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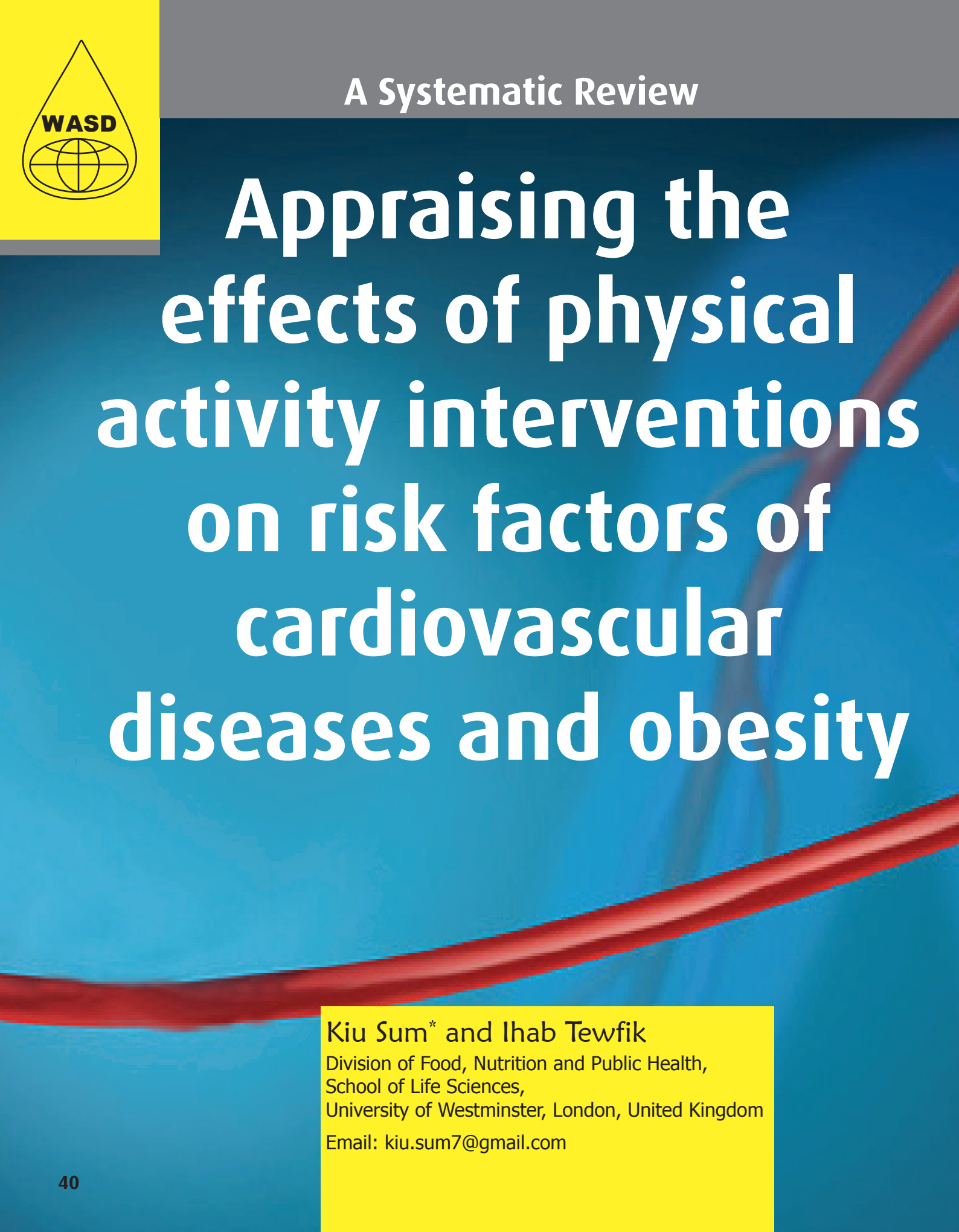


A Systematic Review

# Appraising the effects of physical activity interventions on risk factors of cardiovascular diseases and obesity

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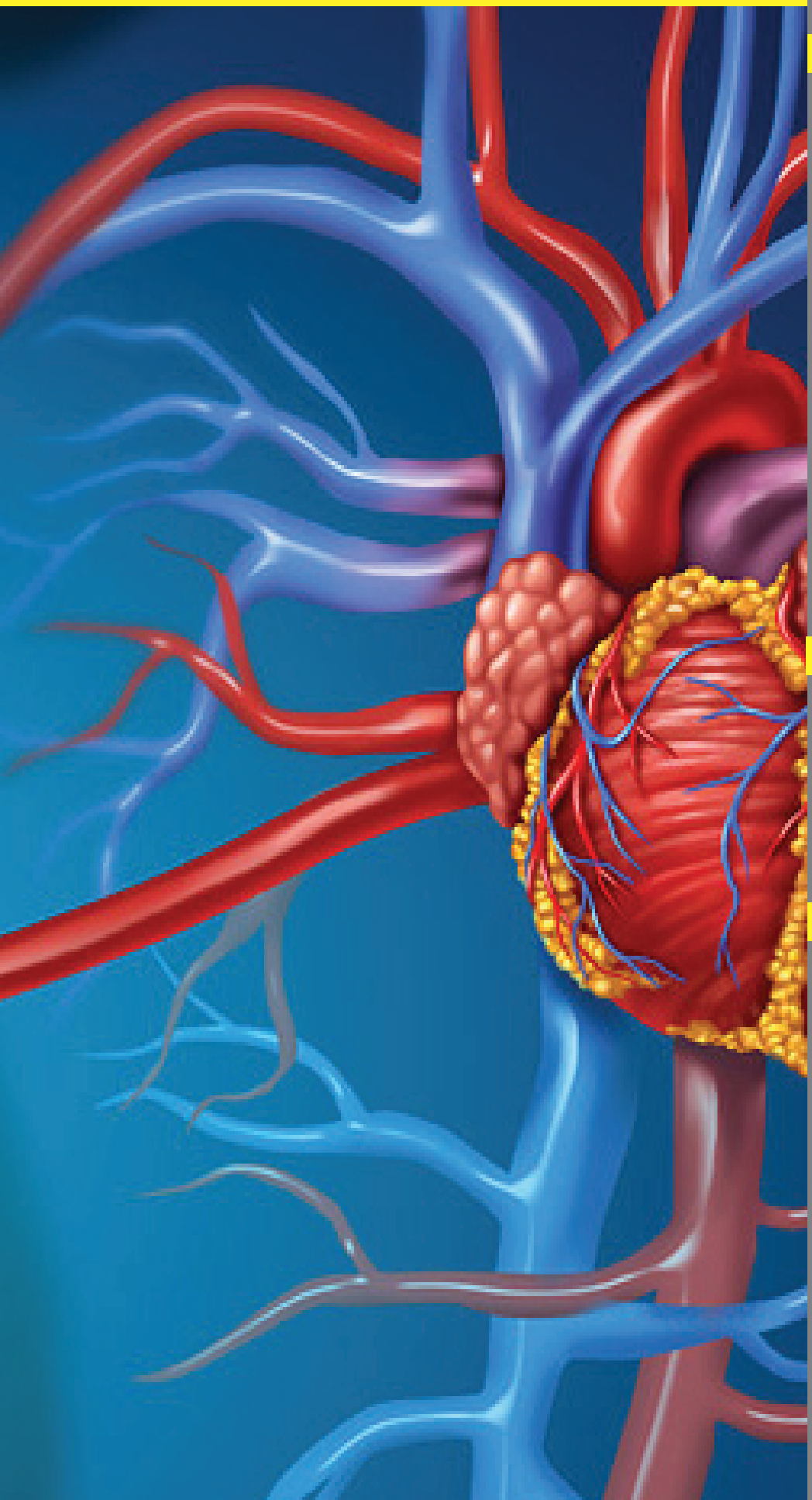

## BACKGROUND

The increase in the global population has placed extra burdens on health services. This is due to the increased risks of cardiovascular disease, with more people falling into the overweight and obese categories. Developed public health interventions prevent risks of health complications, promoting healthier lifestyles and prolonging the quality of life. Those motivated adopt new methods to become healthier. On the other hand, those less motivated are at risk of being overweight and leading a sedentary lifestyle. In 2014, the World Health Organisation (WHO) established that non-communicable diseases were the leading cause of global deaths.

## AIM

This systematic review critically evaluates the effects of physical activity interventions in adults (18–65 years), and the impact on risk factors of cardiovascular diseases and obesity.

## METHODS

Nineteen items of literature published between 2000 and 2016 were examined using quality of assessment tools. These provided a greater understanding of the effectiveness of physical activity interventions.

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## OUTCOMES

The complexity of this topic was experienced, with many aspects (such as inter- and intra-personal factors) affecting the effectiveness of physical activity interventions. It was noted that continuous support should be provided during the intervention period, motivating participants by increasing engagement through peer support and group activities, providing long-term sustainability of the willingness to adopt lifestyle changes. Further recommendations examining quantitative data analysis were suggested, exploring how physical activity intensity affects the risks of metabolic syndromes. Social behaviour and its effects on food consumption was also highlighted for further research, enhancing future public health interventions.


## KEYWORDS

physical activity; cardiovascular disease; obesity; overweight; interventions; behaviour; public health nutrition


## BIOGRAPHY

**Kiu Sum** is a Registered Associate Nutritionist who graduated with a BSc (Hons) in Human Nutrition from the University of Westminster, and then went on to complete an MRes in Clinical Research (Human Nutrition) at Imperial College, London. Kiu's research interest explores the relationship of public health nutrition with physical activity interventions with cardiovascular disease.

# BACKGROUND

## Problem Formulation in Public Health Nutrition

Since 2000, the Department of Health (DoH) and Public Health England (PHE) have published papers demonstrating the growth of obesity with the increasing world population. Local authority excess weight data (PHE, 2014) shows that 64% of the adult population are overweight or obese. This evidence can assist policymakers to have a wider perspective about the future. Yet more interventions and research are needed to implement these challenges.

The Foresight Program informs Government plans that look at possible major complications in the United Kingdom (Government Office for Science, 2013) being obese is becoming the norm (Butland et al., 2007). WHO estimated that 300 million people worldwide fall into the obese category (Butland et al., 2007) using their body mass index (BMI) as an indicator. This can be defined as having a BMI of $\geq$25 Kg/m$^2$ (Lobstein and Jackson, 2007).

Adults and children residing in the UK follow this trend by falling into the overweight (where BMI is $\geq$25 Kg/m$^2$) and above category (Butland et al., 2007). Following the Foresight's Tackling Obesities Future Choices (TOFC) 2007 Report, a review paper demonstrated that, by 2050, 60% of men and 50% of women will be categorised as obese in the UK (Government Office for Science, 2012). The Government's response to the statistics influenced the Cross-Government Obesity Unit's 2008 publication (Cross-Government Obesity Unit, 2008) outlining the strategies needed to reduce the growing concerns of an obesity epidemic, with a potential cost of nearly £50 billion per year by 2050. Therefore, greater needs are required to implement changes in diets and lifestyles.

Following the initial research, guidelines were published providing policies on how best to promote healthy weight (Cross-Government Obesity Unit, 2008, 2009, 2010; Department of Health, 2011a, 2011b and 2012). With similar outcomes and strategies in place, numbers continue to increase and not enough action is implemented to slow down the increase in obesity rate.

## Public Health

Obesity prevention is a global public health priority, because of the worldwide increase in obesity prevalence and its associated chronic diseases. Findings from the WHO (2014) demonstrate that non-communicable diseases are the leading cause of death worldwide, responsible for 68% of deaths in 2012.

One major factor of obesity and causes of non-communicable diseases is the food choices and portions (i.e. intake). As the total calories increases with the variety of food available, studies illustrate that different factors may contribute to over consumption (Downs et al., 2009; French et al., 2001). From psychological behaviours to environmental factors, influences constantly manipulate our minds in food choices. Often, consequences are not taken into consideration during selection, causing harm to the body. Therefore, actions are needed to reduce infirmity, educating the public with the knowledge of how to lead a healthy lifestyle.

Increasing physical activity is a potential cost effective approach to reducing overweight and obesity, and possible health complications such as cardiovascular diseases. Incorporating moderate physical activity is known to sustain a healthy lifestyle and wellbeing (CDC, 1999). Despite physical activity guidelines provided by many professionals such as The National Institute for Health and Care Excellence (NICE), the UK adult obesity rate has increased over the years. NICE recommends that adults (aged 19–64 years) should be involved in 30 minutes of moderate activity 5 times a week (NICE, 2012). Habitual physical activities are therefore required to promote healthy living, reduce risks of obesity and cardiovascular diseases.

