

Effects of physical activity calorie equivalent food labelling to reduce food selection and consumption: systematic review and meta-analysis of randomised controlled studies

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ABSTRACT

Background There is limited evidence that nutritional labelling on food/drinks is changing eating behaviours. Physical activity calorie equivalent (PACE) food labelling aims to provide the public with information about the amount of physical activity required to expend the number of kilocalories in food/drinks (eg, calories in this pizza requires 45 min of running to burn), to encourage healthier food choices and reduce disease.

Objective We aimed to systematically search for randomised controlled trials and experimental studies of the effects of PACE food labelling on the selection, purchase or consumption of food/drinks.

Methods PACE food labelling was compared with any other type of food labelling or no labelling (comparator). Reports were identified by searching electronic databases, websites and social media platforms. Inverse variance meta-analysis was used to summarise evidence. Weighted mean differences (WMD) and 95% CIs were used to describe between-group differences using a random effects model.

Results 15 studies were eligible for inclusion. When PACE labelling was displayed on food/drinks and menus, significantly fewer calories were selected, relative to comparator labelling (WMD=−64.9 kcal, 95% CI −103.2 to −26.6, $p=0.009$, $n=4606$). Presenting participants with PACE food labelling results in the consumption of significantly fewer calories (WMD=−80.4 kcal, 95% CI −136.7 to −24.2, $p=0.005$, $n=486$) relative to comparator food labelling.

Conclusion Based on current evidence PACE food labelling may reduce the number of kilocalories selected from menus and decrease the number of kilocalories/grams of food consumed by the public, compared with other types of food labelling/no labelling.

Trial registration number CRD42018088567.

INTRODUCTION

Obesity is a key contributor to many nutrition-related chronic diseases including type 2 diabetes, cardiovascular disease and cancer.^{1–3} There has been no long-term success in reducing obesity rates and changing behaviour to halt and reverse rises to prevent disease is difficult. There is growing recognition that this is in part due to the physical environments that surround the public, which can exert considerable influences on health behaviours.⁴

One way of reducing kilocalorie (herein referred to as calorie) consumption is nutritional labelling but current evidence shows that current front-of-pack (FoP) nutrition information on food/drinks is having a limited effect on changing purchasing or eating behaviours.^{5 6} Many people do not understand the meaning of calories or grams of fat in terms of energy balance. A key challenge to limiting energy consumption is the significant underestimation by the public of the amount of calories/fat in food/drinks.^{7 8}

An alternative approach to current nutrition labelling, in and out of home settings, is providing calorie information with a clear interpretation of what the calorie content of the item/meal means in terms of energy expenditure. This approach has been termed physical activity calorie equivalent (or expenditure) (PACE) labelling, which aims to show the public how many minutes (or miles/kilometres) of physical activity (eg, walking or running) are equivalent to the calories contained in food/drinks.⁹ For example, ‘the calorie in this chocolate bar requires 55 minutes of walking to burn off’ (figure 1). PACE food labelling could be a useful tool to help the public understand what a calorie means and therefore more able to decide whether the calories are ‘worth it’.¹⁰ PACE labelling is an example of an environmental intervention that seeks to nudge the public towards making healthy food choice and to demonstrate restraint in their eating.¹¹ Unlike other types of food labelling, PACE labelling has the potential to serve as a continual reminder to the public about the importance of participating in regular physical activity to ensure good energy balance. There is also observational evidence that the public prefer PACE food labelling over other types of food labelling.¹²

The Royal Society for Public Health in the UK has called for PACE labelling to be implemented as an FoP food labelling, but evidence to support this view is lacking.¹³ A systematic review of PACE labelling was published recently and showed no effect. However, the review included only a small number of studies ($n=7$) and only the impact of PACE labelling on the number of calories selected from menus was assessed, not the amount of food actually consumed, which is what impacts health.¹⁴ This systematic review aims to provide up-to-date synthesis of the evidence regarding the effects of



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Figure 1 Examples of physical activity calorie equivalent (PACE) labelling.

PACE food labelling and estimate its potential impact on the selection, purchase and consumption of food/drinks, to inform future implementation of PACE food labelling.

METHODS

Registration and reporting

This meta-analysis has been reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses and was registered with PROSPERO on 12th December 2018.

