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A systematic review of SNAPO (Smoking, Nutrition, Alcohol, Physical activity and Obesity) randomized controlled trials in young adult men.

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Abbreviations

SNAPO: Smoking, Nutrition, Alcohol, Physical activity and Obesity

Abstract

Objectives: To investigate the effectiveness of smoking, nutrition, alcohol, physical activity or obesity (SNAPO) interventions in young men exclusively. The secondary aim was to evaluate the recruitment, retention and engagement strategies.

Methods: A search with no date restrictions was conducted across seven databases. Randomized controlled trials recruiting young men only (aged 18-35 years) into interventions targeting any SNAPO risk factors were included.

Results: Ten studies were included (two nutrition, six alcohol use, two targeting multiple SNAPO risk factors). Six studies (two nutrition, three alcohol use and one targeting multiple SNAPO risk factors) demonstrated significant positive short-term intervention effects, but impact was either not assessed beyond the intervention (n=3), had short-term follow-up (≤ 6 months) (n=2) or not sustained beyond six months (n=1). Overall, a high risk of bias was identified across studies. Only one study undertook a power calculation and recruited the required sample size. Adequate retention was achieved in three studies. Effectiveness of engagement strategies was not reported in any studies.

Conclusions: Despite preliminary evidence of short-term effectiveness of SNAPO interventions in young men, few studies characterized by a high risk of bias were identified. High quality SNAPO interventions for young men are warranted.

Key Words: Systematic review, young adult men, Smoking, Nutrition, Alcohol, Physical activity, Obesity.

Highlights

- 6 of 10 RCTs showed short-term effectiveness of SNAPO interventions in young men.
- Only one RCT assessed long term effectiveness (>6 months).
- Evidence of effectiveness is limited by quality and quantity of studies identified.
- Strategies to recruit, retain and engage were mostly ineffective or not reported.
- More high quality SNAPO interventions for young men are warranted.

Background

The prevalence of chronic disease risk factors including smoking, poor diet quality, excessive alcohol intake, physical inactivity and obesity in young men is high (Bauman et al., 2009; Fryer and Ervin, 2013; Ng et al., 2014a; Ng et al., 2014b; World Health Organization, 2014). There is a need to improve these risk factors whilst men are still young, to prevent progression to chronic diseases such as cardiovascular disease (CVD). A large prospective cohort study in the US (CARDIA) showed that maintaining a healthy lifestyle from young to middle age (i.e., average BMI $\leq 25\text{kg/m}^2$, moderate alcohol intake, higher healthy diet score, higher physical activity score, and never smoking) was strongly associated with a low CVD risk profile in middle-age (Liu et al., 2012), with prevalence of low CVD risk being 61% in the healthiest lifestyle group compared to 3% in the unhealthiest (Liu et al., 2012).

Worldwide, approximately 20% of young men (aged 18-39 years) fail to meet national recommendations for physical activity (Bauman et al., 2009). Diet quality is also poor. In the USA the percentage of calories from fast food was highest (15.5%) among young men (20-39 years) compared to men and women in all other age groups (Fryer and Ervin, 2013). Low physical activity coupled with poor diet quality has contributed to high rates of overweight or obesity, with recent estimates indicating around 37% of 20-24 year old men and 47% of 25-29 year old men in developed countries are overweight or obese (Ng et al., 2014a). Globally, there are approximately three times more young males (aged 15-19 years) (16.8%) than females (6.2%) who engage in heavy episodic drinking (World Health Organization, 2014). Despite a 25% reduction in estimated global prevalence of tobacco smoking in men over the past 30 years, the highest prevalence rates in developed countries and across all age and sex groups are currently in men aged 30-34 years (38%) (Ng et al., 2014b).

Previous health research has highlighted difficulties in recruiting, retaining and engaging young men. For example a recent weight gain prevention study took 19 months to recruit 599 young adults and only 130 were young men (Tate et al., 2014). Also an alcohol intervention showed young men were less likely to complete sessions compared to young women (Bingham et al., 2010). Although the Premier League for Health campaign showed promise for reaching UK young men through sports clubs (2134 of 3779 recruited were aged 18-34 years), the study was affected by high

attrition rates with only 29.5% of the sample retained at post intervention (White et al., 2012).

Young men are often underrepresented in health-related research. A systematic review of 244 weight loss trials (published between 1999-2009) found that study samples included on average 27% male vs 73% female (Pagoto et al., 2012). A recent scoping review of risk behavior interventions in young men identified less than half (46/100) recruited young men-only, with most targeting both males and females, but stratified results by sex (Ashton et al., 2014). Using this one-size fits all approach in intervention delivery and design ignores the psychological, social, and physical differences between sexes (Olfiffe and Greaves, 2012) which may result in poorer engagement and retention of men. Moreover, the same scoping review considered 11 different risk behaviors and identified one study at most for interventions targeting tanning/risky sun exposure, violence, gambling or self-harm. Therefore, interventions targeting these behaviors were not considered in this current review. While the scoping review produced a quantitative mapping of interventions in young men, it did not evaluate the effectiveness or quality. There is a need to identify and critique evidence based approaches that can effectively recruit, engage and retain young men in health-related interventions. Therefore, the primary aim of this systematic review was to evaluate the effectiveness of interventions that recruited young men only and targeted SNAPO risk factors. A secondary aim was to evaluate the effectiveness of SNAPO interventions in their ability to recruit, retain and engage young men.

Methods

The conduct and reporting of this review adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) Statement (Moher et al., 2009).

Protocol and registration.

The systematic review protocol was registered with PROSPERO (CRD42014012855):

http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42014012855#.VGmCN8k1Ack. Studies identified from the scoping review (Ashton et al., 2014)

and an updated search informed this current systematic review.

Eligibility criteria.