### What We Know

It is known that many factors influence dietary choices and perceptions of nutritional status. As such, decision-making in food choices relating to behavioural science emphasise the range of influences in food consumption. Therefore, there is no single factor or intervention that can be implemented to resolve the current issues of the increasing rate of overweight and obesity, and cardiovascular diseases faced by healthcare professionals. Hence, all lifestyle aspects can influence individual health status, for example, interventions such as physical activity. It is also known that health care professionals working in cohesive multi-disciplinary teams provide better quality of patient-centred care, assisting individual needs. However, further research is required with a focus on exploring how interventions such as physical exercise can be applied in public health nutrition, raising awareness of healthy living to the wider general population.

## INTRODUCTION TO REVIEW

It is understood from existing literature that consistent care should be provided to address the rising issues concerning public health nutrition. This systematic review aims to compile the current knowledge in the literature, providing a deeper understanding of how implementing physical activity relates to cardiovascular disease following health guidelines. Characteristics will be explored to quantify how the implementation of different interventions and assessments enable health professionals to identify better approaches with the general population, therefore preventing an obesogenic environment.

### Aims

To critically evaluate physical activity interventions and their relationship with cardiovascular disease; exploring the current understanding of rationales underlying the obesity epidemic using qualitative research.

### Objectives

1. To evaluate the effects of moderate physical activity and nutrition education on participants' health status, using physical activity interventions;
2. To explore the relationship of physical exercise and risks of cardiovascular diseases;
3. To ascertain the association between being obese and risks of cardiovascular diseases.

### BIOGRAPHY CONT.

**Ihab Tewfik** is a Registered Nutritionist (Public Health) who has expertise in planning, implementing and evaluating sustainable nutrition-sensitive intervention programmes at the population level. Ihab has developed an independent academic research career that underpins the pivotal role of nutrition science in modulating complications of global chronic diseases through tailored functional recipes (TFRs). These innovative TFRs are optimised using locally produced ingredients that are formulated into meals to nourish vulnerable populations and ascertain their optimum health. Ihab's research theme is "Local Food for Global Health".

## METHOD

### Criteria for Inclusion and Exclusion

A pre-defined inclusion and exclusion criterion (TABLE 1) was implemented to help address the aims and objectives of this review.

### Search Strategy

Complementing TABLE 1, a search strategy was identified to assist with this systematic search using relevant databases: GoogleScholar*, Library Search (via University of Westminster's library)*, Web of Science, JSTOR, PubMed, Cochrane Library, ScienceDirect, Wiley Online Library. (*GoogleScholar and Library Search (via University of Westminster's library) databases were used as an initial search to provide a baseline of papers available.) Embase was initially selected but the University of Westminster is not registered to use this: this database was therefore disregarded.

The following set of initial keywords was used for a systematic search: physical activity, physical exercise, cardiovascular diseases, overweight, obesity, adults. As of August 2016, Appendix 4 documents the search using each database in detail. The keywords listed above were used, together with Mesh terms and filtered categories during the screening process. A '3-step approach' (TABLE 2) was devised for quality control, ensuring any literature found was best matched against the inclusion criterion, for a systematic search.

### Process of Study Selection

Following the development of TABLE 2, FIGURE 1 exhibits the study selection process via a flow diagram adapted from the PRISMA Statement (Moher et al., 2009). After screening using online databases and manually screening against the inclusion and exclusion criteria, 158 items of literature were gathered. Articles were then manually screened, determining their relevance to the preliminary objectives of this project. Relevance against the criterion, the title, abstract, authors and aims were analysed with further scanning on the full article, ensuring a consistent selection process throughout.

After the screening process of Step 2, a total of 62 articles were accepted to be progressed to the final stage (Step 3). Of the 96 articles excluded, the main reasons for exclusion included:

- Not within age group (18–65 years old)
- Not relevant to topic
- Literature only provided background information
- Systematic reviews with no relevance to topic
- Literature published outside the years 2000–2016
- No physical activity interventions
- Study protocols
- Literature withdrawn from database
- Repeated literature during database search

Step 3 consisted of further narrowing literature found. Of these, 19 articles were accepted with 43 rejected following a manual screening process of all the content. Of the 43 rejections, the main reasons for exclusion included:

- Content demonstrates literatures to be systematic reviews
- No physical activity interventions
- Study not active in the years 2000–2016
- Content not relevant to cardiovascular disease, obesity, or physical activity
- Participants not in the age range
- Others, where content was providing background information only

### Alteration to Inclusion Criteria

During Step 2, difficulties were found in obtaining literature published or studies researched in the UK. Therefore, literature screened on this criteria under 'Types of Study' was slightly altered, where literature that includes other inclusion points was included that were not necessarily published in the UK. However, this provided the opportunity to compare studies' interventions and the effectiveness on participants.

TABLE 1

**Inclusion and Exclusion Criterion**

| | *Inclusion Criteria* | *Exclusion Criteria* |
|---|---|---|
| Types of study | Primary research design - articles, preferably from randomised controlled clinical trials. However, cohort, case control, cross-sectional studies, quasi-random allocation and cluster randomisation trials may also be considered for comparisons. | |
| | Articles published in the 17 year period 2000–2016 inclusive | |
| | Articles published and based in the UK, although a few in the US can be selected for comparisons between studies. | |
| | Journal articles, grey literature | Books |
| | The study was published and written in English. | Foreign languages |
| | If multiple articles were published with the same interventions and cohorts, the most detailed articles will be selected (such as larger sample size). | |
| Types of participants | Participants who are employed (18–65 years old) | Participants who are students, unemployed. |
| | Participants to include those with both low and high risks of cardiovascular diseases for comparisons | |
| | Participants not to be on any other dietary intervention other than the intervention provided in study | Participants who are on other dietary interventions outside study |
| Types of interventions | Articles to include interventions such as physical activities and how this affects health status and cardiovascular diseases | Exclude anything mentioning diabetes |
| | Interventions with all types of physical activity (e.g. leisure, occupational, total physical activity) | |
| | Intervention to be a minimum of six weeks | |
| | Intervention to include provided supervision or followed protocol if possible | |
| Types of outcome measures | Articles to have health and intermediate outcomes where possible (e.g. laboratory or clinical measures, and behavioural outcomes) | |
| | Outcomes to have health outcomes that are relevant to physical activity, cardiovascular diseases and obesity. | |

*Source:* Devised by author

## Quality Assessment and Management of Search Results

A quality assessment was implemented for quality control of this review, with the aim of examining its study design, reflecting on the developments of the authors' methods and the impact of bias. The strength of the studies' outcomes will be measured, identifying the strengths, limitations and recommendations outlined. Applications of quality assessment tools facilitate the consistency and impartial perspectives in determining the validity of evidence in this topic. The assessment tools selected all provide assistance in the critical analysis of the literature.

Scoring systems were developed to critically analyse the literature using a variety of validated tools, understanding the risk of bias in design studies. Available assessment checklists and tools were selected for their relevance to this review. Six potential tools determining the quality of the literature for further assessment are as outlined in

**TABLE 2** **The '3-Step Approach'**

| *Step* | *Description* |
|---|---|
| 1 | Input keywords into the database<br>Record the number of articles found<br>If possible, narrow the search down using mesh terms (Appendix 4)<br>Manually screen literature by title only and determine relevance to topic<br>Document literature into list |
| 2 | Using literature from Step 1, manually screen literature by title, author, and abstracts only according to criteria<br>Record literature into list of 'accepted' |
| 3 | Using literature from Step 2, manually screen the whole literature against criteria<br>Record literature into the final list of 'accepted' |

*Source:* Devised by author

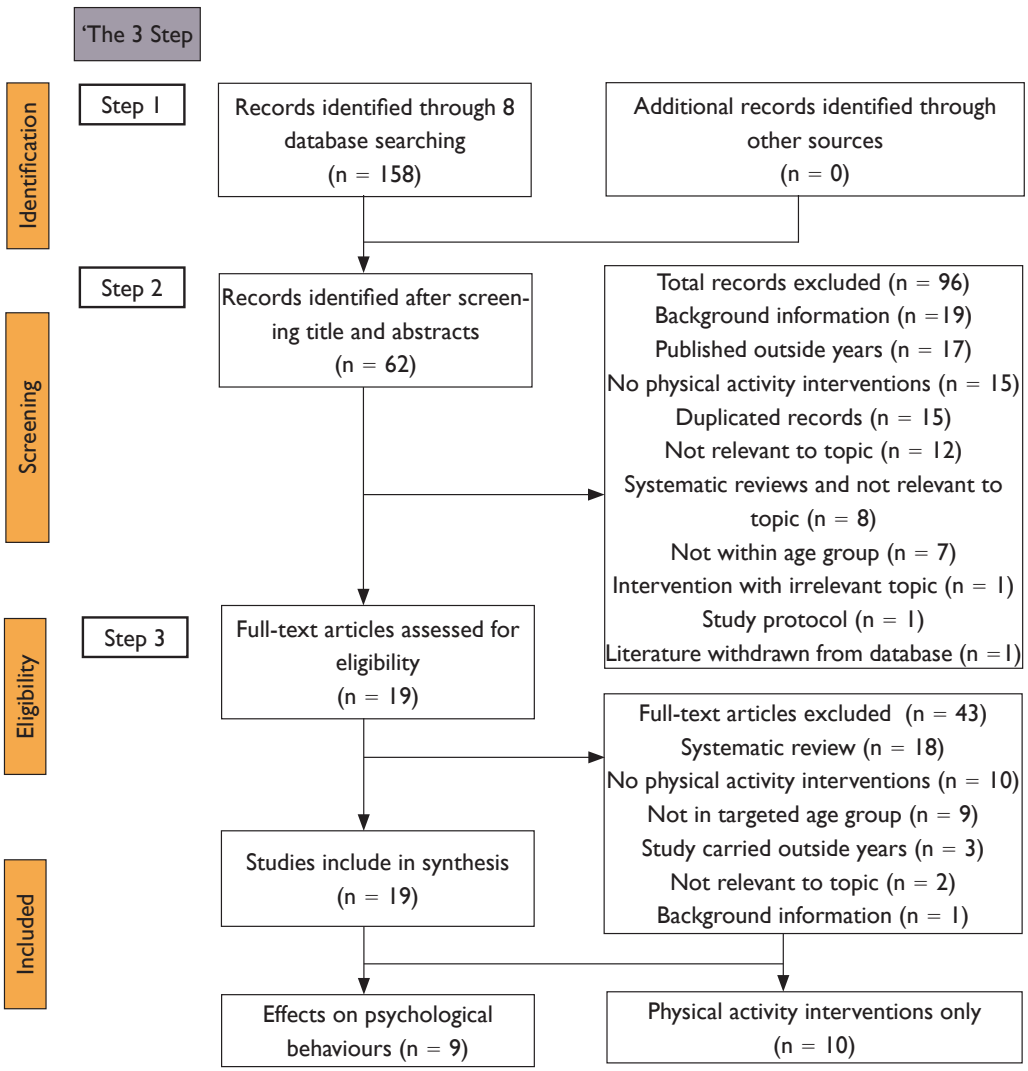


**FIGURE 1** **Studies Selection Process**

*Source:* Devised by author

BOX 1. Two further tools will also be developed from Ke et al. (2013), understanding the characteristics in the literature. These will be used to critically analyse the relevance of the literature compared to the inclusion and exclusion criteria.

## Adapted Tools and Scoring Systems

Using the available tools, assessment checklists and scoring systems were adapted and created, providing relevance to the aims of this systematic review (BOXES 2–8).

**BOX 1**

### Checklist and Tools for Quality Assessment

1. PRISMA - P Checklist (Moher et al., 2009)
   - Was developed to facilitate the qualitative interpretation and evaluations of interventions
2. Cochrane Risk of Bias Tool (Higgins et al., 2011)
   - Seven types of bias (known as principles) were developed to assess the authors' risks of bias in their study.
3. CASP Cohort Study Checklist (CASP, 2014)
   - As part of the eight critical appraisal tools, this checklist presents the researcher with the tool to assess the relevance and reliability of papers.
4. Newcastle-Ottawa Quality Assessment Scale (Wells et al., no date)
   - A quality assessment for non-randomised studies based on three angles: selection of the study groups, the comparability, and the ascertainment of the result outcomes.
5. Downs and Black (Downs and Black, 1998)
   - To critically analyse non-randomised and randomised studies, providing a score to test the strength and validity of intervention and design study.

**BOX 2**

### Study Quality

***Level 1 (Score = 1)***

Studies with no identified aim or objectives; strengths and weaknesses not identified; implications of confounding factors not identified; design study lacks clarity; subject recruitments not mentioned; critical analysis and or reflections identified; no or lack of follow ups post-interventions (within six months); results provided with no or lack of statistical analysis of impact from intervention; outcomes not meeting initial hypothesis and/or aims and objectives; lack of recommendations suggested by authors.