Selection of studies

We aimed to be inclusive as possible and identify randomised controlled trials (RCT) and randomised controlled acute experimental studies that reported data relating to the effects of PACE labelling on the selection, purchase or consumption of food/drinks (non-alcoholic). Both between-subject and within-subject designs were suitable for inclusion. A scoping search was conducted (by SB and AC) initially, focusing on systematic reviews, some background and grey literature to estimate the volume of research on this question. Our initial searches of principal biomedical databases (MEDLINE, MEDLINE In Process, EMBASE) combined terms for exercise and physical activities with terms for food labelling. The initial search strategy used a combination of sensitivity and precision alongside the blending of indexing terms with free-text searches. The main searches covered the following electronic databases:

MEDLINE (Ovid), MEDLINE In Process (Ovid), EMBASE (Ovid), CINAHL (EBSCO) and Science Citation Index SCI (Web of Science). Conference Proceedings Citation Index (Web of Science), ZETOC and Electronic Theses Online (ETHOS) were also searched, as were appropriate websites and sources of grey literature, including social media platforms. A full list of grey literature and social media platforms can be found in the online supplementary file 1. Registers of ongoing trials were examined for research in progress (ClinicalTrials.gov, WHO International Clinical Trials Registry Platform and Cochrane CENTRAL Register of Controlled Trials). There were no date or language limits. In addition, a brief search of the last 12 months (prior to the end search date in the next paragraph) of PubMed ensured no more recent studies and as yet unindexed studies were missed.

A detailed description of the MEDLINE search strategy is provided in the online supplementary file 1. The main database searches took place between 16 February and 6 March 2018. Searches of other resources took place between 16 February and 28 March 2018. Reference lists of relevant and related publications were hand searched for additional studies that were not identified by the main searches.

Inclusion and exclusion criteria

Studies were eligible for inclusion if participants were randomly allocated to study conditions/groups, if participants were exposed to study conditions in a random order, or menu conditions in study locations were displayed in a random order. Conditions or interventions needed to have focused on assessing the effect or impact of PACE labelling on the selection, purchase or consumption of food/drinks, in any setting, context or population to be eligible for inclusion. Studies involving children were eligible. Only studies written in English were eligible, as were published dissertations. Studies were excluded if there was no comparator group or if the aim was to assess the selection/purchases of food for others to consume. PACE labelling could be included as a single intervention or cointervention. Initial title screenings and abstract review was undertaken by two independent reviewers (AD and HMP). Full texts of potentially eligible studies were then retrieved and assessed for eligibility by two independent reviewers (AD and HMP). Any disagreement over the eligibility of studies was resolved through discussion with a third reviewer (EM).

Study characteristics and data extraction

Study characteristics were extracted and summarised by two independent reviewers (AD, HMP, EM). The following data were extracted where applicable: study setting, country, participants, setting, type of study, methodology, outcomes and results. Study authors were contacted by email for additional information when required. The means and SDs (or other sources of variation) were also extracted and independently checked by two reviewers.

Risk of bias

The risk of bias within the included studies was assessed using the Review Manager V.5.3 risk of bias software tool. Risk of bias assessments were conducted by two independent reviewers (AD and HMP). For the criterion 'other bias', studies were assessed according to three subcriteria. Studies needed to meet all three of the following criteria to be considered free from other bias: between-group design adopted, groups generally balanced at baseline and whether the population recruited was likely to produce generalisable findings.

Outcomes and data synthesis

Data on the selection, purchase or consumption of food/drinks in relation to number of kilocalories (calories), grams of food or number of food/drink items were extracted from included studies. We combined studies using an inverse variance meta-analysis with Review Manager. Weighted mean differences (WMD) and 95% CIs were used to describe between-group differences using a random effects model. Heterogeneity was assessed using the I^2 statistic.¹⁵ Where studies contributed more than one intervention or comparator group to the analysis or subgroup analyses we divided the number of participants in a group by the number of comparisons that group contributed to in the analysis. PACE labelling is a new concept and our aim was to summarise as much of the available data as possible. Therefore, as per previous studies,¹⁶ when studies used within-subject designs, data were treated as though they were from between-subject studies and we conducted a sensitivity analysis to investigate the effect of within-subject design studies on the overall effect of PACE labelling on the selection of food. The primary analysis compared PACE labelling with any other type of labelling or no labelling (comparator). Subgroup analyses were conducted according to type of comparator food labelling and no labelling. We did not make comparisons between different types of PACE labelling. If studies reported CIs or SEs we converted these data to SDs. Only one trial reported data related to purchasing, therefore meta-analysis of this outcome was not performed. A funnel plot was conducted but not presented here as there were less than 10 studies in any comparison and can be obtained from the first author on request.