1. Types of participants: Young men aged 18-35 years from upper-middle and high-income countries were included. To align with the criteria for the scoping review and enable comparison with other reviews, low income countries and low-to-middle income countries were excluded. The income group of each country was determined from the World Bank Group website (The World Bank Group, 2013). Only studies with exclusively young adult male samples were accepted for inclusion. The age range of 18-35 years was chosen to align with international definitions of young adulthood (National Institute of Health, 2010; White et al., 2011). As this review was intended to provide recommendations for the general healthy male population, those studies with participants from groups with diagnosed conditions linked to SNAPO risk factors (e.g. type 2 diabetes) or from special populations (e.g. young men with severe mental illness or eating disorders) were excluded. Physical activity interventions with participants classed as 'athletes' (e.g. elite or professional) were excluded.

2. Type of interventions: Interventions designed to promote healthy behavior by improving, reducing or preventing any of the SNAPO risk factors in exclusively young adult male samples. This review considers SNAPO interventions due to the high prevalence of these risk factors in young men. Obesity can be seen as a state or result of other SNAP risk factors but these types of interventions were considered because some publications targeting physical activity or nutrition have been published as obesity interventions.

Interventions must have been designed specifically to promote behavior change. As such, studies which primarily investigated the acute impact of weight loss on other clinical biomarkers (e.g. insulin) were excluded. Supervised, controlled exercise programs primarily examining the impact of exercise on clinical biomarkers and not designed to change lifestyle behaviors, and obesity interventions involving bariatric surgery or anti-obesity medications were excluded.

3. Types of comparators: Any comparators were considered for inclusion. This includes comparison with no-intervention (e.g. waitlist control) and/or compared to active treatments.

4. *Types of Outcome Measures:* Any measures to assess effectiveness of interventions on any SNAPo risk factors as the primary outcome. A measurement at baseline and a minimum of one post-intervention time point was required for inclusion.

5. *Types of studies:* Only randomized controlled trials (RCTs) published in English were considered.

Information sources and search

A previous scoping review, described interventions targeting risk behaviors in young adult males (Ashton et al., 2014). The relevant SNAPo interventions from the scoping review were included in the current systematic review. All sources for the scoping review were searched from the database inception date to May 2013. Details of the scoping review methods are described elsewhere (Ashton et al., 2014).

An additional search was conducted as per the scoping review but for the relevant risk behaviors only, to retrieve articles published from May 2013 to July 2014. See Additional file 1 for the complete search syntax for all databases.

Study selection

One reviewer assessed all included articles from the scoping review for relevance for this systematic review (n = 100) because of the different inclusion criteria for types of interventions and outcome measures. The same reviewer assessed all excluded articles from the scoping review that failed to provide an age range, but were otherwise eligible (n = 109) and contacted the corresponding author via email to confirm eligibility. A second reviewer checked all decisions and any disagreements were resolved by discussion.

Following the updated search one reviewer removed all duplicates, conducted a screening review of titles and excluded those which did not meet inclusion criteria. All abstracts were independently screened by one author and a trained research assistant and a third reviewer was consulted for any disagreements. Full text articles were retrieved and each was independently screened by two reviewers. Any disagreements were discussed by all reviewers until full consensus was achieved. Reference lists of included studies were searched for eligible studies although none were identified.

Data collection process

One reviewer extracted data relating to methodology (e.g. design, setting, treatment length and strategies for recruitment, retention and engagement), participant demographics (e.g. age and ethnicity) and the intervention effect on the relevant SNAPO risk factor (e.g. between-group differences). A second reviewer checked the extracted data for consistency.

Risk of bias in individual studies

Risk of bias was independently assessed by two reviewers using a tool adapted from the Consolidated Standards of Reporting Trials (CONSORT) statement (Schulz et al., 2010) and previously used quality criteria (Van Sluijs et al., 2007) (Table 1). Each item was coded as 'explicitly described and present', 'absent' or 'unclear or inadequately described'. Disagreements between assessors were resolved by discussion. Inter-rater reliability was calculated on a dichotomous scale using percentage agreement and Cohen's κ .

Table 1: Risk of bias checklist.

Item	Description
A	Presentation of baseline characteristics separately for treatment groups (minimum requirement was age and one SNAPO outcome)
B	Randomization clearly described and adequately done (positive when all components of randomization were reported including: generation of allocation sequence, allocation concealment and implementation)
C	Dropout for SNAPO measure $\leq 20\%$ for ≤ 6 -month follow-up and $\leq 30\%$ for > 6 -month follow-up
D	Blinded SNAPO assessment (positive when those responsible for assessing SNAPO at outcome were blinded to group allocation of individual participants)
E	SNAPO outcome assessed ≥ 6 months after pre-test
F	Intention to treat analysis for SNAPO outcomes (must have been reported in the paper)
G	Confounders accounted for in analyses (minimum requirement was adjusting for baseline score)
H	Summary results for each group + estimated effect size (difference between groups) + its precision (e.g. 95% confidence interval, standard deviation or standard Error). Positive when all have been carried out and reported.

-
- I Power calculation reported and study was adequately powered to detect changes in SNAPO outcome
 - J An objective measure of weight used for obesity risk factor or valid measures of smoking, nutrition, alcohol, physical activity (positive when evidence of validation, or reference to validation paper, provided by the authors)*
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*For interventions targeting multiple SNAPO risk factors, all relevant outcomes had to adhere to the criteria to be classed as positive

Synthesis of results

Aim 1: Data were collated and described in a narrative summary for each risk factor. Between-groups differences in the SNAPO outcomes were used to determine if the interventions were effective.

Aim 2: Recruitment was assessed by the researchers' ability to achieve the sample size target based on pre-determined power calculations. Retention was evaluated based on attrition rates at post intervention and follow-up. An engagement strategy was established if the study reported that a particular method was used to boost participant interaction/engagement and this was evaluated based on program adherence, satisfaction and session attendance. Engagement can be assessed on a number of constructs (Fredricks et al., 2004): 1) *behavioral engagement*, which draws on participation and engagement with program components; 2) *emotional engagement* encompasses positive and negative reactions to the program and 3) *cognitive engagement* includes willingness to exert effort to master skills (e.g. motivational goals).