***Level 2 (Score = 2)***

Studies with relatively brief aim and objectives identified; strengths and weaknesses briefly identified; confounding factors briefly or lack of identification; design study briefly provided method of approach; identification of subject recruitments; identified critical analysis and or reflections from authors; follow ups (within three months) post-interventions; results provided brief statistical analysis of results from baseline measurements from intervention; outcomes partly meeting initial hypothesis and/or aims and objectives (if not met, authors gave justification of reasoning); recommendations and improvements suggested for future research.

***Level 3 (Score = 3)***

Studies with clear aims and objectives identified; clear strengths and weaknesses identified; confounding factors discussed and identified; acceptable design study with clear method of approach; subject recruitment randomised and representable where possible with greater number of participants; critical analysis or reflections recognised; immediate and or long term follow ups (one year or more) carried out post-interventions or identified; results provided clear statistical analysis of results on impact with less than 30% drop out rate); outcomes met initial hypothesis and/or aim and objectives with reasons; recommendations and improvements clearly explained by authors.

BOX 3

## Level of Evidence (Adapted from NHMRC, 1999)

***Level 1 (Score = 1)***

Evidence gathered from relevant randomised controlled trials or cohort studies.

***Level 2 (Score = 2)***

Evidence gathered from good design quality study* with or without randomised recruitment.

***Level 3 (Score = 3)***

Evidence gathered from good design quality* with randomised recruitment with more than one group of participants.

***Level 4 (Score = 4)***

Evidence gathered clearly provided rationales of strengths and weaknesses, and comparisons to other research studies with randomised recruitment. Abnormal results (if applicable) were clearly explained.

***Level 5 (Score = 5)***

Evidence gathered based on clinical experiment/interventions with randomised recruitment and more than one treatment group. Abnormal results (if applicable) explained identifying implications of evidence and study.

**where design quality was based from the score calculated from BOX 2 (Study Quality)*

BOX 4

## Adapted Version of PRISMA Checklist (Moher et al., 2009)

**Study to score 1 point for every tick it received, if mentioned on the checklist:**

1. Title: identified the study as an intervention.
2. Abstract: provided a structured summary of: background; objectives; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings.
3. Introduction: review of context from existing research, clearly identifying aims and objectives, potentially also including hypothesis (if applicable).
4. Methods: eligibility criteria, recruitment, intervention applied, data collection process, variables explored, assessing risks of bias, data handling approach, any other data analysis.
5. Results: outcomes, impact from intervention (changes from baseline), summary of intervention, statistical analysis.
6. Discussion: summary of evidence, strengths and weaknesses, limitations, conclusions, future recommendations.
7. Funding

BOX 5

## CASP Cohort Study Checklist (CASP, 2014)

**Study to score 1 point for every tick it received**

1. Did the study address a clearly focused issue? (Population, risk factors, outcomes considered?)
2. Was the cohort recruited in an acceptable way? (Representable?)
3. Was the exposure accurately measured to minimise bias? (Are they valid?/Subjective or objective measurements?)
4. Was the outcome accurately measured to minimise bias? (Use of reliable system?/Subjects and assessors blinded?)
5. Have the authors identified all important confounding factors? (Controls/restrictions)
6. Was the follow up of subjects complete enough? (Was the follow up long enough?)
7. Were the results clearly defined?*
8. Was the precision of the results demonstrated?*
9. Do you believe the results? (Study sufficient enough?/Reliable?)
10. Can the results be applied to the local population? (Benefits and harms)
11. Do the results of this study fit with other available evidence?
12. Were the implications of this study identified?*

**These questions were adapted from the original checklist to be more relevant*

## BOX 6 Adapted Version of the Cochrane Risk of Bias Tool (Higgins et al., 2011)

***Score shown in parentheses***

***Random Allocation for Concealment (Selection Bias)***

Adequate (3): anonymous and randomised selection of subjects and placed into groups if needed, no influence from researchers
Unclear/Not Stated (2)
Inadequate/Not Used (1): list was seen prior to selection, with process being apparent

***Performance Bias (Blinding)***

Double Blind (3)/Single Blind (2)/Unclear or Not Stated (1)/No Blinding (0)

***Detection Bias (Allocation of Interventions)***

Adequate (3): Researchers have no knowledge of allocated treatments
Unclear/Not Stated (2)
Inadequate (1): Researchers know the allocated treatments

***Attrition Bias (Completeness of study and intervention by subjects)***

Adequate (3): Less than 30% dropout rate/response rate
Unclear/Not Stated (2)
Inadequate (1): More than 30% dropout rate/response rate

***Overall Risk of Study***

Low Risk: All qualities above met
Moderate Risk: One or more qualities above only partly met
High Risk: One or more qualities not met

## BOX 7 Adapted Version of Newcastle-Ottawa Quality Assessment Scale (Wells et al., no date)

***Score shown in parentheses***

***Representativeness of Exposed Cohort***

Truly representative of community population (3)
Selective group of users (2)
No description of cohort (1)

***Selection of Cohort***

Drawn from the same community (3)
Drawn from different communities or sources (2)
No description of cohort (1)

***Ascertainment of Exposure***

Supervised intervention (3)
Unsupervised intervention/written self-report (2)
No Description (1)

***Comparability***

Study control for intervention (3)
Unclear/Not Stated (2)
No study control for intervention (1)

***Assessment Outcome***

Body composition measurements, pre- and post-intervention (3)
Self-report (2)
No description (1)

***Was Follow up Long Enough for Outcomes to Occur***

Yes - minimum of six weeks (2)
No (1)

***Adequacy of Follow up of cohort***

All subjects completed study intervention (3)
Subjects loss of <30% (2)
Subjects loss of >30% (1)
No statement (0)

**BOX 8**

**Adapted Version of Downs and Black (1998)**

***Score: if yes to statement = 1, if no to statement = 0***

1. Hypothesis/aim/objectives of the study clearly described
2. Main outcomes clearly described in introduction or method section
3. Subjects' characteristics clearly described
4. Intervention clearly described
5. Confounders clearly described
6. Main findings clearly described
7. Standard error. Standard deviations/confidence intervals reported
8. Implications of study clearly described
9. Losses to subjects, if so, it is clearly explained
10. Actual probability values reported if probability values are <0.001 (instead of <0.05)
11. Random selection of subjects
12. Facilities and subjects used for intervention are representative to those in use on population
13. Subjects were blinded in the received interventions
14. Assessors measuring outcomes were blinded in the received interventions
15. The length for follow-up post-intervention were standardised
16. Statistical tests were used to measure outcomes
17. Standardised intervention compliance throughout study
18. Valid and reliable outcome measured
19. Subjects for different intervention group recruited from the same population
20. Subjects recruited in a set period of time
21. Randomised selection of participants
22. Confounding factors identified and main outcomes were not adjusted
23. Losses of subjects was reported and identified

## RESULTS

The literature review performed prior to this review demonstrates many factors affecting this relationship, as shown by the Foresight Obesity System Atlas (Government Office for Science, 2007)

Literature found in this field were explored using the screening processed developed (The 3-Step Approach) for quality control. Whilst 19 articles were found and be included for this review, they were split into two categories: studies with intervention only, and studies with physical activity intervention and the impact it has on psychological behaviours (TABLES 3–8). Characteristics from the literature and the use of the adapted tools and scoring systems will also be displayed providing quality assessments of each selected study.

A total of 19 articles published between 2000 and 2016 (inclusive) were reviewed. However, due to the limited literature found, studies published and based outside of the UK were included for comparison.

TABLE 3

## Summary of Characteristics of Included Studies (n = 19)

| *Characteristics* | *Number of Studies* |
|---|---|
| Study Country | |
| UK | 7 |
| USA | 4 |
| Australia | 3 |
| Brazil | 1 |
| Finland | 1 |
| Northern Ireland | 1 |
| Tanzania | 1 |
| UK and USA | 1 |
| Study Design | |
| Randomised Controlled Trials | 8 |
| Cohort | 5 |
| Cross Section | 4 |
| Cross Cultural | 2 |
| Type of Intervention | |
| Physical Activity Intervention | 9 |
| Others (Home Based/Group Based/Questionnaire/Post) | 5 |
| Online | 2 |
| Motivational Interviewing | 2 |
| Counselling | 1 |
| Address What Problem | |
| Lifestyle | 7 |
| Cardiovascular Diseases | 5 |
| Quality of Life | 2 |
| Primary Health Care | 2 |
| Psychological Needs | 1 |
| Physical Activity and Cardiovascular Disease | 1 |
| Cardiovascular Disease and Body Composition | 1 |
| Study Perspective | |
| Research Laboratory/Self | 11 |
| Supervised | 3 |
| Home based/Self | 2 |
| Self | 2 |
| Research Laboratory/Work | 1 |
| Setting | |
| Health Clinics/GP Practices | 7 |
| Home Based | 3 |
| Online/Post | 3 |
| Work Place | 2 |
| Laboratory/Home Based | 2 |
| Health Clinic/Home Based | 1 |
| Other (Event) | 1 |

**TABLE 3** **Summary of Characteristics of Included Studies (n = 19) *(cont.)***

| *Characteristics* | *Number of Studies* |
|---|---|
| Type of Support | |
| Face to Face | 6 |
| Face to Face/Phone | 5 |
| Face to Face/Questionnaire | 4 |
| Phone Call | 1 |
| Post | 1 |
| Face to Face/Phone/Online Resource | 1 |
| Unclear | 1 |
| Outcome Measures | |
| Anthropometry | 13 |
| Baseline and Post Intervention | 13 (6 didn't) |
| Blood Pressure | 11 |
| Blood Parameter | 10 |
| Long Term Sustainability | |
| Yes | 10 |
| Potentially yes (to enable better understanding of population) | 7 |
| No | 1 |
| Not Sure | 1 |

*Source:* Adapted from Ke et al., 2013

**TABLE 4** **Number of Studies Fulfilling Inclusion Criteria (n = 19)**

| *Systematic Review's Inclusion Criteria* | *Number of Studies Fulfilling Criteria* |
|---|---|
| 1. Primary research design | 19 |
| 2. Articles published in the 17 year period (2000–2016 inclusive) | 18 |
| 3. Articles published and based in the UK, although a few in the US can be selected for comparisons between studies | 8 |
| 4. Journal articles, grey literature | 19 |
| 5. The study was published and written in English | 19 |
| 6. If multiple articles were published with the same interventions and cohorts, the most detailed articles will be selected (such as larger sample size) | 3 |
| 7. Participants who are employed (18–65 years old) | 19 |
| 8. Participants to include both low and high risks of cardiovascular diseases for comparisons | 18 |
| 9. Participants not to be on any other dietary intervention other than the intervention provided in study | 16 |
| 10. Articles to include interventions such as physical activities and how this affects health status and cardiovascular diseases | 15 |
| 11. Interventions with all types of physical activity (e.g. leisure, occupational, total physical activity) | 10 |
| 12. Intervention to be a minimum of six weeks | 12 |
| 13. Intervention to include provided supervision or followed protocol if possible | 15 |
| 14. Articles to have health and intermediate outcomes where possible (e.g. laboratory or clinical measures, and behavioural outcomes) | 18 |
| 15. Outcomes to have health outcomes, which are relevant to physical activity, cardiovascular diseases and obesity | 19 |

*Source:* Adapted from Ke et al., 2013

TABLE 5

**Summary of Literatures - Physical Activity Interventions (n = 10)**

| *Study* | *Aims and Objectives* | *Study Design* | *Outcomes* | *Limitations* | *Recommendations* | *Critical Appraisal* |
|---|---|---|---|---|---|---|
| Dua et al. (2007) | Evaluate habitual exercise levels of adults with CHD and survey the attitude of exercise in participants | Cross Section | Encouraging patients to exercise more provides them greater confidence in engaging and taking part in PA, and changes their attitudes towards exercising. Those in the Grade I group (lowest chance of CHD, healthiest group) had the highest physical activity questionnaire score. | Limited to the number of participants, no equal samples in each of the three groups, the method used to assess exercise participation (unable to record type of exercise activity and its intensity, especially when accelerometer was removed in wet activities), reasons for lower confidence level was not assessed, and advice provided on exercise participation was not documented | Provide a larger sample size and, where possible, equally in all three groups. | Simple and effective design study capturing an intervention and its impacts on physical activity levels using accelerometers. However, sample size was not equal across groups so results may not be very valid. Body composition measurements and activity intensities could have been measured, to see how PA levels affect health status. |
| Dua et al. (2010) | Assess the feasibility of exercise training and the effects it has using home based exercise training programmes to improve quality of life | Cohort | In all measurements carried out, results shown to improve in all measurements, thus providing evidence supporting that PA is a good and simple intervention to reduce risks of congenital heart disease. Sample group was split according to the New York Heart Association to three groups, comparing their qualitative and quantitative results, with everyone improving their measurements in the post-intervention assessment | Oxygen uptake was not measured; small group of number of participants; a potential bias in recruitment as majority of participants were recruited from the clinic | Bigger sample size, to have a more balanced approach when recruiting participants, avoiding increased efficacy of recruitment from clinics rather than via phone. Also recommended that unequal members of the New York Heart Association groups should be addressed in future research. | A clear design study illustrating the background problems learned. Whilst this study captures the aims and objectives of this research, it was clear that any form of exercise (i.e. walking) provides benefits to adults with congenital heart disease. However, authors used the New York Heart Association system to classify the participants rather than a UK classification system. Recommending body composition and biochemical indices to be measured to determine change from PA intervention |