RESULTS

A total of 2331 reports were identified through our search strategy and 288 reports were screened based on title and

abstract, with 38 full-text reports screened in full. Reasons for exclusion are listed in figure 2. Fourteen reports (15 studies) were considered as eligible.^{17–30} Montford *et al* reported four independent studies in one publication, two of which were eligible for inclusion here (studies 1 and 3).²⁸ Of included studies, one was a cluster RCT,²⁹ eight were hypothetical food selection trials,^{17–24} and five trials (six reports) involved food consumption.^{25–28 30} One trial assessed food purchasing.²⁹ Nine trials assessed the number of calories selected.^{17–24 27} One trial assessed the purchasing of drinks only.²⁹ Three trials used variations of within-subject repeated measures designs.^{24 25 30} The trial by Platkin *et al*²⁶ was considered a between-subject design as only data from lunch 2 were used and relevant here. All studies except Bleich's study reported data on adults.²⁹ See online supplementary file 2 for study characteristics. The trial by Hartley *et al*²⁵ included a fake labelling condition which was not relevant and excluded. Data relating to postexposure to labelling were used in the meta-analysis.

Effects of PACE labelling on selection of food/drinks

When PACE labelling was displayed on food items and menus, on average, the public selected significantly less calories (WMD=−64.9 calories, 95%CI −103.2 to −26.6, $p=0.009$, $n=4606$). Significant heterogeneity was present ($I^2=87%$). The sensitivity analysis where within-subject design studies ($n=1$)²⁴ were removed from the analysis reduced the overall effect for PACE labelling (WMD=−37.2 calories, 95%CI −61.4 to −13.0, $p=0.003$, $n=4515$) and heterogeneity was 60%. In subgroup analyses PACE labelling was more effective than no labelling (WMD=−103.4 calories, 95%CI −158.9 to −47.9, $n=2065$, $I^2=71%$). Comparisons of PACE labelling versus other types of food labelling are reported in figure 3.

