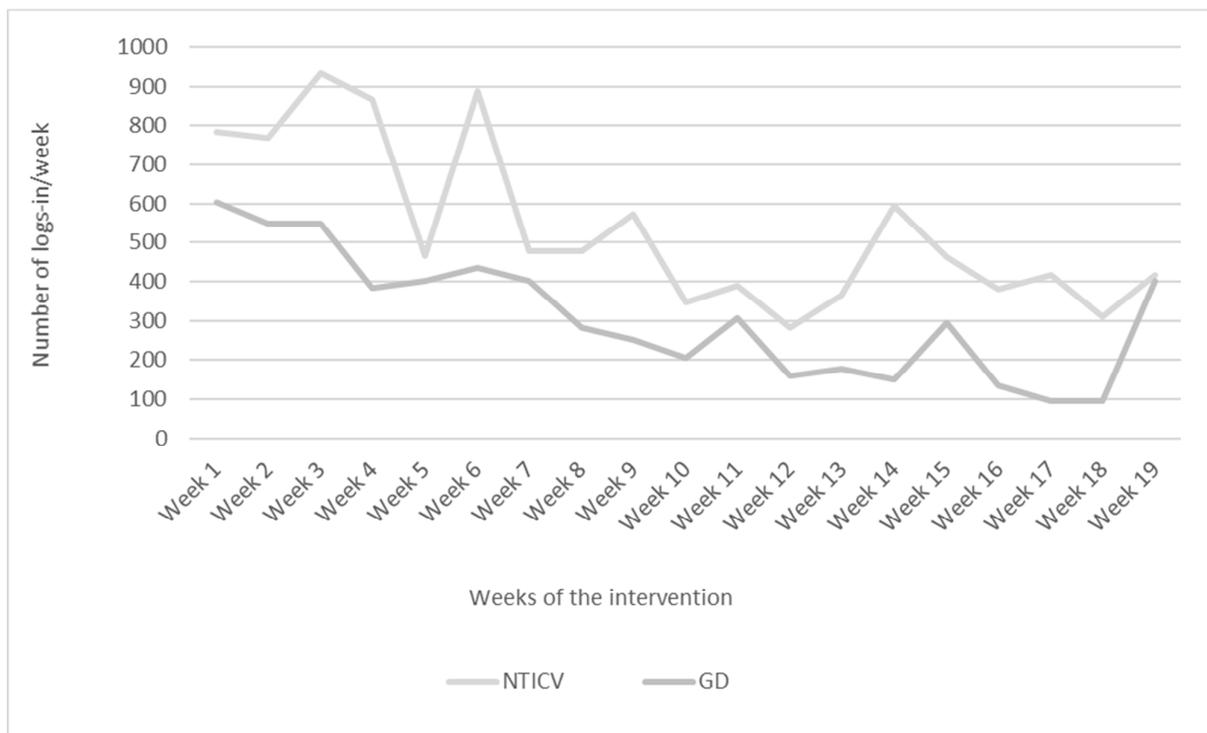| | Weight changes | | | |
	Baseline	Follow-up	Change	P value
Weight				
Control	64.9 (12.6)	66.9 (13.2)	+2.0(1.1)	<0.001
Rational Model (NTICV)	65.4 (13.1)	64.4 (11.5)	-1.0(0.7)	0.001
Stealth Model (GD)	67.9 (14.6)	66.5 (14.2)	-1.3(0.4)	<0.001
BMI				
Control	22.2 (4.4)	22.5 (4.7)	+0.3(0.2)	<0.001
Rational Model (NTICV)	22.4 (4.6)	22.3 (4.1)	-0.1(0.1)	<0.001
Stealth Model (GD)	22.6 (4.9)	22.5 (4.8)	-0.1 (0.1)	0.02

*All data mean (SD)