**TABLE 5** **Summary of Literatures - Physical Activity Interventions (n = 10) *(cont.)***

| *Study* | *Aims and Objectives* | *Study Design* | *Outcomes* | *Limitations* | *Recommendations* | *Critical Appraisal* |
|---|---|---|---|---|---|---|
| Freak-Poli et al. (2011) | Evaluate a pedometer based programme in reducing the risks of diabetes and CVD | Cohort | The 4-month intervention provides improvements in all measurements: anthropometric, behavioural, biomedical and risks of diabetes and CVD. Results shown not only to improve PA levels but more immediate effects and health benefits | Authors highlighted bias concern during workplace recruitment – even though participants were from a range of workplaces, those enrolled had more motivation in achieving targets. Those returning for post-intervention measurements were healthier and motivated, thus difficult to compare results. Study lacked control group, thus unable to have a better comparison of results | To have a control group. To ensure participants are a mixture of both motivated and not so motivated in maintaining PA, as this current study underestimates the general health benefits as listed by the health professionals due to a very motivated cohort | Clear study outlining the design study from recruitment phase to the data collection phase in detail. Good size of cohort sample from different occupations covering variety of measurements. However, it was noted that only BP, BMI and waist circumference was measured under anthropometric measurements. Recommending to include hip circumference to calculate W:H ratio to measure the fat distribution. |
| Golubic et al. (2015) | Examine the relationship between measuring MVPA, sedentary time and total abdominal body at three points time, randomly allocating into three interventions | RCT | Results demonstrate that MVPA has effects on body fat over time, but do not provide much evidence on associating with sedentary time. There was a positive correlation between increase in PA and decrease in body fat that should be considered as a factor of health complications and reasons for decreased PA. | Small sample with the focus on middle aged Caucasian participants with high risk of type 2 diabetes; residual confounding factors were not able to be excluded; participants only wore accelerometer for four consecutive days, unable to capture PA intensity | To have a bigger sample, to include a wider sample of participants from other ethnicities, to measure energy expenditure (including dietary intake), participants to wear accelerometer longer than four days to provide better understanding of their habitual PA | Study provided an understanding of the relationship between PA, sedentary time and change in body fat over three time points. Questions were raised from using the accelerometers on its validity in capturing participants' habitual PA data. No training sessions were mentioned in educating participants in using the technology and/or continuous support throughout study. A lack of details on the three different interventions used. However, many confounding factors were explained explicitly linking to study's limitations |

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| Hagnäs et al. (2012) | Evaluate whether military service has an effect on body composition, a reduction in prevalence of metabolic syndrome, and if BMI is dependent | Cohort | Findings from this study support past data in the field with results showing that decreasing the prevalence of MetS by increasing PA can have a positive effect in reducing visceral and fat mass. BP and weight loss were also reduced, whilst PA and HDL increased | Impossible to control the amount of energy intake and total calories consumed; only male participants were measured; sample was limited to healthy young men | To have a control group; to have both males and females in sample; to limit the food consumed during leisure time | Interesting study looking at military service and how their lifestyle changes according to the training received in BMI groups (<18.5, 18.5-24.9, 25-29.9, ≥30). However, because the sample included different professionals within the service, the length of participation of some participants varied as different tasks and military training determines length of service. Standardisation of intervention was not implemented, which may have affect results |
| Irwin et al. (2004) | To evaluate the effects on exercise stage of change, self-efficacy and past participation in sport and recreational PA, assessing the adherence to a year-long exercise intervention | RCT | A year-long supervised and engaged intervention suggests improvements in prolonging PA duration over a year, with participants improving their health status (physiological and psychological variables) and more likely to adopt a lifestyle change. Participants in two groups: exercise intervention (n = 87) vs control group (n = 86) | Study was unable to recruit an ethnically diverse sample, and participants were all highly educated | To attempt to determine predictors to long term exercise adherence and maintenance in a wider population | A well design and structured design study covering all aspects to explore the initial aim as suggested by authors. Adherence was strongly mentioned to measure participants' behaviour change. It was clear the authors strongly wanted to prevent participants dropping out by setting up a strategic plan ensuring adherence and engagement with participants, who were supported at all times. Although a lot of paperwork was required for logging daily PA, it seems that there was a strong motivation within the sample to adopt lifestyle change – required to sustain the study's outcomes |

**TABLE 5** **Summary of Literatures - Physical Activity Interventions (n = 10) *(cont.)***

| *Study* | *Aims and Objectives* | *Study Design* | *Outcomes* | *Limitations* | *Recommendations* | *Critical Appraisal* |
|---|---|---|---|---|---|---|
| Jones et al. (2016) | To identify the correlation of the patterns between PA and sedentary behaviour, exploring the latent classes | Cross Sectional | Found that those who are less active were female, older in age, smoked, had higher BMI, BP, more at risk or suffer from diabetes, CVD. Emphysema, and required equipment to aid with walking. Conversely, those who were more active were non-Hispanic black, employed, born outside of US, better self-rated health and were classed as "weekend warrior" | Lack of regular monitoring of PA and sedentary behaviour to provide a better understanding of the correlation; data collected was only a snapshot of the behaviour at a certain time; unable to define the potential impact factors associated with sedentary behaviour; potential data collected may not actually reflect on PA carried out as it was worn at the hip | To define potential predictors linked to sedentary behaviour and PA levels; to have a varied sample from different ethnicity; to have a longer intervention (more than one week) | The relationship between PA and sedentary behaviour was explored by the authors using a short intervention (with the recommendation that this should be longer to understand habitual PA). Sample size was split into groups according to BMI, however, data were all self-reported, which may have affected data analysis. Suggesting that more supervision is required to capture true participant data |
| Martinelli et al. (2008) | Evaluation of Quality of Life (QoL) questionnaire at a voluntary visit specific community health event whilst analysing whether their QoL was associated with CVD risk factors | Cohort | Found that diabetes mellitus, dyslipidemia and obesity were related to a lower QoL score, whilst men have a higher QoL score compared to women. Result also demonstrates that an increase in PA level also correlates to a higher QoL score as participants has greater concerns for their health. Only a third of the sample felt they have enough accessibility to CVD information | Participants selected for this study were not representative of the community, therefore results may be biased; self-reported answers from participants may not represent their habitual lifestyle as interview was carried out at an event | Further health promotions should be targeted towards women for a better understanding of why women scored lower on QoL domains (where data from this study are consistent with past studies) | A different approach of intervention in capturing data at a community health event. Although data might potentially be biased as participants were the ones who voluntarily attended event to be more informed of CVD risk factors. Interviews conducted at event may not have been the best environment to capture participants' answers. Suggesting more variables to be measured, including dietary intake to understand their QoL, and have repeated sessions at various days with participants to understand habitual lifestyle. |

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| Oldroyd et al. (2006) | To evaluate the effectiveness of lifestyle intervention on those with impaired glucose intolerance (IGT) | RCT | Those in the intervention group compared to the control group met the targets set with dietitian and physiotherapist for dietary and PA change over 24 month intervention. IGT and obesity risks also improved following motivational counselling sessions | Study was designed to evaluate the risk factors for coronary heart disease and type 2 diabetes instead of impact made by the motivational counselling sessions; insufficient review appointments with participants, which may have limited the amount of understanding in coronary heart disease risk factor changes; difficulties in initial recruitment and maintaining adherence throughout study | To identify more practical ways of screening patients with IGT at primary care level; to develop interventions targeting people with IGT and most at risk of type 2 diabetes in assisting their adoption of lifestyle changes | Clear design study breaking down the different aspects of protocol in a systematic approach. Good comparison between the intervention vs. control group throughout the study; a larger group of health professionals may be required to assess participants. Repeated food diary is also recommended at regular intervals other than the initial self-reporting 4-day food diary consisting of 2 weekdays and 2 weekends (results may have been under-reported, affecting dietary intervention at the later stage). |
| Sherman et al. (2007) | To assess the effectiveness of primary care based walking intervention in rural women | Cohort | Primary care based walking intervention supervised by health care professionals over a period of time has encouraged the three groups of participants (with normal, overweight, and obese BMI) to increase their step counts. More time was spent on PA whilst improving their health status from the collected data. It was found that participants were more encouraged to increase their PA via regular contacts with health professionals as a means of motivation | Only measured short term outcomes; lack of control group for comparing data; lack of data for those classified in the morbidly obese or very inactive women; self-reported values; participants were self-selected Caucasian women and not randomised | To determine if long term benefits can be effective from a primary care setting with regular support and guidance from health professionals during visits | It was clear simple walking intervention can help understand the effectiveness of PA on health status. Sample was split into three groups according to BMI levels, and a lack of data was obtained comparing against a control group. Suggesting a comparison with different means of exercise, determining change in effectiveness. Lack of diversity during recruitment may produce biased results, which may not be representative. However, it was noted that regular contacts with health care professionals and/or with monitoring affects participants' willingness to adopt lifestyle changes. Self-reporting results may contribute to bias |

*Abbreviations: CHD = Coronary Heart Disease, CVD = Cardiovascular Disease, PA = Physical Activity, MVPA = Moderate Vigorous Physical Activity

*Source:* Devised by author

**TABLE 6** **Summary of Literatures - Effects on Psychological Behaviours (n = 9**)**

| *Study* | *Aims and Objectives* | *Study Design* | *Outcomes* | *Limitations* | *Recommendations* | *Critical Appraisal* |
|---|---|---|---|---|---|---|
| Blackford et al. (2015) | Address metabolic syndrome and overweight and obesity by improving physical activity and nutrition behaviours on middle aged adults | RCT | See below Blackford et al. (2016) | See Blackford et al. (2016) | See Blackford et al. (2016) | See Blackford et al. (2016) |
| **Blackford et al. (2016) | See Blackford et al. (2015) | See Blackford et al. (2015) | Home based interventions for those at risk of metabolic syndrome, type 2 diabetes and CVD provides an effective approach to motivate greater behaviour change, increasing PA and improving in nutrition intake | Authors highlighted that a 6-month intervention was not long enough to reflect on behaviour change in adults | Longer term studies are needed to ensure participants' changed behaviour in maintaining body weight and lifestyle changes | A strong and thorough recruitment stage, screening participants to ensure they are as relevant as possible to assist diagnosing metabolic syndrome |
| Carr et al. (2008) | Increasing PA between classroom delivery format and traditional exercise approach with internet delivered based interventions will change the behaviour in PA and prevent CVD risk factors. Determining the efficacy of intervention in those with sedentary and assessing CVD risk factors | RCT in a 2 step design intervention | Internet delivery based intervention increased PA and behaviour change, reducing central adipose tissue and reducing risks of cardiometabolic risk factors | A high attrition rate of 23% and 53% for both studies 1 and 2, not representing population; no measurement for PA intensity; gender imbalance; dissemination was limited by funding | Improving engagement and resources will reduce the high dropout rate; exploring methods to contact participants, tracking internet compliance usage | A comprehensive study with two studies exploring the effects of internet based delivery intervention against traditional methods as demonstrated in the four groups in study 1. However, with gender imbalanced in both studies, and a high dropout rate in study 2, recommendation is to simplify interventions and specify the complexity of intervention and measures. |
| Duncan et al. (2014) | Aims to identify population groups with highest unawareness of sitting associating with behaviours and CVD risks | Cross Sectional | Socio-demographics data provided evidence that lifestyle affects behaviours in the amount of time sitting each day; this differs between age, gender, level of education, employment, etc. | Research carried out over phone, response based on participants' perceived personal level of risks | Replication of study in other geographical locations and populations to understand study's outcomes | Interesting research looking into the awareness of prolonged sitting in relation to CVD risks. However, data collection approach could have been improved ensuring true reflection of participants' knowledge, behaviours and lifestyle |