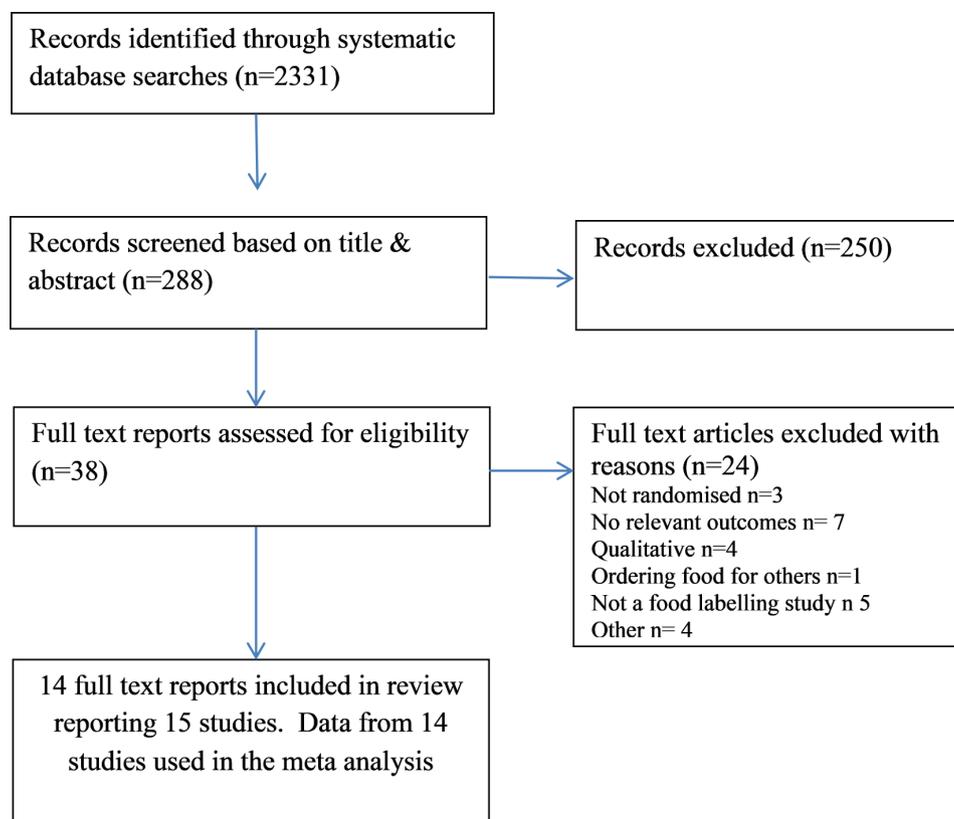


Figure 2 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

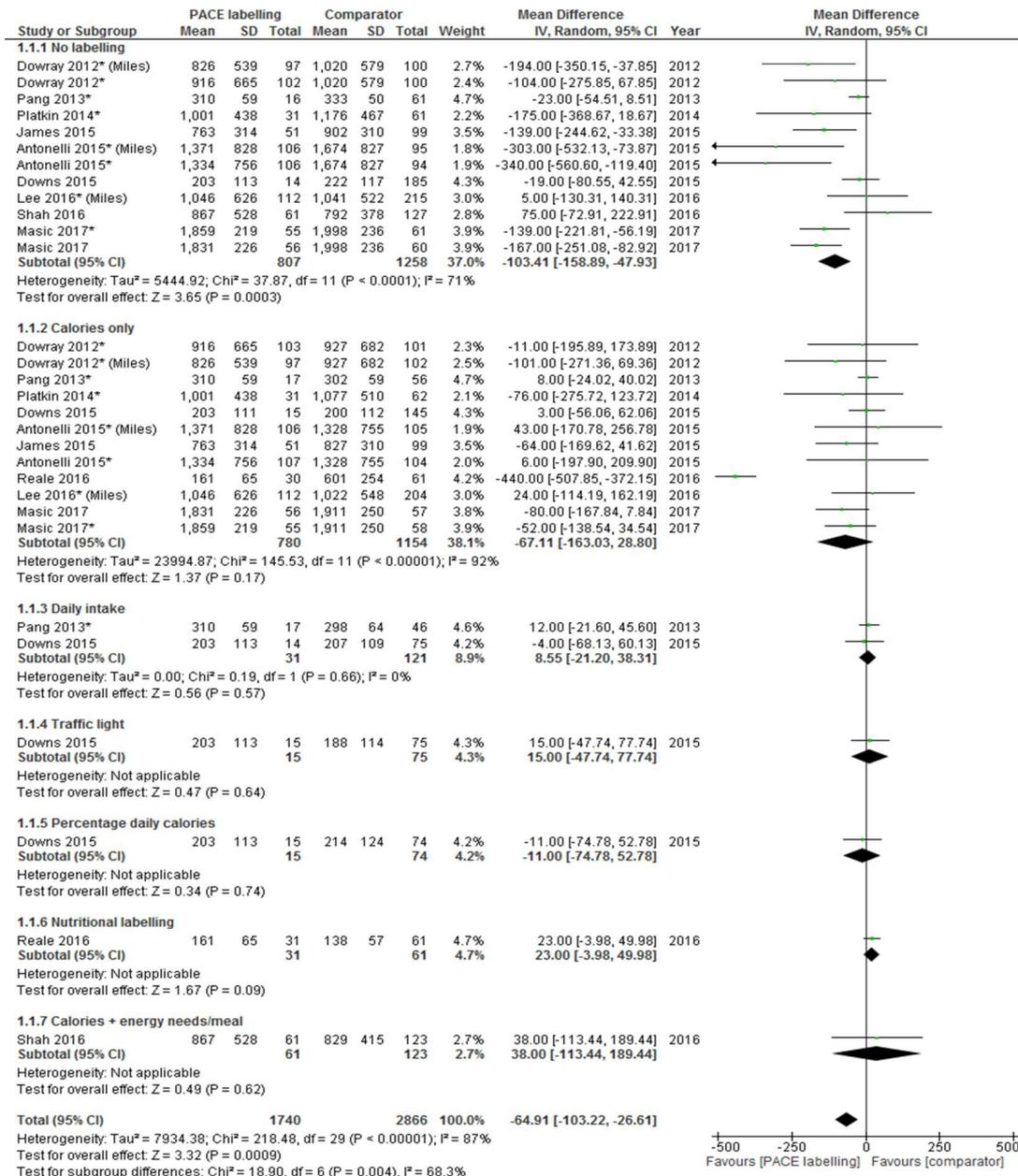


Figure 3 Physical activity calorie equivalent (PACE) labelling compared with comparator labelling (calories selected from menus). Note: *denotes PACE labelling as a co-intervention with additional labelling. The report by Masic reported medians and means and standard deviations were provided by the authors. Additional data and information to facilitate the meta-analysis was provided by the authors of three studies.^{17 21 22}