Results

Study selection

The studies were selected based on two parts of the search process; **part 1**: nine articles were included from the scoping review (Ashton et al., 2014). **Part 2**: The updated search identified a total of 3034 unique citations. From this, one article was identified for inclusion. A total of 10 studies are included in the review. Figure 1 summarizes the selection process.

Figure 1 - Flowchart of studies identified and included in the systematic review

Study characteristics

Table 2 summarizes selected characteristics of all eligible studies by SNAPO risk factors. Of the 10 included studies, two focused on nutrition (Uglen et al., 2013; Williams and Lewis, 2002), six alcohol (Caudill et al., 2007; Daeppen et al., 2011; Fried and Dunn, 2012; Gaume et al., 2011; Murphy et al., 1986; Rohsenow et al., 1985), and two targeted multiple SNAPO risk factors (Cambien et al., 1981; Gmel et al., 2013); of these, one targeted smoking plus alcohol use (Gmel et al., 2013) and another targeted smoking plus obesity (Cambien et al., 1981). No interventions exclusively targeting physical activity, obesity or smoking were identified.

Table 2: A summary of young adult male-only SNAPO risk factor interventions.

Author, year, country	Design & setting	Sample	Designed specifically for YM?	Theoretical framework	Intervention length	Intervention groups	Treatment mode	Treatment intensity	Primary outcome (measurement)	PT & FU duration	Data analysis	Results (between group differences) *
<i>Nutrition Interventions</i>												
(Williams and Lewis, 2002), USA.	RCT, University	n=45, 20-25yr, University students (100% white/Caucasian)	No	None stated	6-wk	1. Nutrition counselling + measurement of serum cholesterol	1. F2F (Individual)	1. 1X 20-30min session per week x 4 weeks + Informed of serum cholesterol results	Reduction in % Kcal from fat (24-hr recall, 2-day food record and FFQ)	PT: 6-wk	ANOVA & least squares means	1>4, 2=4, 3=4 (Only compared each intervention grp with control.)
						2. Nutrition counselling only	2. F2F (Individual)	2. 1X 20-30min session per week x 4 weeks				
						3. Measurement of serum cholesterol only	3. F2F (Individual)	3. Informed of serum cholesterol results				
						4. Control group	4. n/a	4. n/a				
(Uglen et al., 2013), Norway	Cluster RCT, Military	n=481, 18-26yr, Military recruits. (ethnicity not reported)	No	Extension of previous model (Neumark-Sztainer et al., 2003), based on Social Cognitive Theory	5-m	1. Nutrition education intervention	1. Posters, brochures, folders	1. Change in food environment (e.g. self-service salad bar) + nutritional education materials in eating environment x 5-m	Increase in veg & semi-whole grain bread intake: grams/day (food diary)	PT: 5-m	ANCOVA	Both veg & semi-whole grain bread: 1>2
						2. Control group	2. n/a	2. n/a				

Author, year, country	Design & setting	Sample	Designed specifically for YM?	Theoretical framework	Intervention length	Intervention groups	Treatment mode	Treatment intensity	Primary outcome (measurement)	PT & FU duration	Data analysis	Results (between group differences) *
<i>Alcohol use Interventions</i>												
(Caudill et al., 2007), USA	Cluster RCT, University	n=3406, 18-33yr, University students (95% White/Caucasian)	No	Social cognitive theory	Single session	1. Single session social skills training	1. F2F (Group) & Written manuals & video vignettes	1. 3-hr single session	Reduction of alcohol use: total drinks (Alcohol timeline follow back calendar)	FU: 6m, 12m & 18m	Multilevel or mixed-effects regression models	6m: 1>3 12m: 1=3 18m: 3>1
						2. Single session social skills training+ Booster sessions at 5m & 11m	2. F2F (Group) & Written manuals & video vignettes	2. 3hr single session + 1.5hr session at 5m and 3hr session at 11m				6m: 2=3 12m: 2=3 18m: 3>2
						3. Control group	3. n/a	3. n/a				(Did not compare grp 1 vs grp 2)
(Daeppen et al., 2011) Switzerland	RCT, Military	n=622, All 19yrs, Army conscripts (ethnicity not reported)	No	None stated	Single session	1. Brief motivational intervention	1. F2F (Individual)	1. 1x Brief motivational session. Average 15.8mins	Reduction of alcohol use: drinks per week (self-report question)	FU: 6-m	Mann-Whitney U & 2-sample McNemar test of change.	<u>Bingers</u> [§] : 1>2 <u>Non-Bingers</u> : 1=2
						2. Control group	2. n/a	2. n/a				

Author, year, country	Design & setting	Sample	Designed specifically for YM?	Theoretical framework	Intervention length	Intervention groups	Treatment mode	Treatment intensity	Primary outcome (measurement)	PT & FU duration	Data analysis	Results (between group differences) *
(Gaume et al., 2011), Switzerland	RCT, Military	n=572, All 19yrs, Army conscripts (ethnicity not reported)	No	None stated	Single session	1. Brief motivational intervention 2. Waitlist control group	1. F2F (Individual) 2. n/a	1. 1x Brief motivational session. Average 21.8 mins 2. n/a	Reduction of alcohol use: drinks per week (self-report question)	FU: 6-m	Mann-Whitney <i>U</i> & 2-sample McNemar test of change.	<u>Bingers</u> [§] : 1=2 <u>Non-Bingers</u> : 1>2
(Rohsenow et al., 1985) USA	RCT, University	n=40, 20-24yrs, Heavy drinking University students (ethnicity not reported)	No	None stated	3-wk	1. Cognitive-affective stress management training 2. Control group	1. F2F (Individual & Group) 2. n/a	1. 2 x 1hr sessions per week x 3 weeks 2. n/a	Reduction of alcohol use: drinks per 2-wk period (Drinking practices questionnaire)	PT: 3-wk, FU: 2.5m & 5.5m	ANCOVA	3-wk: 1=2, 2.5m: 1=2, 5.5m: 1=2
(Fried and Dunn, 2012), USA	RCT, University	n=250, 18-25yrs, Heavy drinking University students (79% white/ Caucasian, 15% Hispanic, 1% Asian American, 1% African American & 3% other)	No	None stated	Single session	1. Expectancy Challenge Alcohol Literacy Curriculum (ECALC)	1. F2F (Group), video (advertisements)	1. 1x expectancy challenge session. Lasting 50 mins	Reduction of alcohol use: drinking days per week (Self-report timeline follow back)	FU: 4-wk	ANCOVA	1>2