Figure 1: Study Flowchart
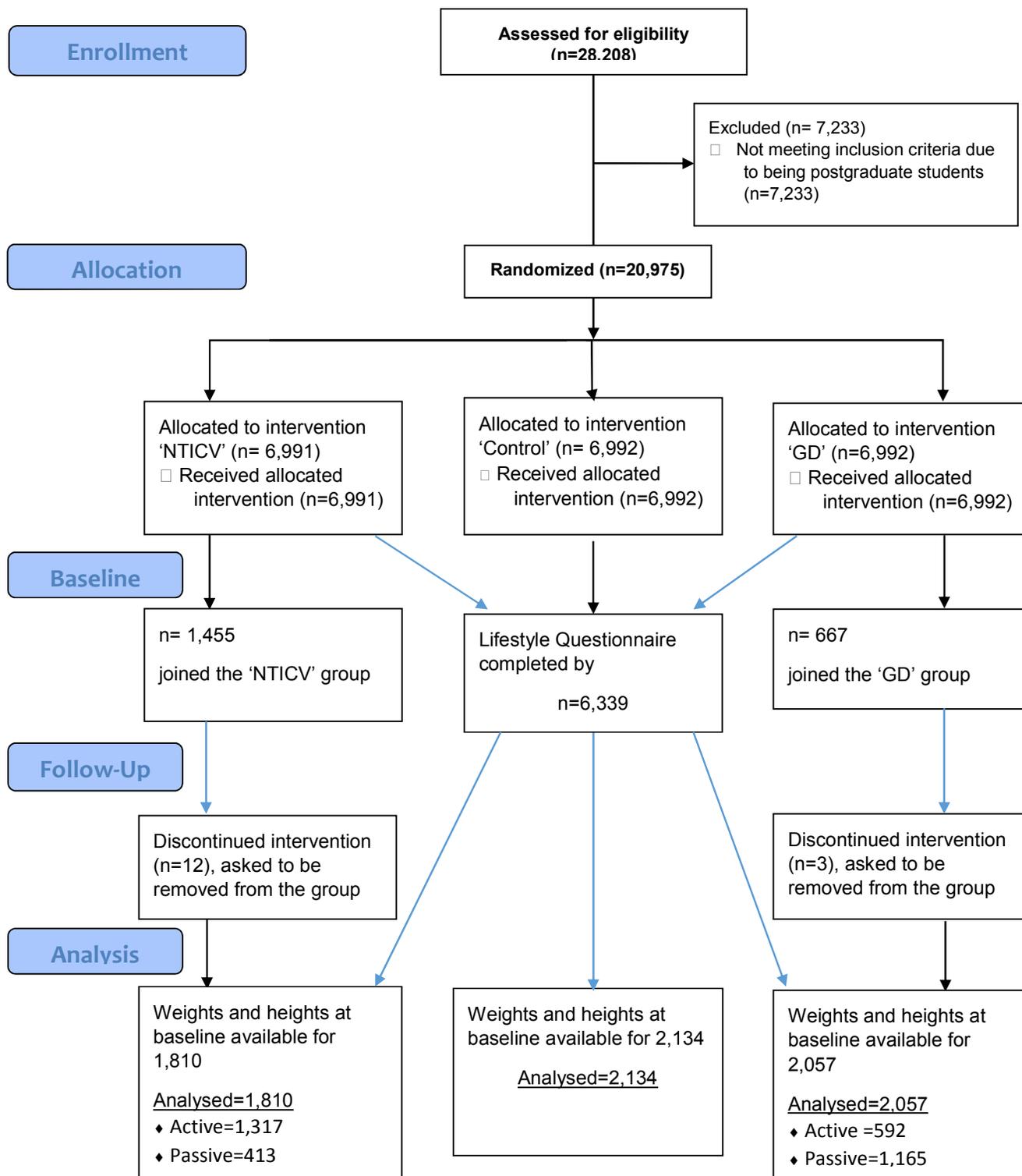
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Mean weight change
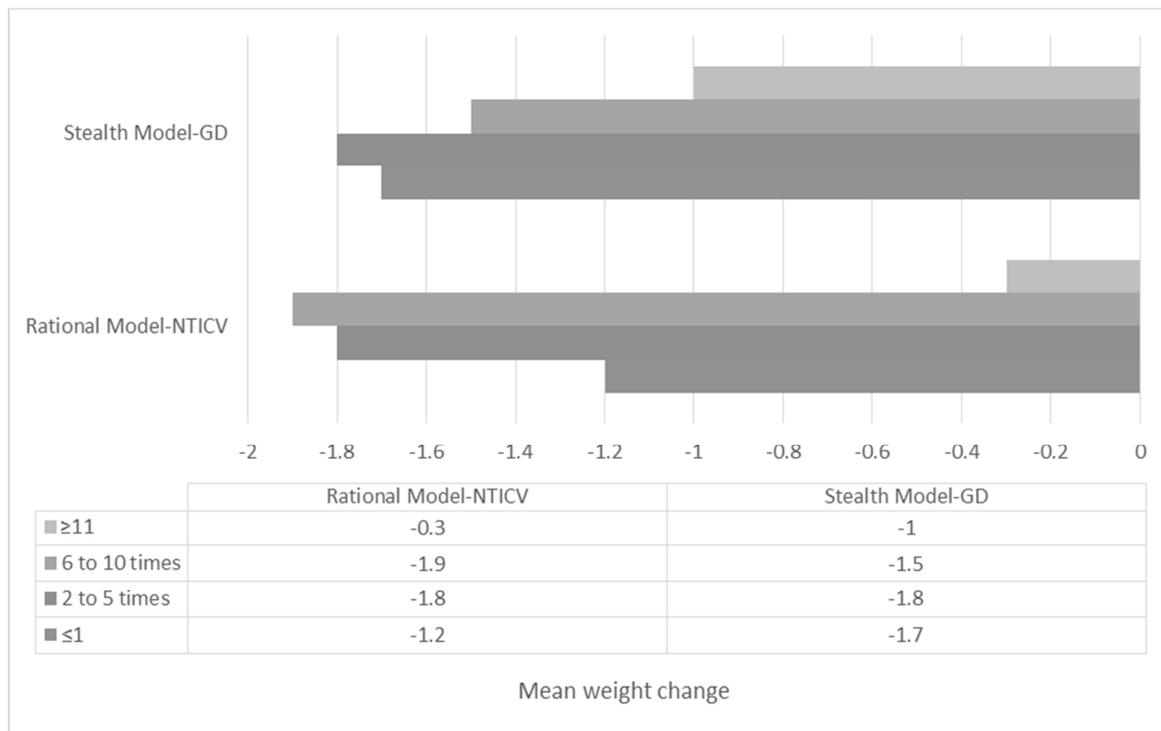
Supplementary Table: 'Active' and 'Non-active' participants' characteristics, at baseline

Characteristic	Treatment 1 NTICV Active Group (Rational Model)	Treatment 2 GD Active Group (Stealth Model)	Treatment 1 NTICV Non-Active Group (Rational Model)	Treatment 2 GD Non-Active Group (Stealth Model)
n	1,317	592	413	1,165
Gender (% Female)	68***	52***	58	58
Age (years)	18.7*** (3.0)	22.3*** (2.5)	18.8 (3.2)	19.9 (3.5)
Weight (kg)	65.1*** (12.9)	69.2*** (13.8)	65.7 (13.3)	66.6 (15.4)
Height (m)	1.69**(0.1)	1.73** (0.1)	1.7 (0.1)	1.71 (0.1)
BMI (kg/m^2)	22.2** (4.2)	22.9** (5.2)	22.4 (4.6)	22.3 (4.6)

All data mean and standard deviation (SD)

x^2-tests were used for categorical variables and t-test for nominal variables

*p<0.05

**p<0.01

***p<0.001