Effects of PACE labelling on purchasing of food/drinks

The study by Bleich *et al* did not report data suitable for meta-analysis.²⁹ No significant difference in the number of purchases of sugar and sweetened beverages (SSB) between labelling conditions was reported by the authors. Compared with providing no information, PACE labelling reduced the odds of a purchase of SSBs by 50% (OR=0.51, 95% CI 0.31 to 0.85) and percentage of daily intake labelling reduced purchases by approximately 40% (OR=0.59, 95% CI 0.34 to 1.02). Calorie-only labelling had no effect.

Effects of PACE food labelling on the number of calories of food/drinks consumed

The inclusion of PACE labelling on food packaging/display and menus resulted in the consumption of significantly less calories (WMD=-80.4 calories, 95% CI -136.7 to -24.2, p=0.005,

n=486) than when other types of labelling or no labelling was provided (non-significant heterogeneity) (figure 4). Subgroup analyses showed that PACE labelling was more effective than no labelling (WMD=-109.9 calories, 95% CI -189.6 to -30.2, p=0.007, n=243) but not calorie-only labelling (WMD=-51.2 calories, 95% CI -130.7 to 28.3, p=0.21, n=243). Sensitivity analysis was not conducted because these results above were already based on the two included within-subject studies.

Effects of PACE labelling on the amount of grams of food/ beverages consumed

PACE labelling resulted in the public consuming less grams of food (WMD=-8.3 g, 95% CI -14.1 to -2.5, p=0.005, n=1145) relative to comparators, but with significant heterogeneity (I²=91%) (figure 5). In a sensitivity analysis excluding within-subject studies and involving two studies of nutritional

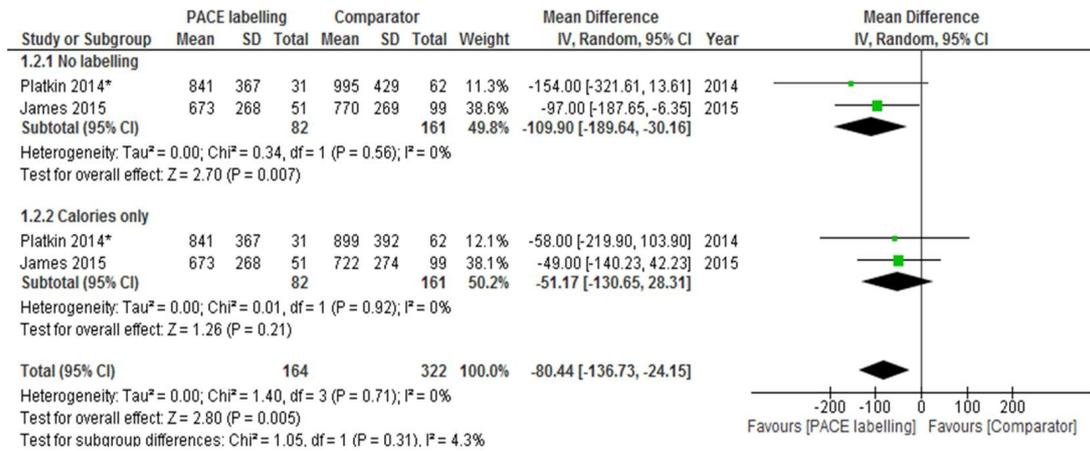


Figure 4 Physical activity calorie equivalent (PACE) labelling compared with comparator labelling/no labelling (calories consumed). Note: *denotes PACE labelling as a co-intervention with additional labelling.

labelling as the comparator,^{25 30} the effect of PACE labelling was increased (WMD = -27.1 g, 95% CI -33.8 to -20.4, p < 0.00001, n = 225) with heterogeneity at 5%.

Risk of bias

For most studies we were not able to assess whether risk of bias criteria were met and therefore most studies were considered unclear. Only 2/15 studies clearly stated the generation process for random sequence allocation, 3/15 stated that allocation concealment had occurred, 5/15 blinded participants/study personnel and 2/15 included the blinding of outcome assessments. A total of 2/15 studies met the criteria for reporting complete outcome data and zero study met the criteria for no reporting bias (selective reporting) and 4/15 were considered free from other biases. See online supplementary file 3. The overall summary evidence according to Grading of Recommendations Assessment, Development and Evaluation³¹ is not reported due to the large number of unclear risk of bias assessments.