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| Franco et al. (2012) | To compare the Quality of Life (QoL) between UK and USA and the impact on health status | Cross Cultural | The US group had a higher mental QoL whilst the UK had a higher physical QoL. Other aspects, such as sleep, age and depressive symptoms, are similarly correlated in both countries | Not enough existing studies to provide evidence associating health status with QoL; both samples were only targeted at Caucasians in Western societies, other factors such as personality, employments, mental status, social support were not included; questions asked in both countries were not standardised and were slightly altered | To understand how mental components have an influence on QoL | Complicated and complex study looking into QoL survey, yet provides an impressive list of data and outcomes. It was much targeted to one population group and not very representative (including gender size). The comparison between US and UK showed similarities and differences that provides future research ideas looking into what intervention can be introduced incorporating the mental behaviour in lifestyle changes |
| Grisolía et al. (2013) | To analyse the trade-offs between lifestyle choices of physical activity, diet, cost and CVD risks | Cross Sectional | Participants were aware that reducing fat intake and increasing PA would reduce risks of CVD. However, they were more willing to engage with more PA sessions and interventions rather than changing dietary habits. Diets and exercise choices were the main components in changing behaviours. | Limited to 40–65 years old only; asking detailed dietary and lifestyle questions may have added to participants' burden in completing with true answers | Public policies to develop targeting and promoting more physical activities rather than healthier diets and choices. | Useful literature facilitating the understanding of factors affecting CVD risks. Results collected were only via online questionnaire-type interviews (Computer Assisted Personal Interviews) providing different approach for data collection. Participants' recruitment process was clear enough, and design study on questionnaire may have perceived subjective results as it was carried out with no mention of tracking who completed the interviews as it was done online at home: this is a potential major limitation. |

**TABLE 6** **Summary of Literatures - Effects on Psychological Behaviours (n = 9**) *(cont.)***

| *Study* | *Aims and Objectives* | *Study Design* | *Outcomes* | *Limitations* | *Recommendations* | *Critical Appraisal* |
|---|---|---|---|---|---|---|
| Hardcastle et al. (2008) | Effectiveness of Motivational Interviews (MI) intervention with CHD risk factors; effects of using counselling sessions and the behaviour change in CHD risk factors; the uptake of consultations with health care professionals and the effects on CHD risk factors | RCT | MI provides better encouragement in behaviour change. Those in the intervention group with counselling sessions (and higher attendance from participants) shows to have a higher increase in PA and reduction in weight, cholesterol and BP. Participants taking part in consultations with Physical Activity Specialists and Registered Dieticians reported that walking was the preferred activity over other types of exercises. Overall conclusion was that there was a bigger impact on the amount of walking over changing dietary behaviour. Therefore, having a dietitian was perhaps unnecessary | Tools to gauge eating behaviour were not sensitive enough to detect behaviour change; participants self-reporting PA measures (perhaps under reporting); low participation rate (perhaps due to participants' readiness for change; exclusion to those over 65 years (as extensive screening may be needed) | To incorporate a health care professional specialised in behaviour change, targeted to lifestyle behaviour change, including diet and PA with change theories and principles | Design study explored effectiveness of counselling sessions to enhance and improve lifestyle and behaviour changes. Whilst literature provides good evidence supporting its hypothesis, perhaps other body composition can be measured to see the effects on body fat. The dietitian in study shown not to be very well used; perhaps have someone who might have had more experience (or have another dietitian) in running sessions on their own rather than a recent graduate looking after the whole group. |
| Hardcastle et al. (2013) | Assess whether weight, BMI, PA, CVD risk factors were maintained one year later; explore effects of counselling session attendance on maintenance outcome; effects of motivational interviewing (MI) on CVD risk factors | RCT | Motivational interviewing (MI) group improved the amount of walking; BMI and cholesterol levels more compared to the minimal intervention group with PA only. Participants' behaviour changes by attending personalised care MI sessions with practitioners, affecting their lifestyle and dietary habits. | Low uptake of intervention due to lack of resources available; biomedical markers, skinfolds, body composition were not measured; relied on self-reported measures on PA levels and dietary behaviours | To measure the social psychological and motivational predictors of behaviour change such as self-efficacy, social support, and other use of behavioural models | A very well designed study capturing the effectiveness of motivational interviewing on patients with risks of CVD. Literature was well written, ensuring blinding during recruitment and baseline/post-intervention measures were taken into consideration to avoid bias. However, body composition measurements could have been included to measure further accuracy in BMI and risks of CVD (perhaps measuring % body fat). |

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| Muhihi et al. (2012) | To assess the relationship of CVD and PA in young and middle aged men in Tanzania | Cross Sectional | Higher energy expenditure in the rural population not correlated to CVD risk factors. Therefore, the higher the physical activity demands, the lower the risk of CVD. However, physical energy expenditure showed no correlation with age, and the socioeconomic status | Study was a cross-sectional study (only provided a snapshot of the population at that time), small sample of men only in the city of Mwanza | Larger sample size with both men and women to understand physical activity and the relationship with CVD risk factors | Simple yet effective design study. Sample size was limited to men only. Not enough evidence to provide understanding how PA is linked to CVD in just a rural area. Recommending intervention to demonstrate change in body composition and biochemical indices in population. Perhaps a longitudinal study is further required |
| Steptoe et al. (2000) | Assess the demographic, social, cognitive predictors of self-reported changes in PA post intervention | RCT | There is an association of psychological needs and supports in changing and improving lifestyle habits. Primary care provided by health care professionals using simple and effective advice on physical activities helps to stimulate the increased participation in exercise intensity. However, study has shown that regular contact with specialist professionals helping with psychological needs (e.g. counselling) can be more effective than the stand alone standard health promotions to reduce BMI and body weight | High dropout rate from those who were smokers, and those remained were highly motivated to change; subjective feedback from interviews and questionnaires by participants with potential bias in results; measure was based on activity sessions lasting 20 minutes and not the total time; guidelines on PA were based on past guidelines and not recent 30 mins for 5 days of the week | To use up to PA guideline when analysing data, to use objective tools of collecting data; to compare short and long term changes, hence longer research is required; more targeted PA intervention linking to CVD risks | Detailed and well-designed study exploring the psychological predictors on the effects of PA changes in obese/overweight participants. Interesting to see how psychological measures were able to be measured. Recommending that more targeted PA interventions should be implemented other than 'advising' participants to do more. To enhance quality control throughout study, recommending using fewer nurses to minimise bias and maintain consistency. |

*Abbreviations: RCT = Randomised Controlled Trial; CVD = Cardiovascular Disease; CHD = Coronary Heart Disease; PA = Physical Activity

**Blackford et al. (2015) was the study protocol where intervention was carried out in 2014–2015. As a result, the follow up paper of Blackford et al. (2016) was published more recently; this was also included to demonstrate the results. Please note, however, that both of these papers are counted as one study and not as two separate literatures.

*Source:* Devised by author

**TABLE 7** **Summary of Literatures - Data Analysis of Interventions to Cardiovascular Diseases and Obesity (n = 19)**

| *Study* | *Sample* | | | *Intervention Setting* | *Duration of Intervention* | *Data Collection Method* | *Follow Ups* | *End Response Rate* | *Outcomes* |
|---|---|---|---|---|---|---|---|---|---|
| | End Sample Size | Features (with mean age) | Location | | | | | | |
| Physical Activity Interventions | | | | | | | | | |
| Dua et al. (2007) | 61 (41 recruited via clinic; 20 recruited by telephone) | Adults (aged 18–63 years, mean 37.7 years ±10.9 years) | Bristol, UK | Health Clinic | 1 week | Physical Activity Questionnaire, face-to-face, accelerometer for physical levels | Yes - after 1 week | 28.37% responded from initial recruitment | Group 1 had a higher Physical Activity than Groups 2 and 3 (where Group 1 was the most healthiest with the least risk of CHD); those in groups 2 and 3 required more encouragement to enhance behaviour change in nutrition status |
| Dua et al. (2010) | 50 (completed both pre and post assessments) | Adults (aged 18–63 years, mean BMI = 25.6 ±8.3) | Bristol, UK | Home based/ clinic | 12 weeks | Face-to-face, exercise treadmill test, questionnaire, accelerometers, 7 day diary | Yes - at 12th week | 81.97% after completing both pre- and post-assessments | Improved at post-assessment in Treadmill Exercise Test, PA Questionnaire, Satisfaction with Life Scale, Short Form, Self-Perception Profile, MVPA, mean kilocalories used. |
| Freak-Poli et al. (2011) | 620 (all who completed both baseline and at 4 months measurement) | Adults (Melbourne workplace employees; mean age of baseline and 4 month attendance = 40.7 years (n = 589); mean BMI = 26.6) | Melbourne, Australia | Workplace | 4 months | Pedometer worn by participants for 125 days, online website daily step-counts diary, face-to-face for measurements, online self-report questionnaire | Yes - at 4 months | 68% of those who completed all baseline and 4 month measurements; 79% returned at 4 month but varied between measurements; 80% had anthropometric measurements at 4 months; 80% had biomedical measurements at 4 month; 70% returned for questionnaire at 4 month | Participants improved on fruit and vegetable intake, takeaway dinner consumption, PA levels, sitting time, BP, waist circumference. Total cholesterol and TG were also improved; and diabetes and CVD risks scores were also improved |

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| Golubic et al. (2015) | 222 after 1 year, 230 after 7 years | Adults (offspring of type 2 diabetes mellitus patients from diabetes registers or family history; mean BMI = 27.7 at baseline, mean age = 41.3 years at baseline) | UK | Home based | 7 years | Participants wore an accelerometer on their lower backs for 4 consecutive days; face-to-face for anthropometric measurements | Yes - at 1 year and 7 years | 365 recruited initially, 231 participants at baseline, 222 at 1 year and 230 at 7 years | Weight, BMI and fat indices were found to have increased over time, while average time in MVPA was less than 30 mins per day, reducing 0.5Kg body weight associated with increased MVPA at 1 year, and reducing 1.4Kg at 16.8 mins per day for MVPA at 7 years. |
| Hagnäs et al. (2012) | 1,160 (attended baseline measurement following initial invitation out of 1,467 men) and 1,046 (those attended both baseline and post assessment) | Adults (aged 18–28 with mean = 19.2 years ±1.0; mean BMI at baseline = 23.9) | Finland | Military based | 6–12 months depending on personnel's military service role (with 8 weeks of PA intervention) | Face-to-face training, and taking measurements (aerobic performance, strength performance, PA intervention) | 6–12 months depending on personnel's military service role | 1,467 men in military, 79% (n = 1160) attended post invitation, 1,046 men attended both baseline and follow up | Measurements improved in all groups following follow-up: reduction in prevalence of obesity, MetS decreased, fat & and fat mass decreased significantly the most in all groups ($p \leq 0.019$), whilst other variables also improved |
| Irwin et al. (2004) | 173 women at 3 months and 170 at 12 months | Adults (postmenopausal women with average age of 61 years at baseline, BMI = <27.5 vs ≥27.5) | Seattle, USA | Research lab/ gym/ home based | 12 months | Face-to-face meetings and self-reported questionnaires. Participants were asked to attend 3 sessions per week for months 1–3 and exercise 2 days per week at home; months 4–12 to attend at least 1 session per week at facility with remaining days exercising at home. Daily logs of PA were required and data were collected on a weekly basis when meeting with trainers. | Yes - at 3 months and 12 months | 173 women at 3 months and 170 at 12 months; 83% of 4,524 expected activity logs completed for 43 weeks (out of 52 weeks); 52% adhered to at least 80% (180 mins per week) of exercise prescription on average over 12 months, while 68% adhered to the national PA recommendation of 150 mins per week over 12 months | Evidence found that those who has a higher adherence will have: smaller circumference, less intra-abdominal fat, high $VO_2$ max, more likely to exercise more in past 3 months, non-Hispanic white, not working full time, higher exercise stage of change, greater participation in supervised exercise session and in group education classes |

**TABLE 7** **Summary of Literatures - Data Analysis of Interventions to Cardiovascular Diseases and Obesity (n = 19) *(cont.)***

| *Study* | *Sample* | | | *Intervention Setting* | *Duration of Intervention* | *Data Collection Method* | *Follow Ups* | *End Response Rate* | *Outcomes* |
|---|---|---|---|---|---|---|---|---|---|
| Jones et al. (2016) | 7,236 participants | Adults (aged 20 and above, mean age = 47 years, 33% obese, 39% hypertension) | USA | Lab/ home based | 1 week | Face-to-face, participants wore accelerometer on right hip | Yes - after 1 week | 100% response rate (n = 7,236), after excluding those who were not eligible prior start of intervention | Those who were older, female, and had a higher BMI and history of chronic diseases were found to be more active, with better self-rated health compared to those who are least active and classed as sedentary (<100 counts/min). |
| Martinelli et al. (2008) | 332 participants (186 women and 146 men) | Adults (mean aged = 57 years ±14; mean BMI = 28 ± 5.1) | Brazil | Event | Weekend | Face-to-face interviews and measurements (weight, height, BP, glycaemia) | No | 100% response as participants answered on the spot with interviewers | Those with a low score QoL were associated with diabetes mellitus, dyslipidemia and had a BMI ≥25 $Kg/m^2$. Those above 50 years showed a higher prevalence with CVD factors. Those who attended the event were more willing to seek advice on CVD prevention, with women more vocal in raising their concerns. |