Author, year, country	Design & setting	Sample	Designed specifically for YM?	Theoretical framework	Intervention length	Intervention groups	Treatment mode	Treatment intensity	Primary outcome (measurement)	PT & FU duration	Data analysis	Results (between group differences) *
						2. Active Control group	2. F2F (Group), video (advertisements)	2. 1 x presentation about deconstructing adverts for personal appearance products (e.g. hair removal products) x 50-min				
(Murphy et al., 1986) USA	RCT, University	n=43, 21-30yrs, Heavy drinking university students (ethnicity not reported)	No	None stated	8-wk	1. Aerobic exercise group	1. F2F (Group & individual)	1. Individualized running regime tailored to aerobic capacity. 3x group sessions and 1x on their own per week at 70min per session x 8-wk	Reduction of alcohol use: weekly means of ethanol (ml) (self-report)	PT: 8-wk FU: 14:-wk	2-way ANOVA with repeated measures	8-wk: 1=2=3 14-wk 1=2=3
						2. Meditation group	2. F2F (Group individual) + workbooks , audiotapes	2. 2x a day concentrative meditation for 20mins x 7 days per week				
						3. Control groups	3. n/a	3. n/a				
<i>Multiple SNAPO risk factor interventions</i>												
(Gmel et al., 2013), Switzerland	RCT, Military	n=853, All 20yrs, Army conscripts (ethnicity not reported)	No	None stated	Single session	1. Brief motivational intervention	1. F2F (Individual)	1. 1 x brief motivational session with psychologist. Average 20mins	<u>Reduction in smoking (tobacco):</u> number of cigarettes per day (Self report questionnaire)	FU: 6-m	Logistic & linear regression	Smoking: 1=2

Author, year, country	Design & setting	Sample	Designed specifically for YM?	Theoretical framework	Intervention length	Intervention groups	Treatment mode	Treatment intensity	Primary outcome (measurement)	PT & FU duration	Data analysis	Results (between group differences) *
						2. Waitlist control group	2. n/a	2. n/a	Reduction in Alcohol use: number of drinks per week (Self report questionnaire)			Alcohol: 1=2
(Cambien et al., 1981) France	RCT, Primary care setting	n=1292, 25-33yrs, Civil servants (ethnicity not reported)	No	None stated	2yr	1. Individualized intervention	1. F2F (individual) audio-visual and printed documents	1. 4x sessions with general practitioner who provided advice on diet, PA & smoking over two years	Reduction in smoking (tobacco): number of cigarettes per day (Self report questionnaire), Weight loss: (measured)	PT: 2yr	Student's t-test	Smoking: 1>2 Weight: 1=2
						2. Control group	2. n/a	2. n/a				

*1 = 2: no differences between groups 1 & 2 ($p > 0.05$); 1 > 2: group 1 had significantly greater improvements on outcome than group 2 ($p < 0.05$).
 §Bingers were defined as: subjects having \geq one episodes per month of \geq 6 drinks on a single occasion. Non-bingers were defined as: users as having these episodes less than once a month, or never.
 Abbreviations/ acronyms: YM: Young men, F2F: Face to Face, Yrs: Years, Wk: week, M: months, hr: hour, RCT: Randomized Controlled Trial, PT: Post-test, FU: Follow up, PA: Physical activity, veg: vegetables, FFQ: Food Frequency Questionnaire, ANOVA: Analysis of Variance, ANCOVA: Analysis of Covariance.

Risk of bias within studies

Table 3 summarizes the risk of bias assessments. Inter-rater reliability metrics indicated substantial agreement for all 100 items (percentage agreement 96%, $k = 0.91$). Discussion resulted in full consensus for all items. Four of the 10 studies used a validated measure for the SNAPO outcome measure (Daeppen et al., 2011; Fried and Dunn, 2012; Gaume et al., 2011; Uglem et al., 2013), three of these were for alcohol (Daeppen et al., 2011; Fried and Dunn, 2012; Gaume et al., 2011) and one for a nutrition outcome (Uglem et al., 2013). However, it was not reported if these measures were validated in young men. A score was not given for reporting an objective measure of weight as there were no individual obesity interventions with primary outcome as weight. Even though one intervention targeting multiple SNAPO risk factors objectively measured weight, a valid measure for smoking was not reported and thus a positive score was not given (Cambien et al., 1981). Assessor blinding was reported in three studies (Daeppen et al., 2011; Gaume et al., 2011; Gmel et al., 2013) and seven studies accounted for confounders in analysis (Caudill et al., 2007; Daeppen et al., 2011; Fried and Dunn, 2012; Gaume et al., 2011; Gmel et al., 2013; Rohsenow et al., 1985; Uglem et al., 2013). Only three studies met the criteria for adequate retention (Cambien et al., 1981; Fried and Dunn, 2012; Gaume et al., 2011) (dropout $\leq 20\%$ for ≤ 6 -month follow-up and $\leq 30\%$ for > 6 -month follow-up) and no studies described the randomization procedure in sufficient detail, with all failing to sufficiently describe the allocation concealment procedure for the randomization process. Two studies implemented an intention-to-treat analysis (Caudill et al., 2007; Gaume et al., 2011) and one provided a power calculation and was adequately powered (Gmel et al., 2013).

Table 3: Methodological quality scores and risk of bias assessment in young male-only SNAPO intervention studies.