DISCUSSION

PACE labelling shows some promise in reducing the number of kilocalories (calories) selected from menus, as well as the number of calories and the amount of food (grams) consumed by the public, relative to comparator food labelling/no labelling.

However, the number of studies in the comparisons of PACE labelling with calorie and nutritional labelling for the outcome number of calories/grams of food consumed was small and heterogeneity was present for some comparisons. The trial not included in the meta-analysis also reported PACE labelling decreased the number of purchases of SSBs.²⁹ Based on current evidence this systematic review showed that PACE labelling is more effective than no food labelling and other types of food labelling.

Our findings are not consistent with the review by Seyedhamzeh,¹⁴ which reported no effect from PACE labelling on the number of calories selected from menus. However, the previous review included only a small number of low-quality trials and did not assess the number of calories consumed or purchased. We were able to include 15 trials of varying quality. Most of the evidence has been from laboratory settings or hypothetical meal selection scenarios but it is possible that the effects of PACE food labelling may vary according to context (eg, restaurants and supermarkets) and/or eating occasions (eg, snacks vs meals). Future research should investigate the effects of PACE labelling in more real-life or naturalistic settings. Real-life studies would introduce variables that are not present during hypothetical studies (eg, marketing, price, time constraints).

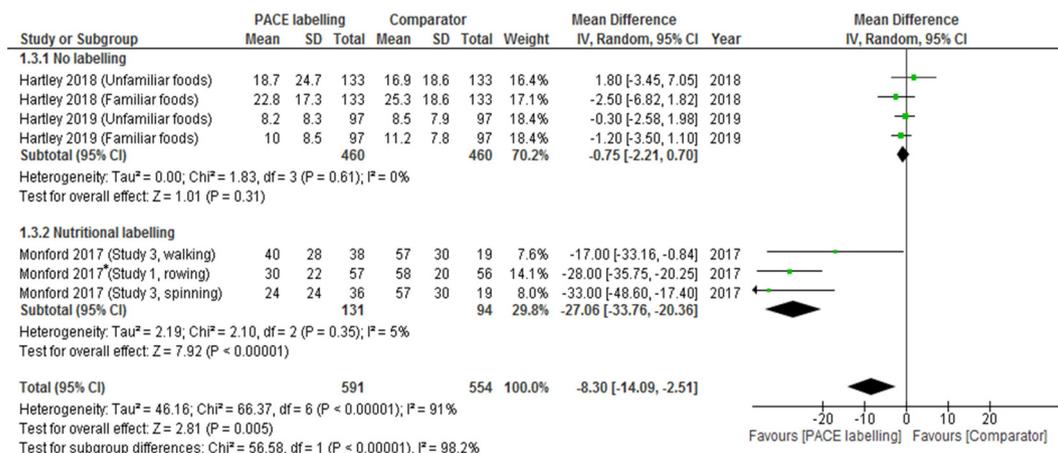


Figure 5 Physical activity calorie equivalent (PACE) labelling compared with comparator labelling/no labelling (grams of food consumed). Note: *denotes PACE labelling as a co-intervention with additional labelling. Additional data and information to facilitate the meta-analysis was provided by one of the study authors.²⁸

Evidence indicates that even a small decrease in calorie intake and increases in physical activity that are sustained are likely to be beneficial for health.^{32–34} Regular overconsumption of a small amount of calories leads to overweight/obesity; evidence suggests that if the population decreased consumption by as little as ~100 calories per day, population obesity could be prevented.³² This review has reported that PACE food labelling may have the potential to help people to achieve this goal. Most people eat three meals per day (plus two snacks); based on our findings for the number of calories consumed after exposure to PACE labelling (–65 calories), PACE labelling could potentially reduce calorie intake by up to 195 calories per day (–65×3 meals per day=–195 calories), although across repeated meals/snacks and over time this effect is likely to be reduced. PACE labelling is a simple strategy that could be easily included on food/beverage packaging by manufacturers, on shelving price labels in supermarkets and/or on menus in restaurants/fast-food outlets. When a consumer sees a visual symbol that denotes it will take 4 hours to walk off a pizza and only 15 min to burn off a salad, this in theory should create an awareness of the ‘energy cost’ of food/drink.