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| Oldroyd et al. (2006) | 54 participants after 24 months (control group = 24, intervention group = 30) | Adults (aged over 24 years, men and women of European origins, who had IGT on two oral glucose tolerance tests) | Newcastle, UK | Research centre, home based | 24 months | Face-to-face measurements, individual counselling sessions with health care professionals (dietitian and physiotherapist), and self-reported food diary | Yes - at 6, 12 and 24 months | After initial randomisation (n = 78); control n = 39 vs intervention n = 39 at baseline; control n = 32 vs intervention n = 37 at 6 months; control n = 30 vs intervention n = 32 at 12 months; control n = 24 vs intervention n = 30 at 24 months | Improved on: meeting dietary targets; higher PA engagement at least once a week in intervention group, change in body mass, reduced hip circumference in both groups, improved on serum insulin concentration. However, no change in total serum cholesterol, TG or fasting or plasma glucose. |
| Sherman et al. (2007) | 60 Caucasian women at the end of study | Adults (aged 22–64 years with mean age of 42 years; from rural locations; recruited from primary care clinic; mean BMI = 30.6 with 22% normal weight, 28% overweight and 50% obese) | Missouri, USA | Clinic/ home based | 6 months | Face-to-face measurements and contacts via telephone; participants were all provided with a pedometer, a free exercise videotape, and written resource of exercise information | Yes - at 1 week, 1 month, 3 months and 6 months | 75 women initially recruited; 44 (58.7%) women completed all 6 months, 10 (13%) women completed up to and including 3 months, 7 (9.3%) women completed up to and including 1 month. | All groups improved in their step counts post-intervention, with the overweight group performing best post-intervention. Other variables measured, such as non-fasting serum, glucose, total cholesterol, BP, weight, all improved |
| Effects on Psychological Behaviours | | | | | | | | | |
| Blackford et al. (2015); Blackford et al. (2016) | 401 (n = 201 intervention, n = 20 control) | Adults (50–69 years), those at risk of metabolic syndrome | Albany, Australia | Home Based | 6 months | Self-reported questionnaires, motivational interview via phone | Yes - for 6 months | 77.8% (Anthropometry Analysed), 68.3 % (Bloods Analysed) | Improved in TG, TC, DSP, SBP, WC, HC, W:H, Weight, BMI, BF |

**TABLE 7** **Summary of Literatures - Data Analysis of Interventions to Cardiovascular Diseases and Obesity (n = 19) *(cont.)***

| *Study* | *Sample* | | | *Intervention Setting* | *Duration of Intervention* | *Data Collection Method* | *Follow Ups* | *End Response Rate* | *Outcomes* |
|---|---|---|---|---|---|---|---|---|---|
| Carr et al. (2008) | 14 (study 1), 32 (study 2) | Adults (21–65 years), no health complications. Study 2: those are overweight/obese and sedentary | Wyoming, USA | Research Laboratory, Medical Clinic, Online/Home Based | 16 weeks | Internet tracking, questionnaires, face-to-face, phone, pedometer (study 1 only) | Yes - for 16 weeks | 77% (study 1), 49% (study 2) | Improved number of steps (study 1); body composition, anthropometric measurements and blood parameters were also improved after 16 weeks |
| Duncan et al. (2014) | 1,265 completed participants | Adults (18 years+, residing in Queensland) | Queensland, Australia | Online | 1 month | Direct dialled landline telephone; questionnaires and surveys | No | 32% | Greater understanding of the socio-demographic groups of awareness in prolonged sitting linking to CVD risks |
| Franco et al. (2012) | 6,472 (UK), 3,684 (US) | Adults (mean age of 55.8 ±6.1 (UK), 58.7 ± 11.9 (US)) | UK and US | Via Post | Not clear | Self-report via questionnaires | No | UK (unclear), US (59.5%) | UK has fewer in lowest social economic status group with lower BMI and WC, smoke less and higher PA than US sample. US sample sleeps more with higher population suffering with hypertension and diabetes but lower CVD risks. Lifestyle variables strongly correlates to physical rather than mental aspects of QoL |

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|---|---|---|---|---|---|---|---|---|---|
| Grisolía et al. (2013) | 493 participants | Adults (40–65 years, mean age of 50.73 years in Northern Ireland) | Northern Ireland | Online | Not clear (but included a 1 week food diary) | Self-report via online questionnaires | Not mentioned | Not mentioned | Participants were more willingly to pay for changing lifestyles and reducing risks of CVD; those who fall into the obese/overweight category were more likely to engage in physical activities rather than changing their diet. |
| Hardcastle et al. (2008) | 218 participants who completed both pre- and post-assessments (125 in intervention group, 93 in control group) | Adults (18–65 years with CHD risk factors; 50.30 years (intervention group), 50.82 years (control group) of 218 participants) | UK | Phone initially and then Health Clinics | 6 months | Self-reported measures (via questionnaires: IPAQ, DINE, FACET) and face-to-face pre- and post-assessments | Yes - 6 months | 218 participants completed both pre- and post-intervention compared to 334 from baseline measurement (65.27% completion) | Improved in: BMI, weight, BP, cholesterol, TG, amount of PA in walking, fruit and vegetable consumption; reduced fat intake; however, no difference in LDL and HDL; attended more counselling consultations had greater reduction in bodyweight and biochemical indices |
| Hardcastle et al. (2013) | 211 participants after 18 months | Adults (18–65 years, mean age 50.22 years, from local primary care health centre) | UK | Phone initially and Health Clinics | 18 months follow up, 26 months study overall | Face-to-face (at assessment for measurements), motivation sessions: 5 sessions each 20–30 mins in the following 6 months post-baseline measurement ; questionnaires (IPAQ, DINE, FACET) | Yes - 6 months, and 18 months | 59.61% (intervention group), 68.70% (control group) | Changes: increased amount of walking (but more with Motivational Interviewing (MI) intervention), decrease in fat intake, drop in BP (MI group), drop in cholesterol for MI group; more MI sessions attended the more reduction in TG, improvements in SBP and HDL those younger and males; decreased CVD risks factors overall |

**TABLE 7** **Summary of Literatures - Data Analysis of Interventions to Cardiovascular Diseases and Obesity (n = 19) *(cont.)***

| *Study* | *Sample* | | | *Intervention Setting* | *Duration of Intervention* | *Data Collection Method* | *Follow Ups* | *End Response Rate* | *Outcomes* |
|---|---|---|---|---|---|---|---|---|---|
| Muhihi et al. (2012) | 97 young and middle aged men | Adults (20–50 years, with mean age of 31.6 ± 6.4 in Mwanza) | Mwanza, Tanzania | Health Clinics | Not mentioned | Face-to-face measurements, self-reported questionnaire (Sub-Saharan African Activity Questionnaire) | Not mentioned | 69.29% (from the 140 participants initially recruited) | Majority of sample (78.9%) were in moderate intensity occupations, 83.3% walk to commute to work, no significant difference of CVD risk between those whose energy expenditure was either more or less than 4,000kcal/week; low CVD risk in this population |
| Steptoe et al. (2000) | 505 completed after 4 months; 418 completed at 12 months | Adults (with mean age of 49.1 years at 4 months, 50.3 years at 12 months) | UK | GP Practices | 12 months follow up | Face-to-face, interviews, counselling, questionnaires (UK National Fitness Survey) with nurses | Yes - 4 month and 12 months | 72.2% (505 completed at 4 months), 59.8% (418 completed at 12 months) from the initial 883 recruited | 4 months: Improved in PA sessions (the Behaviour Counselling group; non-smokers increased PA more than smokers; more support provided the higher PA, also applied to those who are more motivated and had a higher self-efficacy. At 12 months: higher PA in Behaviour Counselling group compared to Controlled Group (8.2 vs. 4.3), |

*Abbreviations: TG = Triglycerides, TC = Total Cholesterol, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, BP = Blood Pressure; WC = Waist Circumference, HC = Hip Circumference, W: H = Waist to Hip Ratio, BMI = Body Mass Index, BF = Body Fat, MVPA = Moderate Vigorous Physical Activity

*Source:* Devised by author

TABLE 8

## Summary of Literatures' Scores from Scoring Systems (n = 19)

BOXES 2–8 under 'Quality Assessment and Management of Search Results' section explains each scoring system

| *Study* | *Study Quality* | *Level of Evidence* | *PRISMA Checklist* | *CASP Checklist* | *Cochrane Risk of Bias* | *Cochrane Risk of Bias: Overall Risk* | *Newcastle – Ottawa* | *Downs and Black* |
|---|---|---|---|---|---|---|---|---|
| Physical Activity Interventions | | | | | | | | |
| Dua et al. (2007) | 2 (study not lasting 3 months) | 4 | 7 | 11 | 4 | Moderate | 17 | 20 |
| Dua et al. (2010) | 2 | 4 | 7 | 9 | 5 | High | 18 | 20 |
| Freak-Poli et al. (2011) | 3 (dropout rate on average was <30%) | 5 | 7 | 11 | 5 | High | 17 | 22 |
| Golubic et al. (2015) | 3 | 5 | 7 | 11 | 6 | Moderate | 16 | 21 |
| Hagnäs et al. (2012) | 3 | 4 | 6 | 11 | 7 | High | 16 | 20 |
| Irwin et al. (2004) | 3 | 5 | 7 | 12 | 8 | Moderate | 18 | 21 |
| Jones et al. (2016) | 1 | 2 | 7 | 9 | 6 | High | 15 | 19 |
| Martinelli et al. (2008) | 1 | 2 | 6 | 9 | 5 | High | 14 | 17 |
| Oldroyd et al. (2006) | 3 | 5 | 7 | 12 | 8 | Moderate | 18 | 21 |
| Sherman et al. (2007) | 3 | 2 | 7 | 10 | 5 | High | 15 | 19 |
| Effects on Psychological Behaviours | | | | | | | | |
| Blackford et al. (2015); Blackford et al. (2016) | 3 | 5 | 6 | 10 | 9 | Moderate | 17 | 21 |
| Carr et al. (2008) | 2 | 5 | 7 | 10 | 6 | High | 17 | 21 |
| Duncan et al. (2014) | 1 | 2 | 5 | 8 | 6 | High | 10 | 17 |
| Franco et al. (2012) | 1 | 4 | 6 | 8 | 5 | High | 12 | 20 |
| Grisolía et al. (2013) | Between 1 and 2 | 2 | 4 | 6 | 6 | Moderate | 12 | 16 |
| Hardcastle et al. (2008) | 3 | 5 | 7 | 10 | 9 | Moderate | 18 | 23 |
| Hardcastle et al. (2013) | 3 (only low participation in MI sessions) | 5 | 7 | 12 | 9 | Moderate | 18 | 23 |
| Muhihi et al. (2012) | 1 (lack follow ups) | 2 (only one group) | 6 | 8 | 7 | Moderate | 12 | 18 |
| Steptoe et al. (2000) | 2 (due to drop out rate) | 4 | 6 | 10 | 5 | Moderate | 18 | 20 |

*Scoring system for Table 10 was stored in a Microsoft Excel Spreadsheet

Source: Devised by author

## DISCUSSION

The initial aim was to critically evaluate physical activity interventions and their relationship with cardiovascular diseases, and understand the factors affecting the increased rate of obesity worldwide. This systematic review focused on how physical activities have an effect on body composition and health complications, focusing on metabolic syndromes such as cardiovascular diseases. TABLES 5 and 6 summarised the number of articles fulfilling the inclusion and exclusion criteria.

### Using Quality Assessment Tools

Impacts of studies were measured using quality assessment tools (TABLE 8). A number of tools were identified; all were included to understand the quality of the literature and the effectiveness of those tools. However, it was found that the tools were not as accurate as anticipated, receiving various perceptions of validity on each article.
The 'Study of Quality' tool was developed by the reviewer with the aim of understanding the aim of the research incorporating the possible factors influencing the outcomes. A high study quality score reflected its validity and reliability; however, studies reviewed noted the impossibility of achieving a full 100% response rate.

The CASP checklist assessed the relevance and reliability of the study. Studies reviewed found there was a lack of blinding in study interventions and authors did not fully report this in their methodology. Therefore, the score against the CASP checklist was determined by the reviewer's judgement based on the presented evidence in each study.

The Cochrane Collaboration Risk of Bias Tool (CCRBT) was based on the subjective feedback from participants. Studies reviewed consisted of interventions where participants were instructed to follow interventions to measure health outcomes, where data collected were self-reported. As such, the 'overall risk of study' was calculated if qualities in the tool were met. Due to low score in 'performance bias' in most of the articles found (scored 0 if authors did not mention in paper and researcher did not make assumptions to prevent subjective decisions), articles were automatically placed either into 'moderate' and or 'high' categories subject to meeting other domains' criteria. Therefore CCRBT provided reasonable support in determining the quality of articles and interventions, but also provided many discrepancies when comparing scores from other tools used (TABLE 8). Consequently, guidance should be provided to the rater to maintain the objectives and be consistent when assessing each study. Also, caution should be considered as no single tool can provide answer to articles' validity.