Study	A) Baseline results reported separately for each group	B) Randomization clearly described and adequately done	C) Dropout $\leq 20\%$ for $\leq 6m$ follow-up and $\leq 30\%$ for $> 6m$ follow-up	D) Assessor blinding	E) SNAPO outcome assessed $\geq 6m$ after baseline	F) Intention-to-treat analysis	G) Confounders accounted for in analyses	H) Summary results presented + estimated effect sizes + precision estimates	I) Power calculation reported and study adequately powered	J) Objective measure for weight used (in Obesity intervention) OR Valid measure for other SNAP behaviors
<i>Nutrition interventions</i>										
(Williams and Lewis, 2002)	✗	✗	?	✗	✗	?	✗	✗	✗	✗
(Uglen et al., 2013)	✓	✗	✗	✗	✗	✗	✓	✗	✗	✓
<i>Alcohol use interventions</i>										
(Caudill et al., 2007)	✗	✗	?	✗	✓	✓	✓	✗	✗	?
(Daepfen et al., 2011)	✓	?	✗	✓	✓	✗	✓	✓	✗	✓
(Gaume et al., 2011)	✓	✗	✓	✓	✓	✓	✓	✓	✗	✓
(Rohsenow et al., 1985)	✗	✗	✗	✗	✗	✗	✓	✗	✗	?
(Fried and Dunn, 2012)	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓
(Murphy et al., 1986)	✗	✗	✗	✗	✗	✗	✗	✗	✗	?
<i>Multiple SNAPO risk factor interventions</i>										
(Gmel et al., 2013)	✓	?	✗	✓	✓	✗	✓	✓	✓	✗
(Cambien et al., 1981)	✓	✗	✓	✗	✓	✗	✗	✗	✗	✗
✓, present; ✗, absent; ?, unclear or inadequately described.										

Effectiveness of smoking interventions

No individual smoking interventions were identified. However, two interventions that targeted multiple risk factors, also intended to reduce smoking (Cambien et al., 1981; Gmel et al., 2013). The first investigated the effectiveness of a brief (single session) motivational intervention to a waitlist control group (Gmel et al., 2013), with no difference between groups at 6-month follow-up (0.0 cigarettes/ day vs +0.3 cigarettes/ day, $p = 0.22$). The second investigated the effects of a cardiovascular risk factor prevention program on young male civil servants (Cambien et al., 1981). The two-year intervention included four brief sessions with a general practitioner who provided advice on health behaviors including smoking and compared to a no-treatment control group. At two-years post-test, the intervention group demonstrated significantly greater reductions in number of cigarettes per day compared with the control group (-2.2 [7.3] cigarettes/ day vs -1.0 [8.3] cigarettes/ day, $p < 0.01$).

Effectiveness of nutrition interventions

Two nutrition interventions were identified (Uglen et al., 2013; Williams and Lewis, 2002). The first was a four-arm RCT investigating the effectiveness of nutrition counselling (one session per week over four weeks) with the addition of a serum cholesterol measurement against nutrition counselling alone, serum cholesterol measurement alone and a no-treatment control group (Williams and Lewis, 2002). After 4-weeks the intervention group with nutrition counselling plus serum cholesterol measurement had significantly greater change in percent energy from fat compared with control group (-3.2% [1.4] vs +0.2% [1.5] $p = 0.02$). No other differences were observed.

The second RCT investigated the effectiveness of an intervention focusing on a combination of increased availability of healthy foods and nutritional information to stimulate intake of vegetables and semi-whole grain bread compared to a no-treatment control group in young men in the Norwegian military (Uglen et al., 2013). At 5 months post-test the intervention group significantly increased their daily vegetable intake (+79g [5.5] vs -8g [11.2] $p < 0.001$) and their semi-whole grain bread intake (+47g [4.5] vs -12g [9.6] $p < 0.001$) when compared with the control group.

Effectiveness of alcohol use interventions

Three of the seven alcohol use interventions (including a multiple SNAPO risk factor intervention that targeted alcohol use) examined effectiveness of a brief (single session) motivational intervention on number of drinks per week compared to a control group (Daeppen et al., 2011; Gaume et al., 2011; Gmel et al., 2013), with conflicting results across studies. The first (Daeppen et al., 2011), found significantly greater reductions in bingers-only at 6-month follow-up compared with controls (-1.5 [13.2] drinks/ week vs +0.8 [10.8] drinks/ week $p = 0.04$). No between-group differences occurred in non-bingers (-1.3 [3.8] drinks/ week vs +0.7 [2.6] drinks/ week $p = 0.87$). The second study (Gaume et al., 2011) found significantly greater between-group differences in non-bingers at 6-month follow-up when compared with control group (+0.4 [3.7] drinks/ week vs +1.7 [4.2] drinks/ week $p = 0.04$) but both groups increased their alcohol intake. No between-group differences occurred in bingers (-0.4 [13.1] drinks/ week vs +0.7 [19.1] drinks/ week $p = 0.90$). Results were not provided for the whole sample in either study. The third study (Gmel et al., 2013) found no between-group differences at 6-month follow-up when compared to control group (-0.5 drinks/ week vs -0.1 drinks/ week $p = 0.63$). Additionally, all three of these studies did not establish any significant between-group effects for number of binge episodes per month.

Two studies compared brief (single session) education interventions with control groups (Caudill et al., 2007; Fried and Dunn, 2012) and found significant intervention effects in the short-term. The first reported significantly greater reductions in total number of alcoholic drinks (over the previous four weeks) at 6-month follow-up ($p < 0.05$) among the intervention group compared with the no-treatment control group. However, no intervention effect was found at 12-months follow-up. Notably, at 18-months follow-up the intervention group had a greater increase in intake from baseline levels in total number of alcoholic drinks relative to the control group ($p < 0.05$). The addition of booster sessions at 5- and 11-months to the intervention group was not effective at any follow-up time point when compared to the control group. An increase in total number of alcoholic drinks occurred at 18-months relative to control group ($p < 0.001$) (Caudill et al., 2007). The authors reported this occurred because of failure to train new fraternity members during the first 12 months which prevented maintaining positive outcomes for longer (Caudill et

al., 2007). The second study demonstrated significantly greater reductions in mean drinking days per week in the Expectancy Challenge Alcohol Literacy Curriculum (ECALC) intervention group compared to inactive control group at 4-week follow-up (-0.59 drinking days/ week vs +0.31 drinking days/ week, $p = 0.001$) (Fried and Dunn, 2012).