In the absence of international agreements, there is considerable variation in the information provided and the presentation format for nutritional labelling, which may lead to confusion among consumers. PACE labelling could be a simple universal method by which policymakers around the world unite to reduce energy consumption and encourage the population to be more active. Gains in public health are unlikely to be made unless decisions are taken in favour of food labels that can actually improve the ability of the public to differentiate products according to their calorie contribution. Our findings are consistent with previous studies reporting that this improvement is most likely to occur with the use of contextual or interpretive food labels.³⁵ A further benefit of PACE food labelling is that it may encourage restaurants and retailers to alter the range of products available and encourage the whole food industry and supply chain to reduce portion sizes and/or reformulate food products to contain fewer calories so they meet government calorie reduction targets, in a similar way to the sugar tax.³⁶

This study has several methodological strengths. PACE labelling is a relatively new concept and as such there are limited data testing the merits of this approach with the public. To our knowledge this is the first meta-analysis to summarise evidence regarding the effects of PACE labelling on food/beverage consumption. We searched widely for evidence in diverse fields including social media platforms. Two independent reviewers selected studies, extracted data and assessed study quality, thus reducing the potential for error and bias. The included studies that assessed food/drink consumption weighed the amount of food eaten/drunk by participants, rather than rely on self-reported accounts. Similarly, Bleich *et al* reported the number of purchases of SSB, not self-reported recall.²⁹ The main analysis was based on a large number of participants (n=4606).

This study should also be interpreted in light of some methodological limitations. It was difficult to assess the risk of bias in most studies because information to allow such assessment was not reported in trials. The only criteria that were clearly reported in studies related to ‘other bias’. For this criterion, only 4/15 studies were considered free of other bias highlighting that data from this review should be interpreted with some caution. Heterogeneity was high for some comparisons and was not explained by subgroup

analyses. It is possible the observed heterogeneity is due to the variability in the types of study designs used, the different types of PACE messages tested (eg, miles vs minutes) and the populations recruited. This would be an important question for future research as more evidence becomes available to allow such analyses to be conducted. It is not clear from the current evidence what the long(er) term impact of PACE labelling might be on consumption patterns, therefore studies that include assessments over time are needed. One of the additional benefits of PACE labelling over other types of food labelling is that it has the potential to encourage the population to engage in regular physical activity. We were not able to assess the effects of PACE labelling on future physical activity behaviour due to a lack of data; this should be a priority for future research. As most of the included studies adopted hypothetical eating methodologies/scenarios this research constitutes evidence of efficacy rather than effectiveness. The first trial to examine the effects of PACE food labelling was published in 2012,²⁹ Thus, we felt that the infancy of this research question warranted the inclusion of as much of the randomised evidence as possible, regardless of study design, but longer RCTs in naturalistic settings are required.

CONCLUSION

PACE food labelling may reduce the number calories selected from menus and decrease the number of calories/grams of food consumed by the public, compared with other types of food labelling/no labelling. The findings emphasise the potential of easily understood food labels to reduce the calorie intake of the population by facilitating increased selection of lower calorie foods and decreased selection of higher calorie ones.

What is already known on this subject

- ▶ There is little evidence that current nutritional labelling on food and drinks is having any impact on changing the eating behaviours of the public.
- ▶ Many people do not understand the meaning of kilocalories (calories) or grams of fat in terms of energy balance leading to a substantial underestimation of the energy content of food and drinks by the public.
- ▶ Regular overconsumption of a small amount of calories can lead to overweight and obesity.

What this study adds

- ▶ Physical activity calorie equivalent (PACE) food labelling may reduce the number of kilocalories selected from menus and decrease the number of kilocalories/grams of food consumed by the public, compared with other types of food labelling/no labelling at mealtimes.
- ▶ Findings highlight the importance of easily understood food labels to reduce the calorie intake of the population, by decreasing the selection of higher calorie food and drinks.
- ▶ Public health agencies may want to consider the possibility of including policies to promote PACE food labelling as a strategy that contributes to the prevention and treatment of obesity and related diseases.

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Contributors AJD conceived the original idea for the study. AJD wrote the protocol with contributions from HMP, SB, AC and EM. AJD wrote the first version of the manuscript with input from all other authors. AJD and HMP extracted the data and conducted the analyses. All authors had full access to the data, take responsibility for the integrity of the data and the accuracy of the data analysis, contributed to the interpretation of the results and reviewed and approved the final manuscript. AJD is the guarantor of the study.

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