### Meeting Research Objectives

*Habitual Exercise Reduces Cardiovascular Diseases*

Habitual exercise sessions can be defined as regular exercise sessions, performed out of habit and incorporated into a participant's lifestyle (Perseghin et al., 2007). Studies provided evidence that habitual exercise reduces risks of cardiovascular disease, improving quality of life, and prolonging immediate and long-term health benefits (Blackford et al., 2016; Jones et al., 2016; Blackford et al., 2015; Muhihi et al., 2012; Freak-Poli et al., 2011; Dua et al., 2010; Dua et al., 2007). Franco et al. (2012) and Martinelli et al. (2008) investigated how quality of life has an effect on cardiovascular disease, suggesting that a more personalised approach should be implemented to further comprehend habitual habits. Although there was a slight adjustment for including articles published outside the UK, studies have shown that there were similarities in results, understanding that habitual exercise reduces cardiovascular disease. Meeting the initial objective in this review, those with frequent physical activity (or in this case longer study interventions compared to studies lasting a week) reduced risks of cardiovascular disease, as suggested by the WHO (2011).

*Risks of Metabolic Syndrome*

Hagnäs et al. (2012) evaluated the risks of metabolic syndrome, exploring weight loss and increased physical activity with military personnel, demonstrating how occupation lifestyle influences cardiovascular disease. Whilst this article provided evidence that types of occupation affect health risks, it has been suggested that health promotions within a work environment can influence lifestyle and dietary changes.

*Reduce Body Fat via Physical Activity*

The WHO (2011) recommends at least 150 minutes of moderate intensity activity throughout the week for adults aged 18–64. Golubic et al. (2015) explored the link between body fat and physical activity, and demonstrated that a sedentary lifestyle facilitates the positive correlation. However, Hardcastle et al. (2013) discuss whether this is maintainable after a year of intervention. Using a motivational intervention incorporated into the physical activity intervention demonstrates the motivation for participants to enhance their exercise sessions, altering their behaviour, thus improving their biomedical indices and body composition. Jones et al. (2016) conversely found a lack of consistency between physical activity and a sedentary lifestyle with body fat and cardiovascular disease. However, they concluded that physical activity should be more personalised according to their demographic.

*Psychology and Self-Efficacy*

Using literature for an intervention demonstrates evidence of acquiring effective behavioural and motivational tools for participants to adopt change in participating in physical activities (Blackford et al., 2016; Blackford et al., 2015; Hardcastle et al., 2013; Carr et al., 2008; Hardcastle et al., 2008; Sherman et al., 2007; Irwin et al., 2004). Changing physical activity behaviour may only be part of the target; however, Grisolía et al. (2013) demonstrate that participants only adopt change in physical activity, not change their dietary behaviour. Although this may be a persistent barrier to reducing risks of obesity and cardiovascular disease, Oldroyd et al. (2006) indicated the intention to change behaviour was more successful with health care professionals acting as a stimulus for the motivation. Articles (TABLES 7 and 8) provided evidence supporting how applying physical activity interventions has an impact on the need for psychological support to achieve set targets.

*Social Factors*

Dua et al. (2010), Dua et al. (2007), Sherman et al. (2007) and Steptoe et al. (2000) evaluated participants' habitual habits, their quality of life, and the predictors affecting risks of cardiovascular disease against participation in physical activity and obesity. Whilst it was clear that health care professionals' support is required to motivate and maintain a constant delivery of studies' interventions, lifestyle habits were evaluated to measure the impact on body composition. Simple walking interventions demonstrated effectiveness for those residing in rural areas (Sherman et al., 2000), and feasibilities for those on home based exercise programmes (Dua et al., 2010). However, Steptoe et al. (2000) assessed predictors, including demographic, social and cognitive, investigating how lifestyle influences interventions. It concludes that an interpersonal social relationship with public health promotion enhances health intervention, reducing risks of health complications and increasing physical activity participation.

*Health Promotion and Personalised Approach*

The selected literature highlighted the need for a personalised approach when designing health promotions and physical activity interventions (Jones et al., 2016; Golubic et al., 2015; Duncan et al., 2014; Martinelli et al., 2008; Steptoe et al., 2000). Health promotions, especially for physical inactivity, have been demonstrated as a global challenge

and a modifiable risk factor for cardiovascular disease. Therefore, to encourage and improve a population's frequent physical activities (and therefore minimising risks of metabolic syndromes), effective public health promotion is required to understand the needs of the population and use a personalised approach to promote physical activity.

## Lessons Learnt

This systematic review has highlighted the importance of interventions at all levels (primary, secondary and tertiary) to increase physical activity. Targeting interventions to suit the population groups, and understanding other factors for physical inactivity, have proven to be the answer to increase motivation in sustaining a healthy lifestyle and minimising risks of cardiovascular disease and obesity. Whilst many public health interventions may be created to tackle the pandemic of physical inactivity and obesity, it has been identified that there are other factors that need to be considered. Factors such as attitudes towards eating, attitudes towards following an intervention for a length of time, and attitudes towards self-efficacy are just a few examples. This systematic review demonstrated the health care professional-participants contact time raised awareness of healthy lifestyle knowledge. Educating people also provides benefits of lifestyle change by modifying their physical activity and dietary behaviour, and this has an impact on risks of cardiovascular disease.

The length of physical activity effects health status. Availability and accessibility of resources performed external to homes were shown to have an impact on physical activity participation. However, those with home-based interventions also provide positive engagement with participants from regular contacts with researchers and health professionals. This concludes that participants with the intention of changing their behaviour and adapting for a healthier lifestyle are likely to sustain researchers' objectives post-studies without the need for continuous support and motivation.

## Limitations to Review

This review encountered a few limitations. Doucerain and Fellows (2012), Sattelmair et al. (2011), Elder and Roberts (2007), and Blundell and Cooling (2000) critically evaluated other literature in the same field, supporting their initial hypothesis. They provided evidence of a relationship between physical activity, food choices/perceptions and cardiovascular disease. Studies concluded that health problems were caused by a lack of physical activity and over-consumption of food. The literature also provided evidence supporting them to be valid, using reliable methods. However, the initial aim explores how physical activity has an impact on cardiovascular disease and obesity. Therefore, the consumption of food was not the main research focus, although this was shown to be a key factor. As a result, there is no clear conclusion of understanding the full extent of how physical activity impacts health status without understanding other predictors.

Second, the inclusion and exclusion criteria provided a challenge when searching for relevant literature. Having a narrow pool of literature initially seemed to provide an understanding of this research topic. However, during the screening process, it was difficult to find those matching the inclusion criteria.

The lack of comparable duration and exercise intensity may have impeded the understanding of the review's aims and objectives. The need to understand this may provide a better understanding whether reaching NICE guidelines can provide better health benefits. Studies with a longer duration (e.g. three months) proved to have better health status outcomes compared to those with shorter interventions. However, the intensity reached by each participant during interventions was different,

as monitoring their progress also varied between studies' protocols. Consequently, this review cannot fully provide an answer to determine if exercise intensity in each study were valid according to the WHO (2011).

## CONCLUSIONS

The growth of urbanisation, economic, lifestyle and population has changed the way people are living. Whilst many factors continue to fuel the perceptions of a 'healthy lifestyle', the definition may vary between individuals who are more and/or less educated and knowledgeable in this topic area.

This systematic review has achieved the objectives as initially listed, critically evaluating the existing literature in the field. Understanding the relationship between physical activity with risk factors of cardiovascular disease and the impact of obesity has demonstrated a complexity of all factors that needed to be considered. No single factor can fully support the understanding of physical inactivity. However, lifestyle and personal behaviour towards change are demonstrated to be the answer in encouraging participation in physical activity.

Whilst health services and government are creating public health interventions, there is a need to understand the target audience and the population to develop interventions personalised to them, rather than urging everyone to follow the same protocol. With the level of obesity increasing and straining the available resources in the health sector, strategies are required to show a measureable and effective result. All aspects of lifestyle play a role in determining health status. Thus, public health interventions should incorporate all health care professionals to work cohesively, presenting an holistic approach for individual needs. Translating the required knowledge from theory into action, and measuring health outcomes in the long term provides a more sustainable approach, making an impact and perhaps investigating the impact on different ethnic groups.

## RECOMMENDATIONS

Key recommendations to enhance this systematic review are:

1) to use meta-analysis on the selected literature, exploring the quantitative data analysis and heterogeneity;
2) to explore the impact on how different physical activity intensity affects risks of cardiovascular disease and obesity rate;
3) to explore how different demographic groups are more susceptible to exercising at high intensity and their effects on risks of cardiovascular disease;
4) to explore how social norms and behaviour has an impact on health complications;
5) to explore how food choices and sensory science have an impact on physical activity and the level of risk of health complications.

## REFERENCES

Blackford, K., Jancey, J., Lee, A.H., James, A.P., Howat, P., Hills, A.P. and Anderson, A. (2015) *A randomised controlled trial of a physical activity and nutrition program targeting middle-aged adults at risk of metabolic syndrome in a disadvantaged rural community. BMC* Public Health, Vol. 15, No. 1, P. 1. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-015-1613-9 [Accessed 27 August 2016]

Blackford, K., Jancey, J., Lee, A.H., James, A.P., Waddell, T. and Howat, P. (2016) Home-based lifestyle intervention for rural adults improves metabolic syndrome parameters and cardiovascular risk factors: A randomised controlled trial. *Preventive Medicine,* Vol. 89, pp.15–22. Available from: http://www.sciencedirect.com/science/article/pii/S0091743516300895 [Accessed 27 August 2016]

Blundell, J.E. and Cooling, J. (2000) Routes to obesity: phenotypes, food choices and activity. *British Journal of Nutrition,* Vol. 83, No. S1, pp.S33–S38. Available from: https://www.cambridge.org/core/journals/british-journal-of-nutrition/article/routes-to-obesity-phenotypes-food-choices-and-activity/0F9CC4F678553B37FFA22F725832A813 [Accessed 27 August 2016].

Butland, B., Jebb, S., Kopelman, P., McPherson, K., Thomas, S., Mardell, J. and Parry, V. (2007) *Tackling*

*Obesities: Future Choices – Project Report.* 2nd Edn. London: Government Office for Science. Available from: https://www.gov.uk/government/publications/reducing-obesity-future-choices [Accessed on 1 June 2016]

Carr, L.J., Bartee, R.T., Dorozynski, C., Broomfield, J.F., Smith, M.L. and Smith, D.T. (2008) Internet-delivered behavior change program increases physical activity and improves cardiometabolic disease risk factors in sedentary adults: results of a randomized controlled trial. *Preventive Medicine,* Vol. 46, No. 5, pp.431–438. Available from: http://www.sciencedirect.com/science/article/pii/S0091743507005038 [Accessed 27 August 2016]

Critical Appraisal Skills Programme (CASP) (2014) *CASP Checklists.* Oxford. CASP. Available from: http://www.casp-uk.net/casp-tools-checklists [Accessed 22 October 2016]

Centres for Disease Control and Prevention (CDC) (1999) *Physical Activity and Health.* Available from: http://www.cdc.gov/nccdphp/sgr/summ.htm [Accessed 3 June 2016]

Cross-Government Obesity Unit (2008) *Healthy Weight, Healthy Lives: A Cross-Government Strategy for England.* London: Department of Health and Department of Children, Schools and Families. Available from: http://webarchive.nationalarchives.gov.uk/20130401151715/http://www.education.gov.uk/publications/eOrderingDownload/DH-9087.pdf [Accessed on 1 June 2016]

Cross-Government Obesity Unit (2009) *Healthy Weight, Healthy Lives: One Year On.* London: Department of Health and Department of Children, Schools and Families. Available from: http://webarchive.nationalarchives.gov.uk/20100407220245/http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_097623.pdf [Accessed on 1 June 2016]

Cross-Government Obesity Unit (2010) *Healthy Weight, Healthy Lives: Two Years On.* London: Department of Health and Department of Children, Schools and Families. Available from: https://www.more-life.co.uk/userfiles/dh_113495.pdf [Accessed on 1 June 2016]

Department of Health (2011a) *Equality Analysis A call to action on obesity in England.* London: Department of Health. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213721/dh_130511.pdf [Accessed on 1 June 2016]

Department of Health (2011b) *Healthy Lives, Healthy People: A call to action on obesity in England.* London: Department of Health. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213720/dh_130487.pdf [Accessed on 1 June 2016]

Department of Health (2012) *The Public Health Outcomes Framework for England, 2013–2016.* London: Department of Health. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/216159/dh_132362.pdf [Accessed on 1 June 2016]

Doucerain, M. and Fellows, L.K. (2012) Eating right: Linking food-related decision-making concepts from neuroscience, psychology, and education. *Mind, Brain, and Education,* Vol. 6, No. 4, pp.206–219. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1751-228X.2012.01159.x [Accessed 27 August 2016]

Downs, S.H. and Black, N. (1998) The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology and Community Health,* Vol. 52, No. 6, pp.377–384. Available from: http://jech.bmj.com/content/52/6/377.short [Accessed 28 October 2016]

Downs, J.S., Loewenstein, G. and Wisdom, J. (2009) Strategies for promoting healthier food choices. *The American Economic Review,* Vol. 99, No. 2, pp.159–164. Available from: http://www.jstor.org/stable/25592393?seq=1#page_scan_tab_contents [Accessed on 2 June 2016]

Dua, J.S., Cooper, A.R., Fox, K.R. and Stuart, A.G. (2007) Physical activity levels in adults with congenital heart disease. *European Journal of Cardiovascular Prevention & Rehabilitation,* Vol. 14, No. 2, pp.287–293. Available from: http://cpr.sagepub.com/content/14/2/287.short [Accessed 27 August 2016]

Dua, J.S., Cooper, A.R., Fox, K.R. and Stuart, A.G. (2010) Exercise training in adults with congenital heart disease: feasibility and benefits. *International Journal of Cardiology,* Vol. 138, No. 2, pp.196–205. Available from: http://www.sciencedirect.com/science/article/pii/S0167527309000485 [Accessed 27 August 2016]

Duncan, M.J., Gilson, N. and Vandelanotte, C. (2014) Which population groups are most unaware of CVD risks associated with sitting time? *Preventive medicine,* Vol. 65, pp.103–108.