Of the two remaining alcohol use interventions one examined the effectiveness of stress management training in reducing alcohol use when compared to no-treatment control group (Rohsenow et al., 1985). There was no significant between-group differences at 3-week post-test (-6 drinks/ two-week period vs 0 drinks/ two-week period $p > 0.05$) or 2.5-month follow-up (-15 drinks/ two-week period vs -1 drinks/ two-week period $p > 0.05$), with both groups returning to baseline levels at 5.5-month follow-up. No intervention effects occurred at any follow-up time point for number of binge episodes per month.

The final alcohol use intervention was a three-arm RCT (Murphy et al., 1986) and found both the aerobic exercise intervention and meditation intervention were not different than a no-treatment control group in reducing alcohol use (weekly means of ethanol in ml), with no significant between-group differences observed at 8-weeks post-test and at 14-weeks follow-up.

Effectiveness of obesity interventions

No obesity interventions exclusively in young men were identified. However one intervention targeting multiple SNAPO risk factors (Cambien et al., 1981) investigated the effectiveness of four brief sessions with a GP who provided advice on multiple health behaviors, including diet and physical activity compared to a control group. The main outcome measure was body weight with no outcome measures for diet or physical activity. Results show there were no significant between-group differences at 2-year post-test for weight (+0.8kg [3.4] vs +1.2kg [3.4] $p > 0.05$).

Recruitment, retention and engagement

Table 4 summarizes recruitment, retention and engagement strategies.

Recruitment

The most common settings young men were recruited from include: universities (40%) (Cambien et al., 1981; Fried and Dunn, 2012; Murphy et al., 1986; Williams

and Lewis, 2002) and military/army (40%) (Daeppen et al., 2011; Gaume et al., 2011; Gmel et al., 2013; Uglem et al., 2013). Others included workplace (10%) (Cambien et al., 1981) and one did not report it (Rohsenow et al., 1985). Half of the studies used a face-to-face method to recruit young men (Cambien et al., 1981; Daeppen et al., 2011; Gaume et al., 2011; Gmel et al., 2013; Uglem et al., 2013) through existing systems during mandatory training days in the army (40%) (Daeppen et al., 2011; Gaume et al., 2011; Gmel et al., 2013; Uglem et al., 2013) or occupation-related CVD screening (Cambien et al., 1981). Other methods included the use of letters (Williams and Lewis, 2002), email (Fried and Dunn, 2012) and advertisements in the student newspapers with placards posted on campus (Murphy et al., 1986) to invite young men to participate. Two studies failed to report recruitment methods (Caudill et al., 2007; Rohsenow et al., 1985). There is evidence to suggest young men were difficult to recruit; six studies provided sufficient data to establish the percentage of those who were invited to participate in relation to those who were actually enrolled/ randomized (Daeppen et al., 2011; Gaume et al., 2011; Gmel et al., 2013; Murphy et al., 1986; Uglem et al., 2013; Williams and Lewis, 2002) (mean = 26%, range 7% to 94%). Of these, five studies (Daeppen et al., 2011; Gaume et al., 2011; Gmel et al., 2013; Murphy et al., 1986; Williams and Lewis, 2002) enrolled <20% of those invited.

Overall, there was large heterogeneity in numbers enrolled into programs (mean = 1010; range: 40 to 3406) and within recruitment settings. Given that only one study (Gmel et al., 2013) reported undertaking a power calculation to determine a sample size target, we were unable to establish the effectiveness of recruitment strategies.

Retention

Four of the 10 studies used a strategy to retain young men in the intervention (Caudill et al., 2007; Gmel et al., 2013; Murphy et al., 1986; Rohsenow et al., 1985). Of these, two provided financial incentives (Murphy et al., 1986; Rohsenow et al., 1985), one included booster sessions (Gmel et al., 2013) and one included both financial incentives and booster sessions (Caudill et al., 2007). There were minimal differences in average retention rates for those with a retention strategy compared to those without (71% vs 74%). Notably, only three studies met the criteria for adequate retention in quality assessment (Cambien et al., 1981; Fried and Dunn, 2012; Gaume et al., 2011) (dropout \leq 20% for \leq 6-month follow-up and \leq 30% for >6-month follow-up) and none reported any specific retention strategies. Average retention rates were

69% (range: 53% to 85%) in studies that only included post-test measurements (5 months to 2 year intervention, n=2) and 74% (range: 52% to 88%) in studies with follow-up assessments (4 week to 18 month intervention, n=7).

Engagement

No studies reported the use of strategies to boost participant interaction/engagement, nor was there any indirect evidence of participant engagement.