Available from: http://www.sciencedirect.com/science/article/pii/S0091743514001741 [Accessed 27 August 2016]

Elder, S.J. and Roberts, S.B. (2007) The effects of exercise on food intake and body fatness: a summary of published studies. *Nutrition Reviews,* Vol. 65, No. 1, pp.1–19. Available from: https://academic.oup.com/nutritionreviews/article-abstract/65/1/1/1897849 [Accessed 27 August 2016]

Franco, O.H., Wong, Y.L., Kandala, N.B., Ferrie, J.E., Dorn, J.M., Kivimäki, M., Clarke, A., Donahue, R.P., Manoux, A.S., Freudenheim, J.L. and Trevisan, M. (2012) Cross-cultural comparison of correlates of quality of life and health status: the Whitehall II Study (UK) and the Western New York Health Study (US). *European Journal of Epidemiology,* Vol. 27, No. 4, pp.255–265. Available from: http://link.springer.com/article/10.1007/s10654-012-9664-z [Accessed 27 August 2016]

Freak-Poli, R., Wolfe, R., Backholer, K., De Courten, M. and Peeters, A. (2011) Impact of a pedometer-based workplace health program on cardiovascular and diabetes risk profile. *Preventive Medicine,* Vol. 53, No. 3, pp.162–171. Available from: http://www.sciencedirect.com/science/article/pii/S0091743511002313 [Accessed 27 August 2016]

French, S.A., Story, M., Neumark-Sztainer, D., Fulkerson, J.A., and Hannan, P. (2001) Fast food restaurant use among adolescents: associations with nutrient intake, food choices and behavioral and psychosocial variables. *International Journal of Obesity,* Vol. 25, No. 12, pp.1823–1833. Available from: http://europepmc.org/abstract/med/11781764 [Accessed on 2 June 2016]

Golubic, R., Wijndaele, K., Sharp, S.J., Simmons, R.K., Griffin, S.J., Wareham, N.J., Ekelund, U. and Brage, S. (2015) Physical activity, sedentary time and gain in overall and central body fat: 7-year follow-up of the ProActive trial cohort. *International Journal of Obesity,* Vol. 39, No. 1, pp.142–148. Available from: http://www.nature.com/ijo/journal/v39/n1/abs/ijo201466a.html [Accessed 27 August 2016]

Government Office for Science (2007) *Foresight Tackling Obesities: Future Choices – Obesity System Atlas*. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295153/07-1177-obesity-system-atlas.pdf [Accessed 19 October 2016]

Government Office for Science (2012) *Tackling Obesities: Future Choices – Mid Term Review (November 2008 to September 2010).* London: Government Office for Science. Available from: https://www.gov.uk/government/publications/reducing-obesity-future-choices-mid-term-review [Accessed on 1 June 2016]

Government Office for Science (2013) *Collection: Foresight Projects*. Available from: https://www.gov.uk/government/collections/foresight-projects [Accessed on 1 June 2016]

Grisolía, J.M., Longo, A., Boeri, M., Hutchinson, G. and Kee, F. (2013) Trading off dietary choices, physical exercise and cardiovascular disease risks. *Social Science & Medicine,* Vol. 93, pp.130–138. Available from: http://www.sciencedirect.com/science/article/pii/S0277953613003250 [Accessed 27 August 2016]

Hagnäs, M.P., Cederberg, H., Mikkola, I., Ikäheimo, T.M., Jokelainen, J., Laakso, M., Härkönen, P., Peitso, A., Rajala, U. and Keinänen-Kiukaanniemi, S. (2012) Reduction in metabolic syndrome among obese young men is associated with exercise-induced body composition changes during military service. *Diabetes Research and Clinical Practice,* Vol. 98, No. 2, pp.312–319. Available from: http://www.sciencedirect.com/science/article/pii/S0168822712003130 [Accessed 27 August 2016]

Hardcastle, S., Taylor, A., Bailey, M. and Castle, R. (2008) A randomised controlled trial on the effectiveness of a primary health care based counselling intervention on physical activity, diet and CHD risk factors. *Patient Education and Counseling,* Vol. 70, No. 1, pp.31–39. Available from: http://www.sciencedirect.com/science/article/pii/S073839910700376X [Accessed 27 August 2016]

Hardcastle, S.J., Taylor, A.H., Bailey, M.P., Harley, R.A. and Hagger, M.S. (2013) Effectiveness of a motivational interviewing intervention on weight loss, physical activity and cardiovascular disease risk factors: a randomised controlled trial with a 12-month post-intervention follow-up. *International Journal of Behavioral Nutrition and Physical Activity,* Vol. 10, No. 1, p.40. Available from: https://ijbnpa.biomedcentral.com/articles/10.1186/1479–5868-10-40 [Accessed 27 August 2016]

Higgins, J.P., Altman, D.G., Gøtzsche, P.C., Jüni, P., Moher, D., Oxman, A.D., Savović, J., Schulz, K.F., Weeks, L. and Sterne, J.A. (2011) The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *British Medical Journal,* Vol. 343, p.d5928. Available from: http://www.bmj.com/content/343/bmj.d5928 [Accessed 22 October 2016]

Irwin, M.L., Tworoger, S.S., Yasui, Y., Rajan, B., McVarish, L., LaCroix, K., Ulrich, C.M., Bowen, D., Schwartz, R.S., Potter, J.D. and McTiernan, A. (2004) Influence of demographic, physiologic, and psychosocial variables on adherence to a yearlong moderate-intensity exercise trial in postmenopausal women. *Preventive Medicine,* Vol. 39, No. 6, pp.1080–1086. Available from: http://www.sciencedirect.com/science/article/pii/S0091743504002300 [Accessed 27 August 2016]

Jones, S.A., Wen, F., Herring, A.H. and Evenson, K.R. (2016) Correlates of US adult physical activity and sedentary behavior patterns. *Journal of Science and Medicine in Sport.* Vol. 19, No. 12, pp.1020–1027 Available from: http://www.sciencedirect.com/science/article/pii/S1440244016300056 [Accessed 27 August 2016]

Ke, K.M., Blazeby, J.M., Strong, S., Carroll, F.E., Ness, A.R. and Hollingworth, W. (2013) Are multidisciplinary teams in secondary care cost-effective? A systematic review of the literature. *Cost Effectiveness and Resource Allocation,* Vol. 11, No. 1, p.7. Available from: http://resource-allocation.biomedcentral.com/articles/10.1186/1478–7547-11-7 [Accessed 1 June 2016]

Lobstein, T. and Jackson Leach, R. (2007) *International Comparisons of Obesity Trends, Determinants and Responses. Evidence Review.* Foresight Tackling Obesities: Future Choices. 2007. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295686/07-926A4-obesity-international.pdf [Accessed on 1 June 2016]

Martinelli, L.M.B., Mizutani, B.M., Mutti, A., D'elia, M.P.B., Coltro, R.S. and Matsubara, B.B. (2008) Quality of life and its association with cardiovascular risk factors in a community health care program population. *Clinics,* Vol. 63, No. 6, pp.783–788. Available from: http://www.scielo.br/scielo.php?pid=S1807-59322008000600013&script=sci_arttext&tlng=pt [Accessed 27 August 2016]

Moher, D., Liberati, A., Tetzlaff, J. and Altman, D.G. (2009) The PRISMA Group. *Preferred Reporting Items for Systematic Reviews and Meta-Analyses:* The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097 Available from: http://prisma-statement.org/PRISMAStatement/FlowDiagram.aspx [Accessed 20 October 2016]

Muhihi, A., Njelekela, M., Mpembeni, R., Masesa, Z., Kitamori, K., Mori, M., Kato, N., Mtabaji, J. and Yamori, Y. (2012) Physical activity and cardiovascular disease risk factors among young and middleaged men in urban Mwanza, Tanzania. *Pan African Medical Journal,* Vol. 11, No. 1. Available from: http://www.ajol.info/index.php/pamj/article/view/75447 [Accessed 27 August 2016]

National Health and Medical Research Council (NHMRC) (1999) *A guide to the development, implementation and evaluation of clinical practice guidelines.* Canberra, NHMRC. Available from: https://www.nhmrc.gov.au/guidelines-publications/cp30 [Accessed 29 October 2016]

National Institute for Health and Care Excellence (NICE) (2012) *Health inequalities and population health.* Available from: http://www.nice.org.uk/advice/lgb4/resources/health-inequalities-and-population-health-1681147764421 [Accessed on 2 June 2016]

Oldroyd, J.C., Unwin, N.C., White, M., Mathers, J.C. and Alberti, K.G.M.M. (2006) Randomised controlled trial evaluating lifestyle interventions in people with impaired glucose tolerance. *Diabetes Research and Clinical Practice,* Vol. 72, No. 2, pp.117–127. Available from: http://www.sciencedirect.com/science/article/pii/S0168822705004079 [Accessed 27 August 2016]

Perseghin, G., Lattuada, G., De Cobelli, F., Ragogna, F., Ntali, G., Esposito, A., Belloni, E., Canu, T., Terruzzi, I., Scifo, P. and Del Maschio, A. (2007) Habitual physical activity is associated with intrahepatic fat content in humans. *Diabetes Care,* Vol. 30, No. 3, pp.683–688. Available from: http://care.diabetesjournals.org/content/30/3/683.long [Accessed 29 December 2016]

Public Health England (PHE) (2014) PHE release local authority adult obesity data. Available from: https://www.gov.uk/government/news/phe-release-local-authority-adult-obesity-data [Accessed on 3 June 2016]

Sattelmair, J., Pertman, J., Ding, E.L., Kohl III, H.W., Haskell, W. and Lee, I.M. (2011) Dose response between physical activity and risk of coronary heart disease: a meta-analysis. *Circulation,* Vol. 124, No. 7, pp.789–795. Available from: https://www.ahajournals.org/doi/full/10.1161/CIRCULATIONAHA.110.010710 [Accessed 27 August 2016].

Sherman, B.J., Gilliland, G., Speckman, J.L. and Freund, K.M. (2007) The effect of a primary care exercise intervention for rural women. *Preventive Medicine,* Vol. 44, No. 3, pp.198–201. Available from: http://www.sciencedirect.com/science/article/pii/S0091743506004580 [Accessed 27 August 2016]

Steptoe, A., Rink, E. and Kerry, S. (2000) Psychosocial predictors of changes in physical activity in overweight sedentary adults following counseling in primary care. *Preventive Medicine,* Vol. 31, No. 2, pp.183–194. Available from: http://www.sciencedirect.com/science/article/pii/S0091743500906881 [Accessed 27 August 2016]

Wells, G.A., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M. and Tugwell, P. The *Newcastle-Ottawa Scale (NOS) for assessing the quality if nonrandomized studies in meta-analyses*. Available from: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp [Accessed 27 October 2016]

World Health Organisation (WHO) (2014) *Global status report on non communicable diseases*. Available from http://apps.who.int/iris/bitstream/10665/148114/1/9789241564854_eng.pdf [Accessed on 3 June 2016]