Table 4: Recruitment, retention and engagement strategies in young adult male-only SNAPO interventions

Study	Strategies to recruit		Recruitment data	Strategies to retain	Retention (PT & FU)	Engagement strategies	Engagement
	Setting	Mode					
<i>Nutrition interventions</i>							
(Williams and Lewis, 2002)	Young men were randomly selected from a university listing	Letters were sent and interested volunteers were screened by telephone	233 invited to participate. 75 responded and 45 were eligible to participate 45 were enrolled/ randomized (19.3% of those invited, ended up participating)	No specific strategies reported.	Unclear*	No specific strategies reported.	No data reported.
(Uglem et al., 2013)	Young men recruited through army/military: two military camps in Norway were targeted.	F2F recruitment during military service enrolment	976 men invited to participate. 917 enrolled/ randomized (94% of those invited, ended up participating).	No specific strategies reported.	52.5% (481/917) completed PT at 5-m	No specific strategies reported.	No data reported
<i>Alcohol use interventions</i>							
(Caudill et al., 2007)	Young men were recruited through a national fraternity from Universities/colleges	Not reported	Unclear, it states: 99% of eligible fraternity members participated in the study and 85% (n=3406) enrolled/ randomized.	-Money incentive: \$20 for participating. -Provided booster sessions at 5 and 11 months for experimental group.	Unclear, the paper states: response rates ranged from 84%-89% at 6, 12 and 18m FU	No specific strategies reported.	No data reported

Study	Strategies to recruit		Recruitment data	Strategies to retain	Retention (PT & FU)	Engagement strategies	Engagement
	Setting	Mode					
(Daeppen et al., 2011)	Young men recruited through military/army.	F2F during mandatory two-day army recruitment process	3460 army conscripts invited to participate. 622 enrolled/ randomized (18% of those invited, ended up participating).	No specific strategies reported.	59.6% (371/ 622) at 6-m FU	No specific strategies reported.	No data reported
(Gaume et al., 2011)	Young men recruited through military/army.	F2F during mandatory two-day army recruitment process	8673 army conscripts invited to participate. 6085 eligible to participate. 727 interested in participating. 572 enrolled/ randomized. (7% of those invited, ended up participating).	No specific strategies reported.	87.9% (503/572) at 6-m FU	No specific strategies reported.	No data reported
(Rohsenow et al., 1985)	No specific strategies reported.	Not reported	40 enrolled/ randomized	Money incentive: \$4 a week for returning questionnaires, \$50 for completing study.	85% (34/40) at 3-wk PT, 70% (28/40) FU 5.5m	No specific strategies reported.	No data reported
(Fried and Dunn, 2012)	Young men recruited from fraternities in University setting	The presidents of all 15 social fraternities were contacted via email.	250 enrolled/ randomized	No specific strategies reported.	83.6% (209/250) at 4-wk FU	No specific strategies reported.	No data reported
(Murphy et al., 1986)	Recruited from undergraduate classes in University.	Advertisements in the student newspaper, and placards posted	Over 700 responded to recruitment materials.	Money incentive: \$4 weekly payment	71.6% (43/60) at 8-wk PT and 51.6% (31/60) at 14-wk FU	No specific strategies reported.	No data reported

Study	Strategies to recruit		Recruitment data	Strategies to retain	Retention (PT & FU)	Engagement strategies	Engagement
	Setting	Mode					
		on campus. Recruitment material emphasized the effects of "getting high" through running and meditation and potential subjects were told how they could possibly achieve an altered state of consciousness or experience a "natural high" while running or meditating.	60 enrolled/ randomized (9% of those invited, ended up participating).				
Multiple SNAPO risk factor interventions							
(Gmel et al., 2013)	Recruited from military/army.	F2F during mandatory two-day army recruitment process	8419 army/ conscripts visited center. 4767 eligible to participate 853 enrolled/ randomized (10% of those invited, ended up participating).	Booster session at 3-m via telephone	78.8% (672/853) at 6-m FU	No specific strategies reported.	No data reported.
(Cambien et al., 1981)	Targeted civil servants in Parisian administration. Everyone in this population is submitted to a CVD screening every 5-yr	F2F: those attending the CVD screening were asked to participate.	32,000 civil servants in Parisian administration. 3336 enrolled/ randomized.	No specific strategies reported.	84.9% (1097/1292) at 2-yr PT	No specific strategies reported.	No data reported.

Study	Strategies to recruit		Recruitment data	Strategies to retain	Retention (PT & FU)	Engagement strategies	Engagement
	Setting	Mode					
			Only recalled the first 1292 subjects for the purpose of this study.				
*Unclear since it does not report if the full sample was retained at post-test, nor does it report if any participants were lost. Abbreviations = Yrs: Years, Wk: week, M: months, PT: Post-test, FU: Follow up, CVD: Cardiovascular Disease							

Discussion

The primary aim of this systematic review was to investigate the effectiveness of interventions targeting SNAPO risk factors and recruiting young men-only. Overall, six of the 10 included interventions (two nutrition, three alcohol use and one multiple SNAPO intervention) demonstrated a significant positive effect for at least one intervention group on a particular SNAPO outcome (Cambien et al., 1981; Caudill et al., 2007; Daeppen et al., 2011; Fried and Dunn, 2012; Uglem et al., 2013; Williams and Lewis, 2002). But impact was either not assessed beyond the intervention (Cambien et al., 1981; Uglem et al., 2013; Williams and Lewis, 2002), had a short-term follow-up (≤ 6 months) (Daeppen et al., 2011; Fried and Dunn, 2012) or not sustained beyond six months (Caudill et al., 2007).

The secondary aim was to evaluate the effectiveness of SNAPO interventions in their ability to recruit, retain and engage young men. Only one study undertook a power calculation and achieved the required sample size target (Gmel et al., 2013). It is unclear if the other studies performed power calculations, but failed to clearly report this or whether they did not undertake a power calculation prior to recruitment. The ability to retain young men was generally ineffective with only three studies meeting the criteria for adequate retention (Cambien et al., 1981; Fried and Dunn, 2012; Gaume et al., 2011). The effectiveness of strategies in engaging young men cannot be determined given that no studies reported this in the current review.

The number of interventions targeting SNAPO risk factors in exclusively young men is not comprehensive, but is clearly a developing area, with half of the studies published since 2007. The interventions had a large degree of heterogeneity in treatment approach, duration, mode of delivery and program intensity. Most notably, the number of interventions is disproportionate across SNAPO risk factors with the majority targeting alcohol use (60%) (Caudill et al., 2007; Daeppen et al., 2011; Fried and Dunn, 2012; Gaume et al., 2011; Murphy et al., 1986; Rohsenow et al., 1985). Given the health consequences from other SNAPO risk factors in young men, future interventions are needed to positively change lifestyle behaviors by addressing smoking, nutrition, physical activity and obesity alone or targeting multiple risk factors.

The positive findings in six out of the 10 interventions suggest potential for effectiveness, but these results should be interpreted with caution because of the high risk of bias identified. The areas of greatest weakness were poor descriptions of the randomization process and failure to report a power calculation. In the items most likely to bias the estimate of an intervention's effectiveness (items B, C, D and F) (Higgins et al., 2008; Liberati et al., 2009) studies scored poorly. No studies adequately reported the randomization procedure, three achieved adequate retention, three appropriately blinded assessors and only two carried out an intention-to-treat analysis. Although four studies used a valid measure for a SNAPO outcome it was unclear if any of these were specifically validated in young adult men.

Insight into the effectiveness of SNAPO interventions in young men was limited by the lack of studies, poor study quality and poor intervention detail and process evaluation metrics reported. However, there is a possibility that studies were conducted more rigorously, but authors failed to adequately or clearly report key methodological components. Therefore, the findings of this review may have underestimated the true quality of studies. Greater transparency in study reporting and closer alignment with the CONSORT statement (Schulz et al., 2010) would assist in interpretation of the effectiveness of strategies tested in future trials.

The lack of long-term effectiveness of interventions and the difficulties apparent in recruiting, retaining and engaging young men may be partly due to failure to address young men's needs and intervention preferences during development (Hagen et al., 2012). No studies mentioned use of a participatory approach and none were gender tailored (i.e. those designed to address individual characteristics of persons within a sample, such as personality factors, goals, needs and preferences (Beck et al., 2010)) specifically for young men. Implementing a participatory design and tailoring the program to the needs of young men may help to engage this population and achieve desired behavior change (Hagen et al., 2012; Kreuter et al., 2013). An example of this is using young men's reported facilitators and barriers to specific health behaviors and their preferences regarding intervention mode and program components in intervention design (Ashton et al., 2015). Furthermore, in accordance with the 'elaboration likelihood model' (Petty and Cacioppo, 1981), more people are likely to process and retain information if they perceive it to be personally relevant, thus increasing the likelihood of attitude change (Petty et al., 1994). Use of a participatory design in informing a gender tailored approach may also help to address

the implications apparent with recruitment, retention and engagement in young men (Hagen et al., 2012).

Moreover most studies (80%) failed to report use of a theoretical framework to develop the program. A number of health behavior theories have been widely used as a basis for tailoring health behavior change messages and suggest factors that affect behavior change. A review with meta-analysis of 57 studies found that studies basing tailoring on theoretical concepts were significantly more effective than those health promotion programs that did not (Noar et al., 2007). In addition, the effectiveness of theoretical tailoring (i.e. tailoring program messages on theoretical concepts) may be more pronounced if messages are also tailored on demographic characteristics (e.g. age and sex) (Noar et al., 2007). Therefore future research involving young men could consider incorporating tailoring in relation to demographic characteristics and theoretical concepts.

The generalizability of findings is limited due to characteristics of the included studies. None of the studies recruited young men through the general population, instead the majority were recruited through existing systems (e.g. fraternities or military) and through mandatory training programs. This may have been done to overcome difficulties in recruiting this 'hard-to-reach' group as large numbers of young men can be obtained through these existing systems. Although these methods were successful in recruiting large numbers, it was unclear whether they were adequately powered given the lack of reporting of sample size requirement targets to maximize study power. Furthermore, recruiting through exiting systems limits the representativeness of the sample (culturally and socio-economically) and more attempts should be made to establish effective ways of recruiting young men through the general population.

All of the included interventions failed to report any information on engagement in young men. The considerable number of studies that carried out single session interventions (50%) may have been due to trying to overcome the previous difficulties with engaging this population group (Bingham et al., 2010; Bingham et al., 2011). Reporting effective or ineffective engagement strategies can inform future research of certain strategies to implement or not. Additionally, use of appropriate techniques for the different constructs of engagement is vital; self-report measures may be useful for emotional and cognitive engagement which is not directly observable (Appleton et al., 2006), but is limited by subjective bias (Fredricks and

McColskey, 2012). Direct observation can be used to assess behavioral engagement but provides limited information on quality of effort or thinking (Fredricks et al., 2004). It is therefore advised to use multiple assessment methods when measuring engagement (Fredricks and McColskey, 2012).

Studies with only young men were included because the complex links between biological sex, social gender and health has highlighted the need for gender-specific research (Doyal, 2001; Gesensway, 2001; Weisman, 2000) and for health promotion policies to be gender sensitive (Doyal, 2001). However, future research should investigate any differences in success rates, recruitment, retention and engagement of male participants in gender-specific programs compared with those that provide a gender-neutral program to a male-only or mixed-sex population.

Strengths and limitations

Strengths of this review include: (1) a comprehensive search strategy across multiple databases with no date restrictions, (2) detailed data extraction to allow comparison between studies and (3) high agreement levels between the two reviewers for quality assessment. Limitations include: (1) restriction of studies to upper-middle and high-income countries and (2) the failure to include studies published in a language other than English. However, as English language publications make up 96.5% of public health publications in Europe (Clarke et al., 2007), it is likely that only a small minority of studies would have been missed.

Conclusions

There is some evidence of short-term effectiveness of SNAPO interventions in young adult men, but this is limited by a scarcity of programs implemented in this population group and the poor quality of included studies. Given the health implications associated with young men's lifestyle, more high quality research is needed to evaluate the impact of SNAPO interventions in their ability to change behavior and improve their overall health. Future research should compare different strategies to promote recruitment, retention and engagement to determine the most effective. This could include a participatory approach during development to account for young men's needs and intervention preferences, and to tailor intervention content.

Conflict of interest statement

CEC receives a honorarium as a member of the Novo Nordisk Obesity Advisory Board. None of the other authors had any financial support or relationships that may pose conflict of interest.

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